

2.

Media as Epistemology

It is my intention in this book to show that a great media-metaphor shift has taken place in America, with the result that the content of much of our public discourse has become dangerous nonsense. With this in view, my task in the chapters ahead is straightforward. I must, first, demonstrate how, under the governance of the printing press, discourse in America was different from what it is now—generally coherent, serious and rational; and then how, under the governance of television, it has become shriveled and absurd. But to avoid the possibility that my analysis will be interpreted as standard-brand academic whimpering, a kind of elitist complaint against “junk” on television, I must first explain that my focus is on epistemology, not on aesthetics or literary criticism. Indeed, I appreciate junk as much as the next fellow, and I know full well that the printing press has generated enough of it to fill the Grand Canyon to overflowing. Television is not old enough to have matched printing’s output of junk.

And so, I raise no objection to television’s junk. The best things on television *are* its junk, and no one and nothing is seriously threatened by it. Besides, we do not measure a culture by its output of undisguised trivialities but by what it claims as significant. Therein is our problem, for television is at its most trivial and, therefore, most dangerous when its aspirations are high, when it presents itself as a carrier of important cultural conversations. The irony here is that this is what intellectuals and critics are constantly urging television to do. The trouble

with such people is that they do not take television seriously enough. For, like the printing press, television is nothing less than a philosophy of rhetoric. To talk seriously about television, one must therefore talk of epistemology. All other commentary is in itself trivial.

Epistemology is a complex and usually opaque subject concerned with the origins and nature of knowledge. The part of its subject matter that is relevant here is the interest it takes in definitions of truth and the sources from which such definitions come. In particular, I want to show that definitions of truth are derived, at least in part, from the character of the media of communication through which information is conveyed. I want to discuss how media are implicated in our epistemologies.

In the hope of simplifying what I mean by the title of this chapter, media as epistemology, I find it helpful to borrow a word from Northrop Frye, who has made use of a principle he calls *resonance*. "Through resonance," he writes, "a particular statement in a particular context acquires a universal significance."¹ Frye offers as an opening example the phrase "the grapes of wrath," which first appears in Isaiah in the context of a celebration of a prospective massacre of Edomites. But the phrase, Frye continues, "has long ago flown away from this context into many new contexts, contexts that give dignity to the human situation instead of merely reflecting its bigotries."² Having said this, Frye extends the idea of resonance so that it goes beyond phrases and sentences. A character in a play or story—Hamlet, for example, or Lewis Carroll's Alice—may have resonance. Objects may have resonance, and so may countries: "The smallest details of the geography of two tiny chopped-up countries, Greece and Israel, have imposed themselves on our consciousness until they have become part of the map of our own imaginative world, whether we have ever seen these countries or not."³

In addressing the question of the source of resonance, Frye concludes that metaphor is the generative force—that is, the

power of a phrase, a book, a character, or a history to unify and invest with meaning a variety of attitudes or experiences. Thus, Athens becomes a metaphor of intellectual excellence, wherever we find it; Hamlet, a metaphor of brooding indecisiveness; Alice's wanderings, a metaphor of a search for order in a world of semantic nonsense.

I now depart from Frye (who, I am certain, would raise no objection) but I take his word along with me. Every medium of communication, I am claiming, has resonance, for resonance is metaphor writ large. Whatever the original and limited context of its use may have been, a medium has the power to fly far beyond that context into new and unexpected ones. Because of the way it directs us to organize our minds and integrate our experience of the world, it imposes itself on our consciousness and social institutions in myriad forms. It sometimes has the power to become implicated in our concepts of piety, or goodness, or beauty. And it is always implicated in the ways we define and regulate our ideas of truth.

To explain how this happens—how the bias of a medium sits heavy, felt but unseen, over a culture—I offer three cases of truth-telling.

The first is drawn from a tribe in western Africa that has no writing system but whose rich oral tradition has given form to its ideas of civil law.⁴ When a dispute arises, the complainants come before the chief of the tribe and state their grievances. With no written law to guide him, the task of the chief is to search through his vast repertoire of proverbs and sayings to find one that suits the situation and is equally satisfying to both complainants. That accomplished, all parties are agreed that justice has been done, that the truth has been served. You will recognize, of course, that this was largely the method of Jesus and other Biblical figures who, living in an essentially oral culture, drew upon all of the resources of speech, including mnemonic devices, formulaic expressions and parables, as a means of discovering and revealing truth. As Walter Ong points out, in

oral cultures proverbs and sayings are not occasional devices: "They are incessant. They form the substance of thought itself. Thought in any extended form is impossible without them, for it consists in them."⁵

To people like ourselves any reliance on proverbs and sayings is reserved largely for resolving disputes among or with children. "Possession is nine-tenths of the law." "First come, first served." "Haste makes waste." These are forms of speech we pull out in small crises with our young but would think ridiculous to produce in a courtroom where "serious" matters are to be decided. Can you imagine a bailiff asking a jury if it has reached a decision and receiving the reply that "to err is human but to forgive is divine"? Or even better, "Let us render unto Caesar that which is Caesar's and to God that which is God's"? For the briefest moment, the judge might be charmed but if a "serious" language form is not immediately forthcoming, the jury may end up with a longer sentence than most guilty defendants.

Judges, lawyers and defendants do not regard proverbs or sayings as a relevant response to legal disputes. In this, they are separated from the tribal chief by a media-metaphor. For in a print-based courtroom, where law books, briefs, citations and other written materials define and organize the method of finding the truth, the oral tradition has lost much of its resonance—but not all of it. Testimony is expected to be given orally, on the assumption that the spoken, not the written, word is a truer reflection of the state of mind of a witness. Indeed, in many courtrooms jurors are not permitted to take notes, nor are they given written copies of the judge's explanation of the law. Jurors are expected to *hear* the truth, or its opposite, not to read it. Thus, we may say that there is a clash of resonances in our concept of legal truth. On the one hand, there is a residual belief in the power of speech, and speech alone, to carry the truth; on the other hand, there is a much stronger belief in the authenticity of writing and, in particular, printing. This second belief

has little tolerance for poetry, proverbs, sayings, parables or any other expressions of oral wisdom. The law is what legislators and judges have written. In our culture, lawyers do not have to be wise; they need to be well briefed.

A similar paradox exists in universities, and with roughly the same distribution of resonances; that is to say, there are a few residual traditions based on the notion that speech is the primary carrier of truth. But for the most part, university conceptions of truth are tightly bound to the structure and logic of the printed word. To exemplify this point, I draw here on a personal experience that occurred during a still widely practiced medieval ritual known as a "doctoral oral." I use the word *medieval* literally, for in the Middle Ages students were always examined orally, and the tradition is carried forward in the assumption that a candidate must be able to talk competently about his written work. But, of course, the written work matters most.

In the case I have in mind, the issue of what is a legitimate form of truth-telling was raised to a level of consciousness rarely achieved. The candidate had included in his thesis a footnote, intended as documentation of a quotation, which read: "Told to the investigator at the Roosevelt Hotel on January 18, 1981, in the presence of Arthur Lingeman and Jerrold Gross." This citation drew the attention of no fewer than four of the five oral examiners, all of whom observed that it was hardly suitable as a form of documentation and that it ought to be replaced by a citation from a book or article. "You are not a journalist," one professor remarked. "You are supposed to be a scholar." Perhaps because the candidate knew of no published statement of what he was told at the Roosevelt Hotel, he defended himself vigorously on the grounds that there were witnesses to what he was told, that they were available to attest to the accuracy of the quotation, and that the form in which an idea is conveyed is irrelevant to its truth. Carried away on the wings of his eloquence, the candidate argued further that there were more than three hundred references to published works in his thesis and

that it was extremely unlikely that any of them would be checked for accuracy by the examiners, by which he meant to raise the question, Why do you *assume* the accuracy of a print-referenced citation but not a speech-referenced one?

The answer he received took the following line: You are mistaken in believing that the form in which an idea is conveyed is irrelevant to its truth. In the academic world, the published word is invested with greater prestige and authenticity than the spoken word. What people say is assumed to be more casually uttered than what they write. The written word is assumed to have been reflected upon and revised by its author, reviewed by authorities and editors. It is easier to verify or refute, and it is invested with an impersonal and objective character, which is why, no doubt, you have referred to yourself in your thesis as "the investigator" and not by your name; that is to say, the written word is, by its nature, addressed to the world, not an individual. The written word endures, the spoken word disappears; and that is why writing is closer to the truth than speaking. Moreover, we are sure you would prefer that this commission produce a written statement that you have passed your examination (should you do so) than for us merely to tell you that you have, and leave it at that. Our written statement would represent the "truth." Our oral agreement would be only a rumor.

The candidate wisely said no more on the matter except to indicate that he would make whatever changes the commission suggested and that he profoundly wished that should he pass the "oral," a written document would attest to that fact. He did pass, and in time the proper words were written.

A third example of the influence of media on our epistemologies can be drawn from the trial of the great Socrates. At the opening of Socrates' defense, addressing a jury of five hundred, he apologizes for not having a well-prepared speech. He tells his Athenian brothers that he will falter, begs that they not interrupt him on that account, asks that they regard him as they

would a stranger from another city, and promises that he will tell them the truth, without adornment or eloquence. Beginning this way was, of course, characteristic of Socrates, but it was not characteristic of the age in which he lived. For, as Socrates knew full well, his Athenian brothers did not regard the principles of rhetoric and the expression of truth to be independent of each other. People like ourselves find great appeal in Socrates' plea because we are accustomed to thinking of rhetoric as an ornament of speech—most often pretentious, superficial and unnecessary. But to the people who invented it, the Sophists of fifth-century B.C. Greece and their heirs, rhetoric was not merely an opportunity for dramatic performance but a near indispensable means of organizing evidence and proofs, and therefore of communicating truth.⁶

It was not only a key element in the education of Athenians (far more important than philosophy) but a preeminent art form. To the Greeks, rhetoric was a form of spoken writing. Though it always implied oral performance, its power to reveal the truth resided in the written word's power to display arguments in orderly progression. Although Plato himself disputed this conception of truth (as we might guess from Socrates' plea), his contemporaries believed that rhetoric was the proper means through which "right opinion" was to be both discovered and articulated. To disdain rhetorical rules, to speak one's thoughts in a random manner, without proper emphasis or appropriate passion, was considered demeaning to the audience's intelligence and suggestive of falsehood. Thus, we can assume that many of the 280 jurors who cast a guilty ballot against Socrates did so because his manner was not consistent with truthful matter, as they understood the connection.

The point I am leading to by this and the previous examples is that the concept of truth is intimately linked to the biases of forms of expression. Truth does not, and never has, come unadorned. It must appear in its proper clothing or it is not acknowledged, which is a way of saying that the "truth" is a kind

of cultural prejudice. Each culture conceives of it as being most authentically expressed in certain symbolic forms that another culture may regard as trivial or irrelevant. Indeed, to the Greeks of Aristotle's time, and for two thousand years afterward, scientific truth was best discovered and expressed by deducing the nature of things from a set of self-evident premises, which accounts for Aristotle's believing that women have fewer teeth than men, and that babies are healthier if conceived when the wind is in the north. Aristotle was twice married but so far as we know, it did not occur to him to ask either of his wives if he could count her teeth. And as for his obstetric opinions, we are safe in assuming he used no questionnaires and hid behind no curtains. Such acts would have seemed to him both vulgar and unnecessary, for that was not the way to ascertain the truth of things. The language of deductive logic provided a surer road.

We must not be too hasty in mocking Aristotle's prejudices. We have enough of our own, as for example, the equation we moderns make of truth and quantification. In this prejudice, we come astonishingly close to the mystical beliefs of Pythagoras and his followers who attempted to submit all of life to the sovereignty of numbers. Many of our psychologists, sociologists, economists and other latter-day cabalists will have numbers to tell them the truth or they will have nothing. Can you imagine, for example, a modern economist articulating truths about our standard of living by reciting a poem? Or by telling what happened to him during a late-night walk through East St. Louis? Or by offering a series of proverbs and parables, beginning with the saying about a rich man, a camel, and the eye of a needle? The first would be regarded as irrelevant, the second merely anecdotal, the last childish. Yet these forms of language are certainly capable of expressing truths about economic relationships, as well as any other relationships, and indeed have been employed by various peoples. But to the modern mind, resonating with different media-metaphors, the truth in economics is believed to be best discovered and expressed in numbers. Per-

haps it is. I will not argue the point. I mean only to call attention to the fact that there is a certain measure of arbitrariness in the forms that truth-telling may take. We must remember that Galileo merely said that the language of *nature* is written in mathematics. He did not say *everything* is. And even the truth about nature need not be expressed in mathematics. For most of human history, the language of nature has been the language of myth and ritual. These forms, one might add, had the virtues of leaving nature unthreatened and of encouraging the belief that human beings are part of it. It hardly befits a people who stand ready to blow up the planet to praise themselves too vigorously for having found the true way to talk about nature.

In saying this, I am not making a case for epistemological relativism. Some ways of truth-telling are better than others, and therefore have a healthier influence on the cultures that adopt them. Indeed, I hope to persuade you that the decline of a print-based epistemology and the accompanying rise of a television-based epistemology has had grave consequences for public life, that we are getting sillier by the minute. And that is why it is necessary for me to drive hard the point that the weight assigned to any form of truth-telling is a function of the influence of media of communication. "Seeing is believing" has always had a preeminent status as an epistemological axiom, but "saying is believing," "reading is believing," "counting is believing," "deducing is believing," and "feeling is believing" are others that have risen or fallen in importance as cultures have undergone media change. As a culture moves from orality to writing to printing to televising, its ideas of truth move with it. Every philosophy is the philosophy of a stage of life, Nietzsche remarked. To which we might add that every epistemology is the epistemology of a stage of media development. Truth, like time itself, is a product of a conversation man has with himself about and through the techniques of communication he has invented.

Since intelligence is primarily defined as one's capacity to

grasp the truth of things, it follows that what a culture means by intelligence is derived from the character of its important forms of communication. In a purely oral culture, intelligence is often associated with aphoristic ingenuity, that is, the power to invent compact sayings of wide applicability. The wise Solomon, we are told in First Kings, knew three thousand proverbs. In a print culture, people with such a talent are thought to be quaint at best, more likely pompous bores. In a purely oral culture, a high value is always placed on the power to memorize, for where there are no written words, the human mind must function as a mobile library. To forget how something is to be said or done is a danger to the community and a gross form of stupidity. In a print culture, the memorization of a poem, a menu, a law or most anything else is merely charming. It is almost always functionally irrelevant and certainly not considered a sign of high intelligence.

Although the general character of print-intelligence would be known to anyone who would be reading this book, you may arrive at a reasonably detailed definition of it by simply considering what is demanded of you *as you read this book*. You are required, first of all, to remain more or less immobile for a fairly long time. If you cannot do this (with this or any other book), our culture may label you as anything from hyperkinetic to undisciplined; in any case, as suffering from some sort of intellectual deficiency. The printing press makes rather stringent demands on our bodies as well as our minds. Controlling your body is, however, only a minimal requirement. You must also have learned to pay no attention to the shapes of the letters on the page. You must see through them, so to speak, so that you can go directly to the meanings of the words they form. If you are preoccupied with the shapes of the letters, you will be an intolerably inefficient reader, likely to be thought stupid. If you have learned how to get to meanings without aesthetic distraction, you are required to assume an attitude of detachment and objectivity. This includes your bringing to the task what

Bertrand Russell called an "immunity to eloquence," meaning that you are able to distinguish between the sensuous pleasure, or charm, or ingratiating tone (if such there be) of the words, and the logic of their argument. But at the same time, you must be able to tell from the tone of the language what is the author's attitude toward the subject and toward the reader. You must, in other words, know the difference between a joke and an argument. And in judging the quality of an argument, you must be able to do several things at once, including delaying a verdict until the entire argument is finished, holding in mind questions until you have determined where, when or if the text answers them, and bringing to bear on the text all of your relevant experience as a counterargument to what is being proposed. You must also be able to withhold those parts of your knowledge and experience which, in fact, do not have a bearing on the argument. And in preparing yourself to do all of this, you must have divested yourself of the belief that words are magical and, above all, have learned to negotiate the world of abstractions, for there are very few phrases and sentences in this book that require you to call forth concrete images. In a print-culture, we are apt to say of people who are not intelligent that we must "draw them pictures" so that they may understand. Intelligence implies that one can dwell comfortably without pictures, in a field of concepts and generalizations.

To be able to do all of these things, and more, constitutes a primary definition of intelligence in a culture whose notions of truth are organized around the printed word. In the next two chapters I want to show that in the eighteenth and nineteenth centuries, America was such a place, perhaps the most print-oriented culture ever to have existed. In subsequent chapters, I want to show that in the twentieth century, our notions of truth and our ideas of intelligence have changed as a result of new media displacing the old.

But I do not wish to oversimplify the matter more than is necessary. In particular, I want to conclude by making three

points that may serve as a defense against certain counterarguments that careful readers may have already formed.

The first is that at no point do I care to claim that changes in media bring about changes in the structure of people's minds or changes in their cognitive capacities. There are some who make this claim, or come close to it (for example, Jerome Bruner, Jack Goody, Walter Ong, Marshall McLuhan, Julian Jaynes, and Eric Havelock).⁷ I am inclined to think they are right, but my argument does not require it. Therefore, I will not burden myself with arguing the possibility, for example, that oral people are less developed intellectually, in some Piagetian sense, than writing people, or that "television" people are less developed intellectually than either. My argument is limited to saying that a major new medium changes the structure of discourse; it does so by encouraging certain uses of the intellect, by favoring certain definitions of intelligence and wisdom, and by demanding a certain kind of content—in a phrase, by creating new forms of truth-telling. I will say once again that I am no relativist in this matter, and that I believe the epistemology created by television not only is inferior to a print-based epistemology but is dangerous and absurdist.

The second point is that the epistemological shift I have intimated, and will describe in detail, has not yet included (and perhaps never will include) everyone and everything. While some old media do, in fact, disappear (e.g., pictographic writing and illuminated manuscripts) and with them, the institutions and cognitive habits they favored, other forms of conversation will always remain. Speech, for example, and writing. Thus the epistemology of new forms such as television does not have an entirely unchallenged influence.

I find it useful to think of the situation in this way: Changes in the symbolic environment are like changes in the natural environment; they are both gradual and additive at first, and then, all at once, a critical mass is achieved, as the physicists say. A river that has slowly been polluted suddenly becomes

toxic; most of the fish perish; swimming becomes a danger to health. But even then, the river may look the same and one may still take a boat ride on it. In other words, even when life has been taken from it, the river does not disappear, nor do all of its uses, but its value has been seriously diminished and its degraded condition will have harmful effects throughout the landscape. It is this way with our symbolic environment. We have reached, I believe, a critical mass in that electronic media have decisively and irreversibly changed the character of our symbolic environment. We are now a culture whose information, ideas and epistemology are given form by television, not by the printed word. To be sure, there are still readers and there are many books published, but the uses of print and reading are not the same as they once were; not even in schools, the last institutions where print was thought to be invincible. They delude themselves who believe that television and print coexist, for coexistence implies parity. There is no parity here. Print is now merely a residual epistemology, and it will remain so, aided to some extent by the computer, and newspapers and magazines that are made to look like television screens. Like the fish who survive a toxic river and the boatmen who sail on it, there still dwell among us those whose sense of things is largely influenced by older and clearer waters.

The third point is that in the analogy I have drawn above, the river refers largely to what we call public discourse—our political, religious, informational and commercial forms of conversation. I am arguing that a television-based epistemology pollutes public communication and its surrounding landscape, not that it pollutes everything. In the first place, I am constantly reminded of television's value as a source of comfort and pleasure to the elderly, the infirm and, indeed, all people who find themselves alone in motel rooms. I am also aware of television's potential for creating a theater for the masses (a subject which in my opinion has not been taken seriously enough). There are also claims that whatever power television might have to un-

dermine rational discourse, its emotional power is so great that it could arouse sentiment against the Vietnam War or against more virulent forms of racism. These and other beneficial possibilities are not to be taken lightly.

But there is still another reason why I should not like to be understood as making a total assault on television. Anyone who is even slightly familiar with the history of communications knows that every new technology for thinking involves a trade-off. It giveth and taketh away, although not quite in equal measure. Media change does not necessarily result in equilibrium. It sometimes creates more than it destroys. Sometimes, it is the other way around. We must be careful in praising or condemning because the future may hold surprises for us. The invention of the printing press itself is a paradigmatic example. Typography fostered the modern idea of individuality, but it destroyed the medieval sense of community and integration. Typography created prose but made poetry into an exotic and elitist form of expression. Typography made modern science possible but transformed religious sensibility into mere superstition. Typography assisted in the growth of the nation-state but thereby made patriotism into a sordid if not lethal emotion.

Obviously, my point of view is that the four-hundred-year imperial dominance of typography was of far greater benefit than deficit. Most of our modern ideas about the uses of the intellect were formed by the printed word, as were our ideas about education, knowledge, truth and information. I will try to demonstrate that as typography moves to the periphery of our culture and television takes its place at the center, the seriousness, clarity and, above all, value of public discourse dangerously declines. On what benefits may come from other directions, one must keep an open mind.

5 :: MEMORY

BERNARD STIEGLER

Introduction by Mark B. N. Hansen

"The Internet age is one of hypomnesis constituting itself as an associated technical milieu." In his wide-ranging history of the concept of memory, Bernard Stiegler aims toward a moment—one that he suggests we are currently living—in which the "industrial model" of memory undergoes fundamental transformation. From Stiegler's vantage point, what is crucial about today's technical memory aids—iPods, smart phones, GPS navigators, and PDAs, not to mention the Internet—is their intimate articulation with anamnesis, a term Stiegler borrows from Plato and uses to designate the embodied act of remembering. Everything hinges on how hypomnesis, the technical exteriorization of memory, articulates with anamnesis, and Stiegler's history of memory can be understood as a history of the changing ecology of these terms. Today's computational technical memory aids—digital *hypomnemata*—differ from the industrial hypomnemata of technical recording (photography, phonography, cinematography) in that they create an "associated hypomnesic milieu" in which "receivers are placed in the position of senders." Rather than dissociating consumption from production, as did broadcast mass media (from phonography to global real-time television), today's microtechnologies and the social networking practices they facilitate connect them: if you can use these technologies to consume, Stiegler suggests, you can also use them to produce.

This is why Stiegler sees digital memory aids as instigators of an "ecology of associated hypomnesic milieus." And it is also why he thinks they have more in common with writing than they do with broadcast media like film and television. Just as the literate citizen learned to read and to write by embodying the practices of literacy through a more or less arduous process of formation, so too the digital citizen acquires facility in networked communication by embodying a procedural logic that views sending and receiving as symmetrical and complicated activities. In both cases, the payoff of the process of formation is a capacity to create, to use a standardized technicity for self-expression; this capacity, Stiegler suggests, stands in direct opposition

to the mode of passive reception endemic to the broadcast media. The new ecology of associated hypomnesic milieus that Stiegler calls for would accordingly inaugurate a new conjugation of technics and memory that would succeed *mnemotechniques* (the artificial storage of individual memories that characterizes hypomnesis from ideogrammatic writing to the print revolution) and *mnemotechnologies* (the embedding of memories within technological systems that systematically order memories according to their own logics). By renewing the possibility for self-expression, and hence for self-exteriorization, today's digital hypomnemata restore a positive dimension to our coevolution with technics. We might even say that they fuse mnemotechniques and mnemotechnologies, furnishing artificial supports for individual (and collective) memories that exist within and are nourished by a larger mnemotechnological milieu—the system of the Internet.

Stiegler's invocation of contemporary digital hypomnemata comes only at the end of a long interrogation of memory, and its constitutive relation to technics, in Western history. From his first book, *Technics and Time*, vol. 1, *The Fault of Epimetheus* (1994), to his latest work on Foucault's conception of "care" (*Prendre le soin*, vol. 1, 2008), Stiegler has concerned himself with the "essential" correlation of the human and technics. Drawing on the work of French paleontologist André Leroi-Gourhan, Stiegler interprets the coincidence of protohuman fossil remains and primitive flint tools to mean that the human is the species that evolves not simply genetically but extragenetically (or, as he puts it, *epiphylogenetically*, "by means other than life"): the human evolves by exteriorizing itself in tools, artifacts, language, and technical memory banks. Technology on this account is not something external and contingent, but rather an essential—indeed, *the* essential—dimension of the human. As Stiegler explains in his essay, this account of technics provides a necessary counterpart to that of Plato, which, despite its insight into the value of artificial memory (in the *Meno*), ultimately dismisses it as false (in the *Phaedrus*). It is this dismissal, Stiegler argues (following his teacher, Jacques Derrida), that informs the antipathy of Western philosophy to the theme of technics.

With respect to memory, this essential, protohistorical correlation of the human with technics appears in the form of "retentional finitude." It is because our memories are finite that we require artificial memory aids, and the ensuing ecology of "natural" and artificial memory, of anamnesis and hypomnesis, has, since its initial theorization by Plato, characterized the differing function and valuation of memory across our history. If we learn from Plato—or rather, from one side of Plato—that artificial memory is a *pharmakon*, a gift that is also a threat (since dependence on artificial memory makes the training of our own memory less imperative), we learn from Derrida that technical exteriorization or supplementation is an intrinsic,

irreducible dimension of the logic and function of memory as such. It is this technical contamination of memory that allows the latter to be historicized, split into distinct epochs of what Stiegler, following Derrida (and the linguist Sylvain Auroux), calls “grammatization”: the exteriorization of memory in the form of discrete marks, traces, or *grammé* that forms the hypomnesic milieu for anamnesis. As Stiegler notes, these epochs include those of the stone tool, of ideogrammatic writing, of the alphabet, of analog and digital recording, and now of digitization and the Internet. As different historically specific configurations of anamnesis with technics, these epochs individually and collectively demonstrate that there is no memory that is not hypomnesic. This, again, is why everything hinges on how hypomnesis is articulated with anamnesis.

The dependence of memory on artificial aids makes the question of technology an irreducibly political question. As Stiegler puts it, the hypomnesic milieu can either be “associated” with or “dissociated” from anamnesis (the embodied act of memory). When they are associated with anamnesis, hypomnemata facilitate the deployment of memory in the constitution of meaningful symbolic practices and communal formations; by contrast, when they are dissociated from anamnesis, they advance the interests of the culture industries (Adorno and Horkheimer) and of “control societies” (Deleuze), which work to transform human beings into mere consumers, passive recipients of prepackaged and standardized commodities and media fluxes who have no hope of becoming producers. Put more simply, reliance on artificial memory aids makes us vulnerable to manipulation if the technologies of memory are controlled by industries intent on exploiting our desire for their gain; yet on the other hand (and in accordance with their *pharmacological* logic), these same memory aids hold the promise of expanding our capacity to produce meaning and to form communities open to the future (this is what Stiegler, following the philosopher Gilbert Simondon, means by “transindividuation”). Once again—and this comprises the fundamental message of Stiegler’s complex and nuanced history of (technical) memory—everything hinges on how hypomnemata are articulated with anamnesis, and on the political struggles that must and can only be waged through the technologies that at once empower us and threaten our individual and collective agency.

+ + +

The Industrial Exteriorization of Memory

We have all had the experience of misplacing a memory-bearing object—a slip of paper, an annotated book, an agenda, a relic or fetish. We discover then that a part of ourselves, a part of our memory, is outside of

us. This material memory, which Hegel named objective, is partial.¹ But it constitutes the most precious part of human memory; in it the totality of the works of spirit (or mind), in all guises and aspects, takes shape. Following Plato—especially the Plato of *Phaedrus*—we call recollection through externalized memory *hypomnesis*.

To write a manuscript is to organize thoughts by externalizing them in the form of traces, that is, symbols whereby thoughts become repeatable, transmissible, *actual* objects of reflection: in short, knowledge. To sculpt, to paint, or to draw is to initiate an encounter with the tangibility of the visible, to see with one's hands while giving-to-be-seen; it is to train the eye of the beholder and, thus, to sculpt, paint, and draw this eye—to *transform* it.

Human memory is originally exteriorized, which means it is technical from the start. It took shape first as a lithic (or stone) tool, two million years ago. A spontaneous memory support, the lithic tool is not, however, made to store memory; not until the late Paleolithic period (before 10,000 BCE) do conscious methods of memory storage, properly called *mnemotechniques*, appear. Ideogrammatic writing, springing up after the Neolithic period, leads to the alphabet—which today still helps the business manager remember a meeting or a relative's birthday. Only now, the personal calendar is an apparatus—the personal digital assistant (PDA). It is no longer simply a method of memory storage, a *mnemotechnique*, but instead a full-fledged *mnemotechnology*, a technology that systematically orders memories.

Originally objectified and exteriorized, memory constantly expands technically as it extends the knowledge of mankind; its power simultaneously escapes our grasp and surpasses us, calling into question our psychical as well as our social organization. This is particularly apparent in the transition from *mnemotechniques* to *mnemotechnologies*—from individual exteriorizations of memory functions to large-scale technological systems or networks that organize memories. Today, memory has become the major element in industrial development; everyday objects increasingly serve as supports of objective memory and, consequently, as forms of knowledge. But the new *technological* forms of knowledge, objectified in equipment and apparatus, conversely engender a loss of knowledge at the very moment one begins speaking of “knowledge societies,” “knowledge industries,” and what has come to be known as “cognitive” or “cultural” capitalism. To the extent that participation in these new societies, in this new form of capitalism, takes place through machinic interfaces beyond the comprehension of participants, the gain in knowledge is exclusively on the side of producers.

We are in constant relation with *mnemotechnological* apparatuses of

all kinds, from televisions and telephones to computers and GPS navigation systems. These cognitive technologies, to which we consign a greater and greater part of our memory, cause us to lose ever-greater parts of our knowledge. To lose a cell phone is to lose the trace of the telephone numbers of our correspondents and to realize that they are no longer, or perhaps never were, in psychical memory but only in that of the apparatus. Faced with this situation, we must ask if the massive industrial development of mnemotechnologies does not in fact represent a systematic loss of memory, or, more precisely, a displacement of memory: a displacement that renders our memory the *object* of knowledge-control, that positions memory as the mnemotechnological system on which the control societies theorized by Gilles Deleuze operate.²

The Question of Hypomnesia

The backdrop of this hypothesis is an ancient concern in philosophy, which, as we have mentioned, was exposed by Plato as *hypomnesia*, and which Michel Foucault (1997) would reactivate as *hypomnēmata*.

We exteriorize ever more cognitive functions in contemporary mnemotechnical equipment. And in so doing, we delegate more and more knowledge to apparatuses and to the service industries that network them, control them, formalize them, model them, and perhaps even destroy them. To the extent that they exceed our grasp, the forms of knowledge particular to these technologies lead toward an “obsolescence of the human”; in the face of their hegemony, we find ourselves more and more at a loss and internally empty.³ Thus, the more the automobile is improved, the less we know how to drive. Eventually, the GPS driving assistant will replace the driver altogether; we will lose control over our own sensory-motor schema as such guidance becomes automatic, a formal element of the navigation system. The more we delegate the small tasks that make up the warp and woof of our lives to the apparatuses and services of modern industry, the more superfluous *we* will become: we will lose not only our know-how but also our knowing-how-to-live-well. The only thing left for us will be the passivity of blind consumption, devoid of knowledge and its rewards. We will become impotent if not obsolete—so long as knowledge is what empowers humanity.

Service economies supported by technologies formalize and manage our hyperindustrial era, which effectively restages what Plato describes as hypomnesia. If what we call industrialization, broadly conceived, is the generalization of a mnemotechnological reproducibility of the motor behavior of producers, *hyperindustrialization* is the generalization of

a mnemotechnological reproducibility of the motor behavior of *consumers*. Like the producer—who is rendered a “proletarian” as his gesture is reproduced and his know-how passed into the machine—the consumer is divested of knowing-how-to-live-well and, in the same stroke, de-individualized through hyperindustrialization.⁴ The consumer, in short, becomes nothing more than an instance of purchasing power, which is to say of heedless consumerism, and thus an “agent” in the heedless destruction of the world.

In “Plato’s Pharmacy,” Jacques Derrida (1981) based a major part of his “deconstruction of metaphysics” on his reading of Plato’s *Phaedrus*. Derrida showed how this dialogue poses a sophistic *hypomnesis* of writing against a philosophical *anamnesis*—a “recollection” or “reminiscence,” which, for Plato, denotes an intelligible, necessary, and true form of knowing. Following his description, in *Of Grammatology*, of the trace as a logic of the supplement, he exposes and undermines Plato’s attempt to *oppose* interior memory and its exterior traces: it is impossible, he shows, to oppose living memory to externalized, dead memory (*hypomnematon*) since externalized memory, as a supplement, constitutes living memory as knowable.⁵ Consequently, Derrida argues, the static oppositions of Western metaphysics must be replaced by dynamic compositions: one must think in terms, not of hierarchies or totalizing systems, but of processes—in particular, the process Derrida theorizes as *différance*.⁶

For all that, it is clear that the exteriorization of memory, and the resulting loss of memory and knowledge that Socrates describes in the *Phaedrus*, is experienced today in our daily lives, in all the aspects of our existence, and, more and more often, in our feeling of powerlessness, if not impotence. And it is experienced, remarkably, at the exact moment when the extraordinary mnesic power of digital networks makes us all the more attuned to the immensity of human memory, which seems to have become infinitely reactivatable and accessible.⁷

This tension between our desire to resist the privileging of interior memory and the present experience of exteriorization as memory loss renders the question of hypomnesis a political one. What is at stake in hypomnesis is a combat: a combat for a politics of memory and, more precisely, for the constitution of *sustainable hypomnesic milieus*. Once it has reached the hyperindustrial stage, the exteriorization of memory and of knowledge at once furthers their limitless impact and strengthens the forces that can implement their control. Consider the cognitive and cultural industries of control societies that formalize neurochemical activity and the sequences of nucleotides: the inscription of the neurobiological substrates of memory and knowledge in the history of what

must be analyzed as a *process of grammatization*—the most recent stage of which is biotechnologies, with nanotechnologies soon to follow—patently raises the question of a biopolitics of memory.

Grammatization as “the History of the Supplement”

By grammatization, I mean the process whereby the currents and continuities shaping our lives become discrete elements. The history of human memory is the history of this process. Writing, as the breaking into discrete elements of the flux of speech (let us invent the word *discretization* for this possibility), is an example of a stage in the process of grammatization (see chapter 21, “Writing”).

To rephrase Derrida’s analysis of the trace as the logic of the supplement, there is no interiority that precedes exteriorization; rather, the interior as such is distinguished and configured in the very course of what paleontologist André Leroi-Gourhan describes as a process of exteriorization.⁸ As Leroi-Gourhan explains, and as Derrida’s analysis confirms, this configuring distinction is constantly displacing itself; in so doing, it continually sets up new relations between psychical individuals and collective ones—new processes of the formation of “psychical and social individuation,” in the sense Gilbert Simondon (2007) confers to this expression when he stipulates that memory is the “associated milieu” of such individuation.⁹

With the advent of mnemotechnics, the process of exteriorization as technical becoming is concretized in a history of grammatization.¹⁰ The process of grammatization as the *technical history of memory* is the process through which hypomnesic memory repeatedly relaunches the constitution of an anamnestic *tension of memory* exteriorized in the works of the spirit (or mind). In each case, anamnesis is made dependent on a specific regime of hypomnesic memory. In sum, each epoch of psychosocial individuation configures itself by means of its own form of discretization. This process of self-configuration is borne out by the epochs we have already considered: those of the lithic tool, the transition to ideogrammatic writing, the alphabet, and digitization.

With the Industrial Revolution, the process of grammatization suddenly surpassed the sphere of language, of *logos*, and came to invest the sphere of bodies. First of all, the gestures of producers were discretized in view of their automatic reproduction. At the same time, mechanical and apparatus-dependent reproducibilities of the visible and the audible—which so interested Benjamin—made their appearance and ushered in the age of mass media.¹¹

This grammatization of gesture, which is the basis of what Marx de-

scribes as the process of proletarianization—of the loss of know-how—will continue with electronic and digital apparatuses to a point at which *all* forms of knowledge will be grammaticized in the guise of cognitive mnemotechnologies. From linguistic knowledge—technologies and industries of language processing—to knowing-how-to-live or behavior in general, knowledge becomes discretized through technologies and industries of language processing, user profiling, and the grammaticization of affects; what results is the cognitive capitalism of today's hyperindustrial service economies.

Grammaticization is the history of the exteriorization of memory in all its forms: nervous and cerebral memory, first linguistic, then auditory and visual; bodily and muscular memory; biogenetic memory. Thus exteriorized, memory becomes the object of sociopolitical and biopolitical channels of control; as a result of economic investments on the part of social organizations, psychical organizations get reconfigured as elements of and by means of mnemotechnical organs, including machine tools and other automata, including household equipment.¹² (Adam Smith analyzed as early as 1776 the effects of the machine on the mind of the worker.¹³)

If we were to restage the question posed by the *Phaedrus* in the hyperindustrial epoch of the mnemotechnological object, we would discover that the question of hypomnesis constitutes the preliminary approach to proletarianization, insofar as the proletariat is an economic actor without memory and, so, without knowledge. Having relinquished that knowledge to the gesture-reproducing machine, but without any knowledge of its workings, the proletariat becomes a slave once again.

To examine the question of technical memory today is to again address hypomnesis, as both the question of the proletariat and that of a process of grammaticization in which, now, it is the consumer who is deprived of memory and knowledge: it is to study the stage of a generalized proletarianization brought on by the generalization of hypomnesic technologies. The "truth" of Plato's *Phaedrus* would thus be found in Marx, provided two supplementary conclusions be drawn: First, that Marx himself does not identify the hypomnesic nature of technics and human existence, which means that he cannot think of human life as fundamentally exteriorized—as life by means other than life. And second, that Plato's inaugural struggle against sophistics over the question of memory and its technicization is the very heart of that political struggle which, from time immemorial, goes by the name of philosophy. The reevaluation of the scope of hypomnesis in Plato, as well as its deconstruction in Derrida, might then become the basis of a renewed political project of philosophy where the main stakes are in technics.

Human Memory as Epiphylogenesis

If philosophy begins with Plato, it becomes concretized in his battle with the sophists over the question of memory as mnemotechnics (hypomnesis, but also rhetoric and language technologies based on *logographics*). Philosophy's first question is memory, that is, knowledge conceived as anamnesis, and it is the process of grammatization that provokes the question. Grammatization is here constituted negatively, as Plato affirms anamnesis in reaction against the sophistic practice of hypomnesis in writing, which he defines as a technicization of linguistic memory that creates false knowledge (*Gorgias*).¹⁴ Platonic philosophy apprehends technics in general as pseudoknowledge (which knows only contingent, sensible, and accidental becoming) and posits true knowledge as the knowledge of the necessary, that is, of intelligible essences of being qua immutability.

Grammatization is unthinkable in the context of the oppositions conceived by Plato on the basis of the polarization of anamnesis and hypomnesis: being versus becoming, the soul versus the body, intelligible thought in the immortal soul versus the sensible thought of the mortal body (the seat of the passions and the trap of the fall). All of these oppositions come down to the clash between *logos* and *technē*, rational formulae and technical knowledge. To oppose psychical living memory and technical dead memory is to generate this whole inductive series. Conversely, by rethinking memory as a process of grammatization in which living and dead compose without end, we are able to move beyond these oppositions bequeathed by Plato to Western philosophy.

Human archaeology and paleontology offer a way of responding to the Platonic opposition of anamnesis and hypomnesis with a theory of memory that views technicity as constitutive of life as ex-sistence, that is, as desire and as knowledge. On such a view, the process of becoming human can be characterized by the appearance of simultaneously hypomnesic and anamnesic *epiphylogenetic* memory: memory that is at once the product of individual epigenetic experience and the phylogenetic support for the accumulation of knowledge that constitutes the intergenerational cultural phylum.¹⁵

Let us review how, according to Leroi-Gourhan (1993), this epiphylogenetic memory emerged. *Zinjanthropus boisei*, a protohuman fossil, was first discovered in the Olduvai Gorge of northern Tanzania in 1959; the earliest specimen was found to be 1.75 million years old (later discoveries in the same region push the history of bipedal primates back to at least 3.6 million years ago). The creature would have weighed about thirty kilos and was a true biped, with an occipital hole perpendicular

to the top of its cranial box and rear limbs freed for mobility. Its limbs were destined to make tools and to express, that is, to *exteriorize*, and indeed, there is evidence of contemporaneous tool use. Based on these facts, Leroi-Gourhan (1993) argued that what constitutes the humanity of the human—the crucial break in the history of life—is the process of the exteriorization of the living. What had up to then been a crucial element of life, namely activities of predation and defense, passed outside the domain of the living: the struggle for life—or rather for existence—was no longer limited to the basic Darwinian scheme. Unique among the animals, the human alone conducts this struggle with nonbiological organs: the artificial organs of techniques. That is why we can now characterize the human struggle for existence as a spiritual one, a struggle that takes place in a domain other than the living.

Human life is no longer simply biological: it is a technical economy of desire sustained by hypomnesic technical milieus, symbolic milieus in which drives find themselves submitted to a principle of reality that requires the postponement of their satisfaction.¹⁶ As a result of this symbolic mediation, an economy arises through which the energy of the drives is transformed into *libidinal* energy, that is, into desire and sublimation. Technical memory sustains this hallucinatory economy through the epiphylogenetic object, as fetish as well as support of narcissistic reflection.¹⁷ Freud, whose theory of the unconscious is a theory of memory and its censorship, constantly circles around this question without being able to formalize it. Because he ignores the constitutive role of technics, his best efforts lead him into a position of neo-Lamarckism, where memory passes from one generation to another by altogether mysterious means.¹⁸

We owe to Leroi-Gourhan the thesis that technics is a vector of memory. He showed that a crucial biological differentiation of the cerebral cortex, the opening of the cortical fan, took place in the passage from what he called the Australanthropian to the Neanderthal. He also showed that, from the Neanderthal onward, the cortical system was practically at the end of its evolution: the neural equipment of the Neanderthal is remarkably similar to ours. Nevertheless, from the Neanderthal to us, technics evolves to an extraordinary extent. We may conclude from this that technical evolution no longer depends on biological evolution. Technical differentiation since the Neanderthal has occurred outside and independent of the biological dimension, the “interior milieu” in which, according to Claude Bernard, the constitutive elements of the organism thrive.¹⁹ The process of exteriorization is in this respect the process of the constitution of a *third layer of memory*.

In the wake of the neo-Darwinism arising from molecular biology, and

also of the research conducted by Weismann in the late nineteenth century,²⁰ consensus has been that living sexuated beings are constituted by two memories, that of the species (the genome, which Weismann calls “the germ”) and that of the individual—somatic memory, rooted in experience and located in the central nervous system. This latter memory has been observed in organisms as basic as freshwater snails and as proximate to us as the chimpanzee. But humans, and humans alone, have access to a third memory supported and constituted by technics. A piece of flint, for example, takes shape through the organization of inorganic matter: the technician’s gesture ingrains an order transmitted via the inorganic, introducing for the first time in the history of life the possibility of transmitting individually acquired knowledge in a nonbiological way. This technical memory is epiphylogenetic; in it, individual epigenetic experience provides phylogenetic support for the intergenerational cultural phylum.

It is because his knowledge is a function of this primordial exteriority of memory that the slave boy Meno in Plato’s dialogue of the same name draws the figure of a geometrical object in sand: to think his object, he must exteriorize it by organizing the inorganicity of the sand, which thus becomes the space and the support of the projection of a concept.²¹ However mutable it may be, the sand that receives this inscription can conserve the characteristics of the figure more durably than can the mind of the slave boy. Because the boy’s mind is essentially fluid, his thoughts are constantly passing away and effacing themselves; in a word, he is retentionally finite. His memory constantly snaps; his attention is drawn toward new ones; and he has a hard time “intentionalizing” the geometrical object—taking it in from the perspective of its organic identity, its necessity, its innermost essence, in sum, its *eidos* or form.

The drawing, as hypomnesic memory, is therefore indispensable to this potential philosopher, the slave boy, and to his passage into action, that is, his anamnesis. It constitutes a crutch for understanding, a space of intuition entirely produced by the gestures of the slave tracing in the sand the figured effects of this reasoning.²² The sand holds “in view” the results of the slave’s intuition and understanding; it thus facilitates the extension and construction of the geometrical proof. But the Platonic opposition between the intelligible and the sensible, between *logos* and *technē*, which became more insistent in the dialogues following the *Meno*, made this technical support literally impossible. As a result, Western metaphysics took shape as the denegation of the originary technicity of memory.

Epiphylogenesis, in becoming the process of grammatization, engenders mnemotechnics which, starting with the Industrial Revolution,

produced analog and digital mnemotechnologies; today, these latter are being reconfigured within microtechnologies, biotechnologies, and nanotechnologies.

From Writing to Digitalization

While technics in general constitute for mankind an originary milieu of epiphylogenetic memory, not all technologies are designed to store memory traces. A flint stone is designed to cut meat, to work up matter. It just happens that in addition, and spontaneously, it is also a vector of memory. It is, however, only in the course of the late Paleolithic era that mnemotechnics in the strict sense of the term appear on the epiphylogenetic horizon, in the form of mythograms—supports of ritual narratives—and tattoos on the bodies of sorcerers—the first instruments of calculation. And it is only in the Neolithic era that the conditions proper to grammatization as hypomnesis lead to the evolution of the letter, by way of the transformation of ideographic systems of numbering and the recording of the social memory of the great empires that emerged from agriculture and sedentarity.²³

Strictly speaking, alphabetization constitutes the Greek city-state; it creates the conditions for communal living as the rules of life are exteriorized and objectified in the form of a written text accessible to all citizens. The political medium takes the form of collective memory, and historical society is born.

The Greek alphabet is a system of diacritical signs—fewer than thirty characters—which can be used by anyone in the role of reader or writer. Its use introduces the possibility of later generations' gaining literal access to what took place in the history of society and in thought. Even today, to read the *Meno* in the Greek of the Platonic era is to be placed in immediate relation with Plato's thought. Literal hypomnesis (the inscription of Plato's text) constitutes the materiality of Plato's thought, and of Western thought more generally: it is the alphabetical organization of access to memory. This is the conclusion reached by Husserl at the end of his life.²⁴

The alphabet is the first mnemotechnique that is orthothetic in nature. *Orthotès* means exactitude, and *thesis* means position: alphabetical statements are "ortho-thetical" because they posit in exact spatial form the past time of the speech they record. Alphabetical writing is the *literal synthesis* of linguistic memory; as such, it configures a properly historical temporality.

At the end of the fifteenth century, the printing press, as the first mechanical technique of reproduction, amplified and transformed the ef-

fects of this synthesis. The sudden proliferation of books made it necessary for readers to look to new systems for navigating accumulated knowledge. These include library catalogs, indexes, and bibliographies, files made possible by the printed book's foliation, its pagination, its summaries, tables of contents, and glossaries. A process of teleguided reading thus began to take shape, through the implementation of techniques that underlie today's electronic editorial supports and random-access search systems. With the development of contemporary techniques of information processing, a veritable automatic activity of memory will, in the near future, accomplish the exteriorization of the functions of the cerebral cortex and, more globally, of the nervous system.

As Elizabeth Eisenstein has shown, the most important political consequence of the printing press was the Reformation.²⁵ The printing press made it possible for everyone to have personal access to the Bible translated by Luther into German. Max Weber has shown that the circulation of printed material made possible by the print revolution is also what allows, through the practice of calculation and the circulation of accounting registers, the advent of capitalism.²⁶

The nineteenth century saw the development of analogic orthothetical mnemotechniques that enabled the synthesis of visual and aural perception. Like the alphabet, photography and phonography conserve and transmit, exactly, an element of the past—in this case, the light and sound-wave frequencies produced by an object of perception are recorded via a technological hypomnesic apparatus. Just as I cannot doubt my access to the very thought of Plato when I read the *Phaedo* in the original Greek, when I listen to a recording of the voice of Sarah Bernhardt, my emotion stems from the certitude that I am hearing, not an image of what may have been her voice, but her voice itself. And likewise when I gaze at the face of Baudelaire photographed by Nadar.

These new orthotheses take up the mnesic function which up to then was assigned to sculpture, painting, monumental architecture, and the arts of memory studied by Frances Yates.²⁷ As a result, they can store and reconstitute more varied and more extensive elements of the past than those stored and reconstituted by the book. These orthotheses developed rapidly in the twentieth century in the form of cinematography, radio broadcasting, and television: this comprises the birth of what Adorno and Horkheimer named the "culture industry."²⁸ Broadcasted audiovisual temporal objects, which, as they flow by, coincide with the flowing consciousnesses to which they are addressed, form and condition the collective flow of masses of consciousnesses: in this way, they constitute audiences. Controlling the temporal flow of mass consciousness allows the culture industries to control behavior, for instance, to guarantee the consumption of

products that the process of permanent innovation (the principle underlying industrial production) constantly releases into the global market.

This power stems from the specificity of analog orthothetic recording, where, in contrast to the literal synthesis of linguistic memory, machines do the coding and decoding. This marks a fundamental shift in the economy linking creator and receiver: in the case of the literal synthesis, one cannot be a reader without being able to write; in the case of analog recording, one can—and typically does—receive audiovisual messages without having the ability to produce them oneself. Thus, industrialization—defined as the separation of producers and consumers—comes into being. Here we have an example that confirms just how fundamentally human memory, which is always both psychical and social, is a technical competency.

Analog orthothetic techniques create the possibility of an industry of audiovisual temporal objects that deploys mass channeling of attention and thereby wields undeniable economic as well as political power—literally a psycho-power. It extends the sway of biopower that Foucault attributed to the disciplinary society and inaugurates a new stage of grammatization—one that, for Adorno and Horkheimer, is tantamount to massive social regression.

In order to amortize the huge productive apparatuses constituted in the development of machinism, industry has since the beginning of the nineteenth century progressively installed a “society of consumption.”²⁹ Such a regime is meant to address the problem posed by permanent innovation: the necessity to absorb new industrial productions for which society is not spontaneously prepared.³⁰ Industrial society presupposes the permanent modification of the behavior of individuals, who are less and less citizens and more and more consumers; the commodity has become the main operator of the socialization of individuals, and it is in this respect that the media are essential to industrial democracies. Media outlets are vectors conducting society toward the permanent adoption of consumable novelty by means of which capitalism subsists.

Ernest Renan has shown that every society is founded upon the adoption of a fictive past that effaces the differences in the origins of individuals and facilitates the identification of a common future through a politics of memory and forgetfulness.³¹ Schooling is the hub of this process, instituting behavioral programs transmitted as knowledge in literal synthesis. For Pierre Nora, who has also studied the politics of education, the process of adoption involves the constitution of places of memory. This is why education has been radically transformed by the psycho-power developed by industrial society through its analog media: by replacing the institutions of programs—grammar schools, high schools, and univer-

sities—with the program industries, it effectively creates a new mechanism of adoption.

In the present era, however, this entire apparatus is redeployed to take advantage of the convergence of analog technologies of communication and digital technologies of the information industries. Digital orthothetic synthesis made its appearance during the second half of the twentieth century in the form of information processing; today, at the beginning of the twenty-first century, it takes form in electronic apparatuses of all kinds: video cameras, mobile telephones, and voice recorders that are no longer analog. Digital technologies arose out of information industries that themselves developed through the strategic commodification of information as stability; as that which allows us to orient ourselves in an ever-changing situation, information thus constitutes a new system of cardinality.

Memory and Information

The industrial economy of information becomes a reality starting in the nineteenth century. Charles Louis Havas prefigured the full-scale industrial apparatus for the exploitation of information when, in 1835, he exploited the then new telegraphic network to create the first press agency. To the extent that it is a commodity, information correlates time and value and thereby upsets historical time. As essential elements in the apparatus through which the mercantile production of memory becomes global and quotidian, networks of current events necessarily function at the speed of light. This is because the value of information as commodity drops precipitously with time (in contrast to that of knowledge, which remains constant or increases over time).

The industries of communication achieve ever greater sway by merging with the information industries. Mass broadcasting implies the concentration of the means of production: the cost of a televised image can be amortized only if it is broadcast to millions of spectators. Thus, relatively few images are needed to supply the global network of television stations that produces the raw material of memory by designating information as “eventful.” What results from this selection process and near-instantaneous transmission of information is the industrial fabrication of the present: an event becomes an event—it literally takes place—only in being “covered.” Industrial time is always at least coproduced by the media. “Coverage”—what is to be covered—is determined by criteria oriented toward producing surplus value. Mass broadcasting is a machine to produce ready-made ideas, “clichés.” Information must be

“fresh” and this explains why the ideal for all news organs is the elimination of delay in transmission time.³²

Information is transmitted at the speed of light. Analog and digital orthotheses make this possible, in contrast to the literal orthothesis, which implied a delay, an essential belatedness between what can be called the event (or its seizure) and its reception or reading. It is precisely at the level of the seizure of information and in its processing that the analogically or digitally in-formed event is submitted to the logic of light-time. Access to the networks or vectors of industrial memory requires the existence of entry and exit organs, called interfaces or terminals: the technical advances of photography rapidly lead to belinography,³³ then to cinematography, and finally to the live teletransmission of images, while the pairing of telegraphic and phonographic principles issue into the telephone, and then into live radio broadcasting. Just as the network of light-time does away with the belatedness between the seizure of an event and its reception by infinitesimally reducing the time of its transmission, so too does the analog or digital instrument eliminate all belatedness between the event and its seizure.

With an effect of the real (of presence) resulting from the coincidence of the event and its seizure and with the real-time or “live” transmission resulting from the coincidence of the event seized and its reception, a new experience of time, collective as well as individual, emerges. This new time betokens an exit from the properly historical epoch, insofar as the latter is defined by an essentially deferred time—that is, by a constitutive opposition, posited in principle, between the narrative and that which is narrated. This is why Pierre Nora can claim that the speed of transmission of analog and digital transmissions promotes “the immediate to historical status”:

Landing on the moon was the model of the modern event. Its condition remained live retransmission by Telstar. . . . What is proper to the modern event is that it implies an immediately public scene, always accompanied by the reporter-spectator or the spectator-reporter, who sees the event taking place. This “voyeurism” gives to current events both their specificity with regard to history and their already historical feel as immediately out of the past.³⁴

In writing, the very medium of history, an event typically precedes its seizure, and the latter precedes its reception or reading. This configures the present-ation of the past as the retroactivity of an originary default, of a belatedness of the narrative and of the reception of the event with respect to the time of the event, which nevertheless constitutes itself

only in this delayed action. The time of relation, of “narrative,” is always belated with respect to what is narrated, is always cited in being recited.

The daily and industrial fabrication of time by a press agency is not a mere account of the news: the current events industries are not satisfied with recording what happens, for then everything happening would have to be recorded. Rather, “what happens” happens only in *not* being everything, through its distinction from all the rest. Information has value only as the result of this hierarchization: only that which is “covered” attains the status of event. This is the plight of memory in general (and the theme of “Funes the Memorious” by Jorge Luis Borges).³⁵ Memory must be a selection in the present, and its passing, its becoming past, is its diminution. But in the present account, the criteria of selection become industrial—and the selection takes place in real time, not through this work of time that is history, whether as *Historie* (the facticity of “what happened”) or *Geschichte* (its meaning).³⁶

The conservation of memory, of the memorable that is itself constituted through selection from within the memorizable, is always already its elaboration as well; it is never the mere reporting of what takes place. What takes place only takes place in not quite actually taking place. One memorizes only by forgetting, by effacing, by selecting what deserves to be retained from all that could have been retained; in the same vein, one memorizes only by anticipating, positively or negatively, that which could have happened (which means that retention is always already pro-tention), and this remains the case despite Freud’s insistence that such selection is also, at the psychological level, a repression.³⁷ The question for psychoanalytic theory is how psychological and social memory can be articulated, given that such articulation is the very condition for the constitution of the superego, at least as long as there is one. An essential aspect of the elimination of deferred time, which is to say, of the work of delayed action, is precisely that it sets off a process of desublimation and disindividuation brought on by the loss of knowledge in the era of industrial hypomnesia.

It can be said that the media coproduces that which takes place, here meaning that it produces its effects and so anticipates what will happen. There is nothing intrinsically novel about this situation: it is the very law of memory that it must precede itself. As a result, the past of the present is never situated behind it but has “always already preceded it” (as Heidegger says) without determining it. Nonetheless, something absolutely new happens when the conditions of memorization, that is, the criteria of effacement, selection, forgetting, anticipation, retention-pro-tention—in a word, of temporalization—become concentrated in a technico-industrial machine whose finality is the production of surplus

value. In the wake of this development, what hegemonically rules the activity of memory is the imperative to gain time. Just as abstract, capitalizable money is nothing but the credit accorded the future in advance, so too is memory nothing but the future time of the mass audience. Industrial memory retention is ruled by the law of the audience as a source of credit, in all senses of the term. This law irresistibly predetermines the nature of events themselves: social “actors” anticipate the conditions of the recordability of their acts; their actions become a function of the constraints of this industrial surface of time. In this sense, the media is never satisfied with “coproducing” events. ever more often, they produce them through and through: 9/11 was precisely such a production.

There has today occurred a veritable inversion in the relation between life and media: the media now relates life each day with such force that this “relation” seems not only to anticipate but ineluctably to precede, that is, to determine, life itself. In the rivalry among the media, this relation has become drive-oriented—for such is the law of the sensational—and has promoted both the staging of terrorist acts and the ordinary pornography of television. What this means is that the media today destroys the superego as much as it preserves it, which is to say that it destroys the very condition for the transformation of drives into desire, that is, into social energy.

The Ecology of Hypomnesia: The Time of Associated Milieus

Unlike analog and digital orthotheses, literal synthesis presupposes that the receiver of a textual message is literate. The literal reader is herself an apparatus, “equipped” and independently able to access the content of a literal recording. Assuming that she has spent the number of years needed to instrumentalize, automatize, and mechanize the functioning of her memory, the literal reader will have transformed herself, by and for herself, into an instrument of reading.

With analog and digital technologies, however, the functions of coding and decoding are delegated to machines. The video recorder “reads” the videotape and the computer “reads” the file. What is important here is not, however, the instrumentalization of memory, which has ample precedent, but the *displacement* of its initial instrumentality. This displacement fundamentally transforms memory, for with analog and digital technologies, sender and receiver no longer coincide with encoder and decoder. This transformation is obviously not without consequences for reading, which is to say for reading as well as writing memory: when collective memory becomes analog or digital, the relations between statements, the sender’s and receiver’s, are transformed to a consider-

able extent. These two poles correspond to what is found at the two extremities of a network: on one side, industrial producers; on the other, consumers.

If the continuous flow of information can cultivate an actual consumerism of memory, the reason lies as much in the delegation of reading and writing skills to machines as in the transformation of memory into a commodity; the latter would be impossible without the former. Such is the organization of the loss of knowledge in industrial hypomnesia: it operates by eliminating—or at least by appearing to eliminate—all opportunity for anamnesis. Hypomnesic milieus without anamnesis are dissociated milieus: they are industrially disorganized, desocialized and desymbolized. The exercise of industrial hypomnesia imposes the rules and regulations of the industrial division of work on symbolic life as a whole. This industrialization of the symbolic produces a situation in which society is separated into producers and consumers of symbols. The result is the destruction of the symbolic as such.

A symbolic mnemonic milieu is in its structure an associated milieu allowing for the constitution and expression of singularities. In interlocution—the very life of language—a receiver (one who listens, hears, and is destined to a language) is a receiver only to the extent that she can also assume the position of sender (that is, speaking what no one else could). In short, you cannot hear a language unless you are able to speak it, and to speak it in an utterly singular fashion. Language is in this respect substantially dialogical: speech as symbolic exchange constitutes a circuit wherein those who receive a symbolic address in the form of words render what they have received in the form of other words spoken to other receivers. In speaking they produce a process of individuation and thereby participate in the transformation of language itself.

This process of psychic and collective individuation requires that the linguistic milieu involve permanent interlocution, that is, the participation of everyone in its becoming. The speaker individuates herself—transforms herself and becomes what she is—through her statements, but these statements also contribute to the transformation of the language in which they are pronounced, precisely following the degree of individuation of the speaker. The psychic individuation of the speaker is in the same movement a collective individuation, constituting the shared language of the speakers who constitute themselves in speaking.

The life of language is in interlocution, and it is precisely interlocution that the audiovisual mass media short-circuit and destroy. The social milieus in which psychic existences individuate themselves and the groups through which they exchange and transform themselves exist in general milieus only to the extent that they are participative: the individuation

of the milieu takes place through the individuation of those living within it, and vice versa. Generally speaking, the service economy, of which the media are the main sector, deprives the psychical individual of all opportunity of participation in collective individuation. Because it is rooted in the short-circuiting of its users' knowledge by way of industrial hypomneses, the service economy effectively stunts the development of the individual's life milieu.

But at the end of the twentieth century, the Internet has profoundly modified this situation. Now that it has been integrated into a digital environment, audiovisual memory can be produced through participative technologies *that no longer impose the producer/consumer opposition*. That is why the Internet age is an age of hypomnesia constituting itself as an *associated* technical milieu. It marks the end of the era of dissociated milieus—the escape from milieus that separate the functions of producers and consumers, deprive both of their knowledge, and consequently strip their capacity to participate in the socialization of the world through its transformation.

Gilbert Simondon (1989) speaks of associated technical milieus in his analysis of the tide-propelled electrical power plant: the power plant as technical milieu is called “associated” because the technical object of which it is the milieu structurally and functionally associates the energies and natural elements composing this milieu, such that nature becomes a function of the technical system. This is the case of the Guimbal turbine, which assigns to saltwater (the natural element) a triple technical function: to furnish energy, to cool the structure of the turbine, and to catalyze the water-proofing of the stages.³⁸

The era of digital networked hypomnemata inaugurates the industrial hypomnesic milieu, where the human element of geography is associated with the becoming of the technical milieu. The Internet makes possible a typical participative economy of free software and cooperative technologies—an associated hypomnesic milieu where the receivers are placed in the positions of senders. In that respect, it constitutes a new stage of grammatization that allows us to envisage a new economy of memory supporting an industrial model no longer based on dissociated milieus or on disindividuation. Industrial hypomnesic memory now comprises the very heart of contemporary societies, and it is striking to see objects of daily use become ever more closely linked to media by becoming communicative: iPods, smart phones, GPS navigators, and many other devices using micro- and nanotechnologies—all of these are hypomnesic objects.

Analog mass media imposed an industrial calendarity, with schedules and programs that also served as cardinalities, orienting us in the images

of the world through the hierarchization of news and of demographics. The demassification of media brought on by podcasting, personal media, and the suspension of the producer/consumer opposition constitutes a new age of memory in which memory once again becomes transindividual.³⁹ The catalyst for this new age is the liberation of hypomnesic memory from its industrial function. For if dissociation is what causes the short-circuiting of transindividuation, then the associated hypomnesic milieus of digital networks mark a crucial point of rupture: insofar as they are cooperative and participative, they can reconstitute the circuits necessary for transindividuation. Such a transformation, I want to suggest, requires a change of industrial model, a new economy of hypomnesis and anamnesis that underscores their fundamental complementarity. Cooperative digital technologies can be placed in the service of individuation, but only if the industrial politics of hypomnesis are implemented in the service of a new age of anamnesis. Let us conceive this new age as an ecology of associated hypomnesic milieus.

Notes

1. G. W. F. Hegel, *The Encyclopaedia Logic*, trans. T. F. Geraets, W. A. Suchting, and H. S. Harris (Indianapolis: Hackett, 1991).
2. Gilles Deleuze, "Control and Becoming" and "Postscript on Control Societies," in *Negotiations*, trans. M. Joughin (New York: Columbia University Press, 1995).
3. Gunther Anders, *L'obsolescence de l'homme* (Paris: Encyclopédie des nuisances, 2002).
4. According to Gilbert Simondon's reading of Marx, the passage of our know-how into the machine makes all of us, not simply the working class, proletarians. (Eds.)
5. Jacques Derrida, *Of Grammatology*, trans. Gayatri Chakravorty Spivak (Baltimore: Johns Hopkins University Press, 1998).
6. Jacques Derrida, *Writing and Difference*, trans. Alan Bass (Chicago: University of Chicago Press, 1980).
7. Stiegler's use of the term *reactivable* is an indirect reference to Husserl's account of hypomnesic memory; the tradition of geometry, according to Husserl (1970), can be "reactivated" by future geometers only because it has been written down. (Eds.)
8. Derrida, *Of Grammatology*, 84.
9. A student of Maurice Merleau-Ponty and Georges Canguilhem, Simondon developed a theory of individuation that spanned processes from the physical through the biological to the psychic and collective. The central insight of his account is the fundamental incompleteness of all processes of individuation, which, even as they produce concrete individuals, retain ties to two dimensions of exteriority: the preindividual and the associated milieu. Thus, in Stiegler's reference, we can gloss the associated milieu as an environment in which individuation takes place, a dimension external to the individual undergoing individuation. (Eds.)
10. This concept of grammatization is borrowed from an analysis of the history of language knowledge in Auroux 1992.

11. Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Illuminations*, ed. Hannah Arendt (New York: Schocken, 1969), 217–52.
12. The fundamentals of a general organology—that is, a theory of the articulation of bodily, artificial, and social organs—are set forth in Bernard Stiegler, *De la misère symbolique*, vol. 2, *La Catastrophè du sensible* (Paris: Galilée, 2004).
13. Adam Smith, *An Inquiry in the Nature and Causes of the Wealth of Nations* (Chicago: University of Chicago Press, 1977).
14. Plato, *Gorgias*, trans. Robin Waterfield (Oxford: Oxford University Press, 1994).
15. Stiegler introduces the term *epiphylogenesis* in *Technics and Time*, vol. 1, *The Fault of Epimetheus* (Stanford: Stanford University Press, 1996), to designate the evolution of (human) life by means other than life, that is, through technical exteriorization. This conception resonates with much contemporary work in the evolutionary cognitive sciences that emphasizes the role of culture in evolutionary processes. (Eds.)
16. On this point, see especially Bernard Stiegler, *Mécréance et discrédit*, vol. 3, *L'esprit perdu du capitalisme* (Paris: Galilée, 2006).
17. The "epiphylogenetic object" would be a technical object that supports epiphylogenesis, or extragenetic evolution. (Eds.)
18. This is particularly clear in Sigmund Freud, *Moses and Monotheism* (New York: Vintage, 1955) and *The Ego and the Id*, trans. James Strachey (New York: W. W. Norton, 1962).
19. Claude Bernard, *Leçons sur les propriétés physiologiques et les altérations pathologiques des liquides de l'organisme* (Paris: Ballière's, 1859).
20. August Weismann, *The Germ-Plasm: A Theory of Heredity* (New York: Scribner's, 1893).
21. Plato, *Meno and Other Dialogues*, trans. Robin Waterfield, (Oxford: Oxford University Press, 2005).
22. Bernard Stiegler, *La technique et le temps*, vol. 3, *Le temps du cinéma et la question du mal-être* (Paris: Galilée, 2001).
23. See Harold Innis, *Empire and Communications* (Lanham, MD: Rowman & Littlefield, 2007). (Eds.)
24. Husserl 1970. See Jacques Derrida, *Edmund Husserl's "Origin of Geometry": An Introduction* (Lincoln: University of Nebraska Press, 1989). (Eds.)
25. Elizabeth Eisenstein, *The Printing Press as Agent of Change: Communications and Cultural Transformations in Early Modern Europe* (New York: Cambridge University Press, 1979).
26. Max Weber, *The Protestant Ethic and the Spirit of Capitalism*, trans. Talcott Parsons (London: Routledge, 2001).
27. Frances Yates, *The Art of Memory* (Chicago: University of Chicago Press, 2001).
28. Theodor Adorno and Max Horkheimer, *The Dialectic of Enlightenment*, ed. Gunzelin Schmid Noerr, trans. Edmund Jephcott (Stanford, CA: Stanford University Press, 2002).
29. See Jean Baudrillard, *The Consumer Society: Myths and Structures* (London: Sage, 1988).
30. The *velocipède*, whose fabrication was entrusted to the Parisian Company of Bicycles, founded in 1867, could not have developed socially without print media. Five specialized journals came out between 1880 and 1900, while *Le Petit Journal*, a daily with a huge readership, ran its own promotional campaign, promoting competitions and finally the Tour de France, which continues to receive extensive media coverage. Before showing performances, the aim of these publications was to show future cyclists that rolling on two wheels without falling down is possible!

31. Ernest Renan, *Qu'est-ce qu'une Nation?* (Toronto: Tapir Press: 1996).
32. "Laurel? —Yeah? —Where did you put the newspaper? —Where it belongs. —You mean? —In the fridge . . . —And why in the fridge? —To have fresh news."
33. Invented by Édouard Belin in 1913, the Belinograph could capture pictures with a photocell and transmit them over regular telephone lines. (Eds.)
34. Jacques Le Goff and Pierre Nora, *Faire de l'histoire 2* (Paris: Gallimard, 1974), 295. Telstar, the first communication satellite to "serve as a relay for the transatlantic exchange of televised programmes," also impressed Heidegger. See his essay "Traditional Language and Technical Language," trans. W. Gregory, *Journal of Philosophical Research* 23 (1998).
35. Jorge Luis Borgès, "Funes the Memorious," *Labyrinths: Selected Stories and Other Writings*, (New York: New Directions, 1964).
36. In *Being and Time* (trans. J. Macquarrie and E. Robinson [New York: HarperOne, 2008]), Heidegger distinguishes *Historie*, which is concerned with the empirical question of occurrence, from *Geschichte*, which, linked to *Geschick* (fate), concerns the deeper significance or directionality of the past toward the future. (Eds.)
37. The terms *retention* and *protention* come from Edmund Husserl's exploration of the structure of time consciousness in *On the Phenomenology of the Consciousness of Internal Time*, trans. J. Brough (Dordrecht: Kluwer Academic Publishers, 1991). Retention names the "just-past" and protention names the "just-to-come," which both belong to the present now, or impression, and constitute it as a thick now. (Eds.)
38. The Guimbal turbine thus exemplifies the complementarity of the process of individuation (here a technical individuation) and the associated milieu of that individuation. Just as its operation renders nature "a function of the technical system," the operation of hypomnesic milieus render anamnesis a part of the larger mnemotechnological system of the Internet. (Eds.)
39. For Simondon, transindividuation comprises a collective individuation that requires first a disindividuation of individual (psychic) individuations and draws directly on the "preindividual," i.e., that which exceeds but nonetheless remains bound to any given process of individuation. Simondon theorizes transindividuation in *L'individuation psychique et collective* and correlates it with the functioning of technical objects in *Du mode d'existence des objets techniques*. Stiegler here suggests that the new digital hypomnesic milieus enable a collective individuation that does not take already individuated individuals as its starting point, but rather directly individuates the collective and sustains the ongoing individuation of this collective. (Eds.)

References and Suggested Readings

- Auroux, Sylvain. 1992. *La révolution technologique de la grammatisation*. Liège: Mardaga.
- Derrida, Jacques. 1981. "Plato's Pharmacy" [*La pharmacie de Platon*]. In *Dissemination*, trans. Barbara Johnson, 61–171. Chicago: University of Chicago Press.
- Foucault, Michel. 1997. "Self Writing" [*L'écriture de soi*]. In *Ethics: Subjectivity and Truth*, ed. Paul Rabinow. New York: New Press.
- Husserl, Edmund. 1970. "The Origin of Geometry." In *Crisis of the European Sciences and Transcendental Phenomenology*, trans. David Carr. Evanston: Northwestern University Press.

- . 1991. *On the Phenomenology of the Consciousness of Internal Time*, trans. J. Brough. Dordrecht: Kluwer Academic.
- Leroi-Gourhan, André. 1993. *Gesture and Speech [Le geste et la parole]*. Trans. Anna Bostock Berger. Cambridge, MA: MIT Press.
- Plato. 2003. *Phaedrus*. Trans. Christopher Rowe. New York: Penguin.
- Simondon, Gilbert. 1989. *Du mode d'existence des objets techniques*. Paris: Aubier.
- . 2007. *L'individuation psychique et collective*. Paris: Flammarion.

Principles of New Media

The identity of media has changed even more dramatically. Below I summarize some of the key differences between old and new media. In compiling this list of differences I tried to arrange them in a logical order. That is, the principles 3-5 are dependent on the principles 1-2. This is not dissimilar to axiomatic logic where certain axioms are taken as starting points and further theorems are proved on their basis.

Not every new media object obeys these principles. They should be considered not as some absolute laws but rather as general tendencies of a culture undergoing computerization. As the computerization affects deeper and deeper layers of culture, these tendencies will manifest themselves more and more.

1. Numerical Representation

All new media objects, whether they are created from scratch on computers or converted from analog media sources, are composed of digital code; they are numerical representations. This has two key consequences:

1.1. New media object can be described formally (mathematically). For instance, an image or a shape can be described using a mathematical function.

1.2. New media object is a subject to algorithmic manipulation. For instance, by applying appropriate algorithms, we can automatically remove "noise" from a photograph, improve its contrast, locate the edges of the shapes, or change its proportions. In short, media becomes programmable.

When new media objects are created on computers, they originate in numerical form. But many new media objects are converted from various forms of old media. Although most readers understand the difference between analog and digital media, few notes should be added on the terminology and the conversion process itself. This process assumes that data is originally continuos, i.e. "the axis or dimension that is measured has no apparent indivisible unit from which it is composed."¹⁶ Converting continuos data into a numerical representation is called digitization. Digitization consists from two steps: sampling and quantization. First, data is sampled, most often at regular intervals, such as the grid of pixels used to represent a digital image. Technically, a sample is defined as "a measurement made at a particular instant in space and time, according to a specified procedure." The frequency of sampling is referred to as resolution. Sampling turns continuos data into discrete data. This is data occurring in distinct units: people, pages of a book, pixels. Second, each sample is quantified, i.e.

assigned a numerical value drawn from a defined range (such as 0-255 in the case of a 8-bit greyscale image).¹⁷

While some old media such as photography and sculpture is truly continuous, most involve the combination of continuous and discrete coding. One example is motion picture film: each frame is a continuous photograph, but time is broken into a number of samples (frames). Video goes one step further by sampling the frame along the vertical dimension (scan lines). Similarly, a photograph printed using a halftone process combine discrete and continuous representations. Such photograph consist from a number of orderly dots (i.e., samples), however the diameters and areas of dots vary continuously.

As the last example demonstrates, while old media contains level(s) of discrete representation, the samples were never quantified. This quantification of samples is the crucial step accomplished by digitization. But why, we may ask, modern media technologies were often in part discrete? The key assumption of modern semiotics is that communication requires discrete units. Without discrete units, there is no language. As Roland Barthes has put it, “language is, as it were, that which divides reality (for instance the continuous spectrum of the colors is verbally reduced to a series of discontinuous terms).”¹⁸ In postulating this, semioticians took human language as a prototypical example of a communication system. A human language is discrete on most scales: we speak in sentences; a sentence is made from words; a word consists from morphemes, and so on. If we are to follow the assumption that any form of communication requires discrete representation, we may expect that media used in cultural communication will have discrete levels. At first this explanation seems to work. Indeed, a film samples continuous time of human existence into discrete frames; a drawing samples visible reality into discrete lines; and a printed photograph samples it into discrete dots. This assumption does not universally work, however: photographs, for instance, do not have any apparent units. (Indeed, in the 1970s semiotics was criticized for its linguistic bias, and most semioticians came to recognize that language-based model of distinct units of meaning can’t be applied to many kinds of cultural communication.) More importantly, the discrete units of modern media are usually not the units of meanings, the way morphemes are. Neither film frames nor the halftone dots have any relation to how film or a photographs affect the viewer (except in modern art and avant-garde film — think of paintings by Roy Lichtenstein and films of Paul Sharits — which often make the “material” units of media into the units of meaning.)

The more likely reason why modern media has discrete levels is because it emerges during Industrial Revolution. In the nineteenth century, a new organization of production known as factory system gradually replaced artisan labor. It reached its classical form when Henry Ford installed first assembly line in his factory in 1913. The assembly line relied on two principles. The first was standardization of parts, already employed in the production of military uniforms

in the nineteenth century. The second, never principle, was the separation of the production process into a set of repetitive, sequential, and simple activities that could be executed by workers who did not have to master the entire process and could be easily replaced.

Not surprisingly, modern media follows the factory logic, not only in terms of division of labor as witnessed in Hollywood film studios, animation studios or television production, but also on the level of its material organization. The invention of typesetting machines in the 1880s industrialized publishing while leading to standardization of both type design and a number and types of fonts used. In the 1890s cinema combined automatically produced images (via photography) with a mechanical projector. This required standardization of both image dimensions (size, frame ratio, contrast) and of sampling rate of time (see “Digital Cinema” section for more detail). Even earlier, in the 1880s, first television systems already involved standardization of sampling both in time and in space. These modern media systems also followed the factory logic in that once a new “model” (a film, a photograph, an audio recording) was introduced, numerous identical media copies would be produced from this master. As I will show below, new media follows, or actually, runs ahead of a quite a different logic of post-industrial society — that of individual customization, rather than of mass standardization.

2. Modularity

This principle can be called “fractal structure of new media.” Just as a fractal has the same structure on different scales, a new media object has the same modular structure throughout. Media elements, be it images, sounds, shapes, or behaviors, are represented as collections of discrete samples (pixels, polygons, voxels, characters, scripts). These elements are assembled into larger-scale objects but they continue to maintain their separate identity. The objects themselves can be combined into even larger objects -- again, without losing their independence. For example, a multimedia “movie” authored in popular Macromedia Director software may consist from hundreds of still images, QuickTime movies, and sounds which are all stored separately and are loaded at run time. Because all elements are stored independently, they can be modified at any time without having to change Director movie itself. These movies can be assembled into a larger “movie,” and so on. Another example of modularity is the concept of “object” used in Microsoft Office applications. When an object is inserted into a document (for instance, a media clip inserted into a Word document), it continues to maintain its independence and can always be edited with the program used originally to create it. Yet another example of modularity is the structure of a HTML document: with the exemption of text, it consists from a number of

separate objects — GIF and JPEG images, media clips, VRML scenes, Shockwave and Flash movies -- which are all stored independently locally and/or on a network. In short, a new media object consists from independent parts which, in their turn, consist from smaller independent parts, and so on, up to the level of smallest “atoms” such as pixels, 3D points or characters.

World Wide Web as a whole is also completely modular. It consists from numerous Web pages, each in its turn consisting from separate media elements. Every element can be always accessed on its own. Normally we think of elements as belonging to their corresponding Web sites, but this just a convention, reinforced by commercial Web browsers. Netomat browser which extract elements of a particular media type from different Web pages (for instance, only images) and display them together without identifying the Web sites they come from, highlights for us this fundamentally discrete and non-hierarchical organization of the Web (see introduction to “Interface” chapter for more on this browser.)

In addition to using the metaphor of a fractal, we can also make an analogy between modularity of new media and the structured computer programming. Structural computer programming which became standard in the 1970s involves writing small and self-sufficient modules (called in different computer languages subroutines, functions, procedures, scripts) which are assembled into larger programs. Many new media objects are in fact computer programs which follow structural programming style. For example, most interactive multimedia applications are programs written in Macromedia Director’s Lingo. A Lingo program defines scripts which control various repeated actions, such as clicking on a button; these scripts are assembled into larger scripts. In the case of new media objects which are not computer programs, an analogy with structural programming still can be made because their parts can be accessed, modified or substituted without affecting the overall structure of an object. This analogy, however, has its limits. If a particular module of a computer program is deleted, the program would not run. In contrast, just as it is the case with traditional media, deleting parts of a new media object does not render its meaningless. In fact, the modular structure of new media makes such deletion and substitution of parts particularly easy. For example, since a HTML document consists from a number of separate objects each represented by a line of HTML code, it is very easy to delete, substitute or add new objects. Similarly, since in Photoshop the parts a digital image are usually placed on separate layers, these parts can be deleted and substituted with a click of a button.

3. Automation

Numerical coding of media (principle 1) and modular structure of a media object (principle 2) allow to automate many operations involved in media creation, manipulation and access. Thus human intentionally can be removed from the creative process, at least in part.¹⁹

The following are some of the examples of what can be called “low-level” automation of media creation, in which the computer user modifies or creates from scratch a media object using templates or simple algorithms. These techniques are robust enough so that they are included in most commercial software for image editing, 3D graphics, word processing, graphic layout, and so on. Image editing programs such as Photoshop can automatically correct scanned images, improving contrast range and removing noise. They also come with filters which can automatically modify an image, from creating simple variations of color to changing the whole image as though it was painted by Van Gog, Seurat or other brand-name artist. Other computer programs can automatically generate 3D objects such as trees, landscapes, human figures and detailed ready-to-use animations of complex natural phenomena such as fire and waterfalls. In Hollywood films, flocks of birds, ant colonies and crowds of people are automatically created by AL (artificial life) software. Word processing, page layout, presentation and Web creation programs come with “agents” which can automatically create the layout of a document. Writing software helps the user to create literary narratives using formalized highly conventions genre convention. Finally, in what maybe the most familiar experience of automation of media generation to most computer users, many Web sites automatically generate Web pages on the fly when the user reaches the site. They assemble the information from the databases and format it using generic templates and scripts.

The researchers are also working on what can be called “high-level” automation of media creation which requires a computer to understand, to a certain degree, the meanings embedded in the objects being generated, i.e. their semantics. This research can be seen as a part of a larger initiative of artificial intelligence (AI). As it is well known, AI project achieved only very limited success since its beginnings in the 1950s. Correspondingly, work on media generation which requires understanding of semantics is also in the research stage and is rarely included in commercial software. Beginning in the 1970s, computers were often used to generate poetry and fiction. In the 1990s, the users of Internet chat rooms became familiar with bots -- the computer programs which simulate human conversation. The researchers at New York University showed a “virtual theater” composed of a few “virtual actors” which adjust their behavior in real-time in response to user’s actions.²⁰ The MIT Media Lab developed a number of different projects devoted to “high-level” automation of media creation and use: a “smart camera” which can automatically follow the action and frame the shots given a script;²¹ ALIVE, a virtual environment where the user interacted with

animated characters;²² a new kind of human-computer interface where the computer presents itself to a user as an animated talking character. The character, generated by a computer in real-time, communicates with user using natural language; it also tries to guess user's emotional state and to adjust the style of interaction accordingly.²³

The area of new media where the average computer user encountered AI in the 1990s was not, however, human-computer interface, but computer games. Almost every commercial game includes a component called AI engine. It stands for part of the game's computer code which controls its characters: car drivers in a car race simulation, the enemy forces in a strategy game such as Command and Conquer, the single enemies which keep attacking the user in first-person shooters such as Quake. AI engines use a variety of approaches to simulate human intelligence, from rule-based systems to neural networks. Like AI expert systems, these characters have expertise in some well-defined but narrow area such as attacking the user. But because computer games are highly codified and rule-based, these characters function very effectively. That is, they effectively respond to whatever few things the user are allowed to ask them to do: run forward, shoot, pick up an object. They can't do anything else, but then the game does not provide the opportunity for the user to test this. For instance, in a martial arts fighting game, I can't ask questions of my opponent, nor do I expect him or her to start a conversation with me. All I can do is to "attack" my opponent by pressing a few buttons; and within this highly codified situation the computer can "fight" me back very effectively. In short, computer characters can display intelligence and skills only because the programs put severe limits on our possible interactions with them. Put differently, the computers can pretend to be intelligent only by tricking us into using a very small part of who we are when we communicate with them. So, to use another example, at 1997 SIGGRAPH convention I was playing against both human and computer-controlled characters in a VR simulation of some non-existent sport game. All my opponents appeared as simple blobs covering a few pixels of my VR display; at this resolution, it made absolutely no difference who was human and who was not.

Along with "low-level" and "high-level" automation of media creation, another area of media use which is being subjected to increasing automation is media access. The switch to computers as means to store and access enormous amount of media material, exemplified by the by "media assets" stored in the databases of stock agencies and global entertainment conglomerates, as well as by the public "media assets" distributed across numerous Web sites, created the need to find more efficient ways to classify and search media objects. Word processors and other text management software for a long time provided the abilities to search for specific strings of text and automatically index documents. UNIX operating system also always included powerful commands to search and filter text files. In the 1990s software designers started to provide media users with

similar abilities. Virage introduced Virage VIR Image Engine which allows to search for visually similar image content among millions of images as well as a set of video search tools to allow indexing and searching video files.²⁴ By the end of the 1990s, the key Web search engines already included the options to search the Internet by specific media such as images, video and audio.

The Internet, which can be thought of as one huge distributed media database, also crystallized the basic condition of the new information society: over-abundance of information of all kind. One response was the popular idea of software “agents” designed to automate searching for relevant information. Some agents act as filters which deliver small amounts of information given user's criteria. Others are allowing users to tap into the expertise of other users, following their selections and choices. For example, MIT Software Agents Group developed such agents as BUZZwatch which “distills and tracks trends, themes, and topics within collections of texts across time” such as Internet discussions and Web pages; Letizia, “a user interface agent that assists a user browsing the World Wide Web by... scouting ahead from the user's current position to find Web pages of possible interest”; and Footprints which “uses information left by other people to help you find your way around.”²⁵

By the end of the twentieth century, the problem became no longer how to create a new media object such as an image; the new problem was how to find the object which already exists somewhere. That is, if you want a particular image, chances are it already exists -- but it may be easier to create one from scratch when to find the existing one. Beginning in the nineteenth century, modern society developed technologies which automated media creation: a photo camera, a film camera, a tape recorder, a video recorder, etc. These technologies allowed us, over the course of one hundred and fifty years, to accumulate an unprecedented amount of media materials: photo archives, film libraries, audio archives... This led to the next stage in media evolution: the need for new technologies to store, organize and efficiently access these media materials. These new technologies are all computer-based: media databases; hypermedia and other ways of organizing media material such the hierarchical file system itself; text management software; programs for content-based search and retrieval. Thus automation of media access is the next logical stage of the process which was already put into motion when a first photograph was taken. The emergence of new media coincides with this second stage of a media society, now concerned as much with accessing and re-using existing media as with creating new one.²⁶ (See “Database” section for more on databases).

4. Variability

A new media object is not something fixed once and for all but can exist in different, potentially infinite, versions. This is another consequence of numerical coding of media (principle 1) and modular structure of a media object (principle 2). Other terms which are often used in relation to new media and which would be appropriate instead of “variable” is “mutable” and “liquid.”

Old media involved a human creator who manually assembled textual, visual and/or audio elements into a particular composition or a sequence. This sequence was stored in some material, its order determined once and for all. Numerous copies could be run off from the master, and, in perfect correspondence with the logic of an industrial society, they were all identical. New media, in contrast, is characterized by variability. Instead of identical copies a new media object typically gives rise to many different versions. And rather being created completely by a human author, these versions are often in part automatically assembled by a computer. (The already quoted example of Web pages automatically generated from databases using the templates created by Web designers can be invoked here as well.) Thus the principle of variability is closely connected to automation.

Variability would also will not be possible without modularity. Stored digitally, rather than in some fixed medium, media elements maintain their separate identity and can be assembled into numerous sequences under program control. In addition, because the elements themselves are broken into discrete samples (for instance, an image is represented as an array of pixels), they can be also created and customized on the fly.

The logic of new media thus corresponds to the post-industrial logic of "production on demand" and "just in time" delivery which themselves were made possible by the use of computers and computer networks in all stages of manufacturing and distribution. Here "culture industry" (the term was originally coined by Theodor Adorno in the 1930s) is actually ahead of the rest of the industry. The idea that a customer determines the exact features of her car at the showroom, the data is then transmitted to the factory, and hours later the new car is delivered, remains a dream, but in the case of computer media, it is reality. Since the same machine is used as a showroom and a factory, i.e., the same computer generates and displays media -- and since the media exists not as a material object but as data which can be sent through the wires with the speed of light, the customized version created in response to user's input is delivered almost immediately. Thus, to continue with the same example, when you access a Web site, the server immediately assembles a customized Web page.

Here are some particular cases of the variability principle (most of them will be discussed in more detail in later chapters):

4.1. Media elements are stored in a media database; a variety of end-user objects which vary both in resolution, in form and in content can be generated, either beforehand, or on demand, from this database. At first, we may think that this is simply a particular technological implementation of variability principle,

but, as I will show in “Database” section, in a computer age database comes to function as a cultural form of its own. It offers a particular model of the world and of the human experience. It also affects how the user conceives of data which it contains.

4.2. It becomes possible to separate the levels of "content" (data) and interface. A number of different interfaces can be created to the same data. A new media object can be defined as one or more interfaces to a multimedia database (see introduction to “Interface” chapter and “Database” section for more discussion of this principle).²⁷

4.3. The information about the user can be used by a computer program to automatically customize the media composition as well as to create the elements themselves. Examples: Web sites use the information about the type of hardware and browser or user's network address to automatically customize the site which the user will see; interactive computer installations use information about the user's body movements to generate sounds, shapes, and images, or to control behaviors of artificial creatures.

4.4. A particular case of 4.3 is branching-type interactivity (sometimes also called menu-based interactivity.) This term refers to programs in which all the possible objects which the user can visit form a branching tree structure. When the user reaches a particular object, the program presents her with choices and let her pick. Depending on the value chosen, the user advances along a particular branch of the tree. For instance, in Myst each screen typically contains a left and a right button, clicking on the button retrieves a new screen, and so on. In this case the information used by a program is the output of user's cognitive process, rather than the network address or body position. (See “Menus, Filters, Plug-ins” for more discussion of this principle.)

4.5. Hypermedia is another popular new media structure, which conceptually is close to branching-type interactivity (because quite often the elements are connected using a branch tree structure). In hypermedia, the multimedia elements making a document are connected through hyperlinks. Thus the elements and the structure are independent of each other --rather than hard-wired together, as in traditional media. World Wide Web is a particular implementation of hypermedia in which the elements are distributed throughout the network . Hypertext is a particular case of hypermedia which uses only one media type — text. How does the principle of variability works in this case? We can conceive of all possible paths through a hypermedia document as being different versions of it. By following the links the user retrieves a particular version of a document.

4.6. Another way in which different versions of the same media objects are commonly generated in computer culture is through periodic updates. Networks allow the content of a new media object to be periodically updating while keeping its structure intact. For instance, modern software applications can

periodically check for updates on the Internet and then download and install these updates, sometimes without any actions from the user. Most Web sites are also periodically updated either manually or automatically, when the data in the databases which drives the sites changes. A particularly interesting case of this “updateability” feature is the sites which update some information, such as such as stock prices or weather, continuously.

4.7. One of the most basic cases of the variability principle is scalability, in which different versions of the same media object can be generated at various sizes or levels of detail. The metaphor of a map is useful in thinking about the scalability principle. If we equate a new media object with a physical territory, different versions of this object are like maps of this territory, generated at different scales. Depending on the scale chosen, a map provides more or less detail about the territory. Indeed, different versions of a new media object may vary strictly quantitatively, i.e. in the amount of detail present: for instance, a full size image and its icon, automatically generated by Photoshop; a full text and its shorter version, generated by “Autosummarize” command in Microsoft Word 97; or the different versions which can be created using “Outline” command in Word. Beginning with version 3 (1997), Apple’s QuickTime format also made possible to imbed a number of different versions which differ in size within a single QuickTime movie; when a Web user accesses the movie, a version is automatically selected depending on connection speed. Conceptually similar technique called “distancing” or “level of detail” is used in interactive virtual worlds such as VRML scenes. A designer creates a number of models of the same object, each with progressively less detail. When the virtual camera is close to the object, a highly detailed model is used; if the object is far away, a lesser detailed version is automatically substituted by a program to save unnecessary computation of detail which can’t be seen anyway.

New media also allows to create versions of the same object which differ from each other in more substantial ways. Here the comparison with maps of different scales no longer works. The examples of commands in commonly used software packages which allow to create such qualitatively different versions are “Variations” and “Adjustment layers” in Photoshop 5 and “writing style” option in Word’s “Spelling and Grammar” command. More examples can be found on the Internet were, beginning in the middle of the 1990s, it become common to create a few different versions of a Web site. The user with a fast connection can choose a rich multimedia version while the user with a slow connection can settle for a more bare-bones version which loads faster.

Among new media artworks, David Blair’s WaxWeb, a Web site which is an “adaptation” of an hour long video narrative, offers a more radical implementation of the scalability principle. While interacting with the narrative, the user at any point can change the scale of representation, going from an image-based outline of the movie to a complete script or a particular shot, or a VRML

scene based on this shot, and so on.²⁸ Another example of how use of scalability principle can create a dramatically new experience of an old media object is Stephen Mamber's database-driven representation of Hitchcock's Birds. Mamber's software generates a still for every shot of the film; it then automatically combines all the stills into a rectangular matrix. Every cell in the matrix corresponds to a particular shot from the film. As a result, time is spatialized, similar to how it was done in Edison's early Kinetoscope cylinders (see "The Myths of New Media.") Spatializing the film allows us to study its different temporal structures which would be hard to observe otherwise. As in WaxWeb, the user can at any point change the scale of representation, going from a complete film to a particular shot.

As can be seen, the principle of variability is useful in allowing us to connect many important characteristics of new media which on first sight may appear unrelated. In particular, such popular new media structures as branching (or menu) interactivity and hypermedia can be seen as particular instances of variability principle (4.4 and 4.5, respectively). In the case of branching interactivity, the user plays an active role in determining the order in which the already generated elements are accessed. This is the simplest kind of interactivity; more complex kinds are also possible where both the elements and the structure of the whole object are either modified or generated on the fly in response to user's interaction with a program. We can refer to such implementations as open interactivity to distinguish them from the closed interactivity which uses fixed elements arranged in a fixed branching structure. Open interactivity can be implemented using a variety of approaches, including procedural and object-oriented computer programming, AI, AL, and neural networks.

As long as there exist some kernel, some structure, some prototype which remains unchanged throughout the interaction, open interactivity can be thought of as a subset of variability principle. Here useful analogy can be made with theory of family resemblance by Wittgenstein, later developed into the influential theory of prototypes by cognitive psychologist Eleanor Rosch. In a family, a number of relatives will share some features, although no single family member may possess all of the features. Similarly, according to the theory of prototypes, the meanings of many words in a natural language derive not through a logical definition but through a proximity to certain prototype.

Hypermedia, the other popular structure of new media, can also be seen as a particular case of the more general principle of variability. According to the definition by Halacz and Swartz, hypermedia systems "provide their users with the ability to create, manipulate and/or examine a network of information-containing nodes interconnected by relational links."²⁹ Since in new media the individual media elements (images, pages of text, etc.) always retain their individual identity (the principle of modularity), they can be "wired" together into more than one object. Hyperlinking is a particular way to achieve this wiring. A

hyperlink creates a connection between two elements, for example between two words in two different pages or a sentence on one page and an image in another, or two different places within the same page. The elements connected through hyperlinks can exist on the same computer or on different computers connected on a network, as in the case of World Wide Web.

If in traditional media the elements are "hardwired" into a unique structure and no longer maintain their separate identity, in hypermedia the elements and the structure are separate from each other. The structure of hyperlinks -- typically a branching tree - can be specified independently from the contents of a document. To make an analogy with grammar of a natural language as described in Noam Chomsky's early linguistic theory,³⁰ we can compare a hypermedia structure which specifies the connections between the nodes with a deep structure of a sentence; a particular hypermedia text can be then compared with a particular sentence in a natural language. Another useful analogy is with computer programming. In programming, there is clear separation between algorithms and data. An algorithm specifies the sequence of steps to be performed on any data, just as a hypermedia structure specifies a set of navigation paths (i.e., connections between the nodes) which potentially can be applied to any set of media objects.

The principle of variability also exemplifies how, historically, the changes in media technologies are correlated with changes the social change. If the logic of old media corresponded to the logic of industrial mass society, the logic of new media fits the logic of the post-industrial society which values individuality over conformity. In industrial mass society everybody was supposed to enjoy the same goods -- and to have the same beliefs. This was also the logic of media technology. A media object was assembled in a media factory (such as a Hollywood studio). Millions of identical copies were produced from a master and distributed to all the citizens. Broadcasting, cinema, print media all followed this logic.

In a post-industrial society, every citizen can construct her own custom lifestyle and "select" her ideology from a large (but not infinite) number of choices. Rather than pushing the same objects/information to a mass audience, marketing now tries to target each individual separately. The logic of new media technology reflects this new social logic. Every visitor to a Web site automatically gets her own custom version of the site created on the fly from a database. The language of the text, the contents, the ads displayed — all these can be customized by interpreting the information about where on the network the user is coming from; or, if the user previously registered with the site, her personal profile can be used for this customization. According to a report in USA Today (November 9, 1999), "Unlike ads in magazines or other real-world publications, 'banner' ads on Web pages change wit every page view. And most of the companies that place the ads on the Web site track your movements across the Net, 'remembering' which ads you've seen, exactly when you saw them, whether

you clicked on them, where you were at the time and the site you have visited just before.”³¹

More generally, every hypertext reader gets her own version of the complete text by selecting a particular path through it. Similarly, every user of an interactive installation gets her own version of the work. And so on. In this way new media technology acts as the most perfect realization of the utopia of an ideal society composed from unique individuals. New media objects assure users that their choices — and therefore, their underlying thoughts and desires — are unique, rather than pre-programmed and shared with others. As though trying to compensate for their earlier role in making us all the same, today descendants of the Jacquard's loom, the Hollerith tabulator and Zuse's cinema-computer are now working to convince us that we are all unique.

The principle of variability as it is presented here is not dissimilar to how the artist and curator Jon Ippolito uses the same concept.³² I believe that we differ in how we use the concept of variability in two key respects. First, Ippolito uses variability to describe a characteristic shared by recent conceptual and some digital art, while I see variability as a basic condition of all new media. Second, Ippolito follows the tradition of conceptual art where an artist can vary any dimension of the artwork, even its content; my use of the term aims to reflect the logic of mainstream culture where versions of the object share some well-defined “data.” This “data” which can be a well-known narrative (Psycho), an icon (Coca-Cola sign), a character (Mickey Mouse) or a famous star (Madonna), is referred in media industry as “property.” Thus all cultural projects produced by Madonna will be automatically united by her name. Using the theory of prototypes, we can say that the property acts as a prototype, and different versions are derived from this prototype. Moreover, when a number of versions are being commercially released based on some “property”, usually one of these versions is treated as the source of the “data,” with others positioned as being derived from this source. Typically the version which is in the same media as the original “property” is treated as the source. For instance, when a movie studio releases a new film, along with a computer game based on it, along with products tie-ins, along with music written for the movie, etc., usually the film is presented as the “base” object from which other objects are derived. So when George Lucas releases a new Star Wars movie, it refers back to the original property — the original Star Wars trilogy. This new movie becomes the “base” object and all other media objects which are released along with refer to this object. Conversely, when computer games such as Tomb Rider are re-made into movies, the original computer game is presented as the “base” object.

While I deduced the principle of variability from more basic principles of new media — numerical representation (1) and modularity of information (2) — it can also be seen as a consequence of computer's way of to represent data and model the world itself: as variables rather than constants. As new media theorist

and architect Marcos Novak notes, a computer — and computer culture in its wake — substitute every constant by a variable.³³ In designing all functions and data structures, a computer programmer tries to always use variables rather than constants. On the level of human-computer interface, this principle means that the user is given many options to modify the performance of a program of a media object, be it a computer game, a Web site, a Web browser, or the operating system itself. The user can change the profile of a game character, modify how the folders appear on the desktop, how files are displayed, what icons are used, etc. If we apply this principle to culture at large, it would mean that every choice responsible for giving a cultural object a unique identity can potentially remain always open. Size, degree of detail, format, color, shape, interactive trajectory, trajectory through space, duration, rhythm, point of view, the presence or absence of particular characters, the development of the plot — to name just a few dimensions of cultural objects in different media — all these can be defined as variables, to be freely modified by a user.

Do we want, or need, such freedom? As the pioneer of interactive filmmaking Graham Weinbren argued in relation to interactive media, making a choice involves a moral responsibility.³⁴ By passing these choices to the user, the author also passes the responsibility to represent the world and the human condition in it. (This is paralleled by the use of phone or Web-based automated menu systems by all big companies to handle their customers; while the companies are doing this in the name of “choice” and “freedom,” one of the effects of this automation is that labor to be done is passed from company’s employees to the customer. If before a customer would get the information or buy the product by interacting with a company employee, now she has to spend her own time and energy in navigating through numerous menus to accomplish the same result.) The moral anxiety which accompanies the shift from constants to variables, from tradition to choices in all areas of life in a contemporary society, and the corresponding anxiety of a writer who has to portray it, is well rendered in this closing passage of a short story written by a contemporary American writer Rick Moody (the story is about the death of his sister):³⁵

I should fictionalize it more, I should conceal myself. I should consider the responsibilities of characterization, I should conflate her two children into one, or reverse their genders, or otherwise alter them, I should make her boyfriend a husband, I should explicate all the tributaries of my extended family (its remarriages, its internecine politics), I should novelize the whole thing, I should make it multigenerational, I should work in my forefathers (stonemasons and newspapermen), I should let artifice create an elegant surface, I should make the events orderly, I should wait and write about it later, I should wait until I’m not angry, I shouldn’t clutter a narrative with fragments, with mere recollections of

good times, or with regrets, I should make Meredith's death shapely and persuasive, not blunt and disjunctive, I shouldn't have to think the unthinkable, I shouldn't have to suffer, I should address her here directly (these are the ways I miss you), I should write only of affection, I should make our travels in this earthy landscape safe and secure, I should have a better ending, I shouldn't say her life was short and often sad, I shouldn't say she had demons, as I do too.

5. Transcoding

Beginning with the basic, "material" principles of new media — numeric coding and modular organization — we moved to more "deep" and far reaching ones — automation and variability. The last, fifth principle of cultural transcoding aims to describe what in my view is the most substantial consequence of media's computerization. As I have suggested, computerization turns media into computer data. While from one point of view computerized media still displays structural organization which makes sense to its human users — images feature recognizable objects; text files consist from grammatical sentences; virtual spaces are defined along the familiar Cartesian coordinate system; and so on — from another point of view, its structure now follows the established conventions of computer's organization of data. The examples of these conventions are different data structures such as lists, records and arrays; the already mentioned substitution of all constants by variables; the separation between algorithms and data structures; and modularity.

The structure of a computer image is a case in point. On the level of representation, it belongs to the side of human culture, automatically entering in dialog with other images, other cultural "sems" and "mythemes." But on another level, it is a computer file which consist from a machine-readable header, followed by numbers representing RGB values of its pixels. On this level it enters into a dialog with other computer files. The dimensions of this dialog are not the image's content, meanings or formal qualities, but file size, file type, type of compression used, file format and so on. In short, these dimensions are that of computer's own cosmogony rather than of human culture.

Similarly, new media in general can be thought of as consisting from two distinct layers: the "cultural layer" and the "computer layer." The examples of categories on the cultural layer are encyclopedia and a short story; story and plot; composition and point of view; mimesis and catharsis, comedy and tragedy. The examples of categories on the computer layer are process and packet (as in data packets transmitted through the network); sorting and matching; function and variable; a computer language and a data structure.

Since new media is created on computers, distributed via computers, stored and archived on computers, the logic of a computer can be expected to

significant influence on the traditional cultural logic of media. That is, we may expect that the computer layer will affect the cultural layer. The ways in which computer models the world, represents data and allows us to operate on it; the key operations behind all computer programs (such as search, match, sort, filter); the conventions of HCI — in short, what can be called computer's ontology, epistemology and pragmatics — influence the cultural layer of new media: its organization, its emerging genres, its contents.

Of course what I called a computer layer is not itself fixed but is changing in time. As hardware and software keep evolving and as the computer is used for new tasks and in new ways, this layer is undergoing continuous transformation. The new use of computer as a media machine is the case in point. This use is having an effect on computer's hardware and software, especially on the level of the human-computer interface which looks more and more like the interfaces of older media machines and cultural technologies: VCR, tape player, photo camera.

In summary, the computer layer and media/culture layer influence each other. To use another concept from new media, we can say that they are being composited together. The result of this composite is the new computer culture: a blend of human and computer meanings, of traditional ways human culture modeled the world and computer's own ways to represent it.

Throughout the book, we will encounter many examples of the principle of transcoding at work. For instance, "The Language of Cultural Interfaces" section will look at how conventions of printed page, cinema and traditional HCI interact together in the interfaces of Web sites, CD-ROMs, virtual spaces and computer games.

"Database" section will discuss how a database, originally a computer technology to organize and access data, is becoming a new cultural form of its own. But we can also reinterpret some of the principles of new media already discussed above as consequences of the transcoding principle. For instance, hypermedia can be understood as one cultural effect of the separation between an algorithm and a data structure, essential to computer programming. Just as in programming algorithms and data structures exist independently of each other, in hypermedia data is separated from the navigation structure. (For another example of the cultural effect of algorithm—data structure dichotomy see "Database" section.) Similarly, the modular structure of new media can be seen as an effect of the modularity in structural computer programming. Just as a structural computer program consists from smaller modules which in their turn consist from even smaller modules, a new media object as a modular structure, as I explained in my discussion of modularity above.

In new media lingo, to "transcode" something is to translate it into another format. The computerization of culture gradually accomplishes similar transcoding in relation to all cultural categories and concepts. That is, cultural categories and concepts are substituted, on the level of meaning and/or the language, by new ones which derive from computer's ontology, epistemology and

pragmatics. New media thus acts as a forerunner of this more general process of cultural re-conceptualization.

Given the process of “conceptual transfer” from computer world to culture at large, and given the new status of media as computer data, what theoretical framework can we use to understand it? Since on one level new media is an old media which has been digitized, it seems appropriate to look at new media using the perspective of media studies. We may compare new media and old media, such as print, photography, or television. We may also ask about the conditions of distribution and reception and the patterns of use. We may also ask about similarities and differences in the material properties of each medium and how these affect their aesthetic possibilities.

This perspective is important, and I am using it frequently in this book; but it is not sufficient. It can't address the most fundamental new quality of new media which has no historical precedent — programmability. Comparing new media to print, photography, or television will never tell us the whole story. For while from one point of view new media is indeed another media, from another is simply a particular type of computer data, something which is stored in files and databases, retrieved and sorted, run through algorithms and written to the output device. That the data represents pixels and that this device happened to be an output screen is besides the point. The computer may perform perfectly the role of the Jacquard loom, but underneath it is fundamentally Babbage's Analytical Engine - after all, this was its identity for one hundred and fifty years. New media may look like media, but this is only the surface.

New media calls for a new stage in media theory whose beginnings can be traced back to the revolutionary works of Robert Innis and Marshall McLuhan of the 1950s. To understand the logic of new media we need to turn to computer science. It is there that we may expect to find the new terms, categories and operations which characterize media which became programmable. From media studies, we move to something which can be called software studies; from media theory — to software theory. The principle of transcoding is one way to start thinking about software theory. Another way which this book experiments with is using concepts from computer science as categories of new media theory. The examples here are “interface” and “database.” And, last but not least, I follow the analysis of “material” and logical principles of computer hardware and software in this chapter with two chapters on human-computer interface and the interfaces of software applications use to author and access new media objects.

3 Language

The authors of the eighteenth-century French *Encyclopédie* midwived the birth of a language to describe artisans' work and their machines, and, over the course of centuries, this became the ancestor of what we know today as programming languages. By printing as text and diagrams what the artisans spoke in the workshop, the encyclopedists paired the mechanical arts and the liberal arts. This coupling was a radical intervention at a time and place where the two had been kept separate for centuries. The French encyclopedists translated the everyday language of the workshop, a language of the mechanical arts, into a language of literature and learned discourse, the language of the liberal arts.

Like all remarkable translators, the encyclopedists had to invent new language. Specifically, they invented what I will call a “work language” and another I will term a “machine language.” I define “work language” to mean the language—the text and talk—employed to describe the processes and products of work. A “machine language” is a work language employed in the design and analysis of machines. When a machine is designed to replace a human in a work process, the actions performed by the human must be translated into a machine language.

At the center of computing is the work language and machine language of operations, birthed in the eighteenth-century workshops of the French artists, designers, and artisans. A century after the publication of the *Encyclopédie*, Charles Babbage and Ada Lovelace together were able to translate a work language of operations into a machine language in an endeavor Lovelace called a “science of operations.” Even now, the operations of computing are confused with the functions of mathematics, but there is a huge gap between the artisans' operations of computing and the functions of mathematics. Many careers have been devoted to trying to bridge that gap—to make computing a form of pure or applied mathematics—yet no perfect translation between the two has been found. Consequently, computing remains an art and a craft quite unlike

mathematics and not at all a science written in functions, despite Lovelace's wishful phrase of a "science of operations."

Bacon's *Organum*

Lord Chancellor Francis Bacon was one year away from political disgrace and a fall from power and was six years away from his death when he published the *Novum Organum Scientiarum* (New Instrument of Science), considered the founding document of empirical science and the first description of a form of logical induction subsequently named the "scientific method."

The "organum," the "instrument," in his title refers to Aristotle's writings on logic collected under the title *Organum*. Bacon understood the study of nature, under the influence of Aristotelian philosophers, to have been stalled for two thousand years. His book was a critique of the Aristotelians and was a proposal to refound the study of nature by, among other things, patterning it after and enlisting the aid of the mechanical arts.

According to Bacon, compared to the mechanical arts, the liberal arts had made almost no progress in the previous two millennia. Bacon attributes various "discoveries" to the mechanical arts, including printing, gunpowder, and the compass: "For these three have changed the appearance and state of the whole world: first in literature, then in warfare, and lastly in navigation; and innumerable changes have been thence derived, so that no empire, sect, or star, appears to have exercised a greater power and influence on human affairs than these mechanical discoveries."¹

Like many writers of the era, Bacon figured nature as feminine and consequently described the study of nature in terms of gender, sex, and reproduction. For instance, he writes of the "womb of nature." If nature-as-woman were a loose or rare metaphor in Bacon's writings, one might pay it no heed, but, as historian and philosopher of science Evelyn Fox Keller writes in a chapter titled "Baconian Science: The Arts of Mastery and Obedience,"² Bacon's sexual imagery was systematic, ubiquitous to his writings about science and thus not at all casual. Bacon's aim was for man to attain mastery over nature for his purposes, just as in seventeenth-century England a husband was thought to be within his rights to gain mastery over and require obedience from his wife.

At first, Bacon's prescription for the reinvigoration of the sciences seems like a call for domestic abuse made by a cuckold,³ hardly a positive role model for the scientist. But further on in the *Novum Organum*, Bacon moves to several positive ideas for reinvigorating the sciences: "The plan to be pursued is this: all the mechanical, and even the liberal arts (as far as they are practical), should be visited and thoroughly examined, and thence there should be formed a compilation or particular history of the great

masterpieces, or most finished works in each, as well as of the mode of carrying them into effect."⁴

The Encyclopedists as Midwives

Many, including German mathematician and philosopher Gottfried Leibniz, were subsequently inspired by this plan for a compilation of the masterworks of the arts—mechanical and liberal. A century after the publication of Bacon's book, the compilation was undertaken as a large-scale project conducted by philosopher and writer Denis Diderot, mathematician Jean Le Rond d'Alembert, and their colleagues, who together produced the multivolume *Encyclopédie*.

However, the encyclopedists did not figure their role as being akin to the role of man over nature or husband over wife. Rather, they saw themselves in a very different role, remarkably that of midwife; not literally a midwife but "literately" a midwife—one who could put the inchoate, oral descriptions of artists and artisans into a printable, literate language.

They saw this as a necessary role because the artisan—like the artist and the designer of today—was frequently assumed to be a taciturn intuitive worker able to operate and practice but unable to articulate or interrogate machines, instruments, and processes of production and manufacturing. In the "Preliminary Discourse" to the *Encyclopédie*, Jean Le Rond d'Alembert wrote, "Most of those who engage in the mechanical arts have embraced them only by necessity and work only by instinct. Hardly a dozen among a thousand can be found who are in a position to express themselves with some clarity upon the instrument they use and the things they manufacture. We have seen some workers who have worked for forty years without knowing anything about their machines."⁵

Yet d'Alembert, reporting on work that was directed primarily by his co-editor Diderot—the son of an artisan, a cutler—wrote, "We approached the most capable of them in Paris and in the realm. We took the trouble of going into their shops, of questioning them, of writing at their dictation, of developing their thoughts and of drawing therefrom the terms peculiar to their professions, of setting up tables of these terms and of working out definitions for them, of conversing with those from whom we obtained memoranda, and (an almost indispensable precaution) of correcting through long and frequent conversations with others what some of them imperfectly, obscurely, and sometimes unreliably had explained."⁶ He summarized by saying, "With [the artisans], it was necessary to exercise the function in which Socrates gloried, the painful and delicate function of being midwife of the mind, *obstetrix animorum*."⁷

I will argue that Diderot, d'Alembert, and the encyclopedists did indeed midwife the birth of a language to describe artisans' work and their machines and that, over the course of the centuries, this became the root of what we know today as programming languages. By printing as text and diagrams what the artisans usually just spoke in the workshop, the encyclopedists paired the mechanical arts and the liberal arts. This pairing was a radical intervention at a time and place where the two had been kept separate for centuries.

The Aristotelian Barrier

We can call this traditional separation the "Aristotelian barrier." In the words of historian of science Pamela Long, "Aristotle delineated three areas of human activity: first, material and technical production (*techne*); second, action (*praxis*), such as political or military action, that requires judgment in contingent or uncertain situations (*phronesis*); and third, theoretical knowledge or knowledge of unchanging things (*episteme*). Aristotle's separation of material production from action and from theoretical knowledge presupposed a hierarchy with *techne* at the bottom and *episteme*, or theoretical knowledge, at the top."⁸

These epistemological divisions led to divisions in the educational system, where the liberal arts were taught separately from the mechanical arts. To this day, the Aristotelian barrier separates language that belongs to the liberal arts (specifically the language arts of the trivium) from machines that belong to the mechanical arts.

Given a social context in which this barrier is accepted, d'Alembert's comments about inarticulate artisans seem quite natural, but notice also how self-contradictory d'Alembert's declaration is when he states that he was "writing at their [the artisans'] dictation." So, the artisans could not express themselves in words, yet the words written about their various crafts are the words dictated by the artisans themselves!?

Obviously, the artisans could communicate their craft; they just could not do it in the then-current languages of the liberal arts. Put more plainly, the workingman's language needed to be translated into the upper-class language of the liberal arts before it could be printed in the *Encyclopédie*. Diderot and d'Alembert's accomplishment, thus phrased, is an accomplishment of translation, a translation across class divides.

Breaking the Aristotelian barrier was an imperative for Bacon and then for Diderot and d'Alembert, and it continues to be an imperative even today. Pamela Long's own research emphasizes the important role of artisans in the history of science. Breaking the Aristotelian barrier in the history of astronomy, for instance, might lead us to

investigate the role of the artisan who made Galileo's telescope. Are Galileo's astronomical discoveries to be credited to Galileo or/and to the artisans who made the discoveries possible?

Breaking the Aristotelian barrier also remains one of the most pressing issues in contemporary philosophy. Philosopher Bernard Stiegler both highlighted and broke this barrier in the first volume of his book *Technics and Time*, where he wrote, "At the beginning of its history philosophy separates *tekhné* from *épistème*.... The separation is determined by a political context, one in which the philosopher accuses the Sophist of instrumentalizing the *logos* as rhetoric and logography, that is, as both an instrument of power and a renunciation of knowledge. It is in the inheritance of this conflict—in which the philosophical *épistème* is pitched against the sophistic *tekhné*, whereby all technical knowledge is devalued—that the essence of the technical entities is conceived."⁹

As industrial capitalism came to dominate the economy, the Aristotelian barrier was an impediment for the upper classes to understand the sources of their wealth. Writing almost a century after Diderot, in the preface to his book *On the Economy of Machinery and Manufactures*,¹⁰ Charles Babbage admonishes his peers—those who have wealth, leisure, and a liberal arts education—for being ignorant of the mechanical arts. He writes, "Those who possess rank in a manufacturing country, can scarcely be excused if they are entirely ignorant of principles, whose development has produced its greatness. The possessors of wealth can scarcely be indifferent to processes which, nearly or remotely have been the fertile source of their possessions. Those who enjoy leisure can scarcely find a more interesting and instructive pursuit than the examination of the workshops of their own country, which contain within them a rich mine of knowledge, too generally neglected by the wealthier classes."¹¹ Moreover, Babbage tells his peers that learning something about the sources of their wealth will not be too difficult: "The difficulty of understanding the processes of manufactures has unfortunately been greatly overrated. To examine them with the eye of a manufacturer, so as to be able to direct others to repeat them, does undoubtedly require much skill and previous acquaintance with the subject; but merely to apprehend their general principles and mutual relations, is within the power of almost every person possessing a tolerable education."¹²

With these statements, Babbage clearly indicates that his perspective is one from the berth/birth of the upper class; he also assures his readers that the mechanical arts can in fact be translated into the languages of the liberal arts since, at the time, "a tolerable education" was, axiomatically, for the upper class, a liberal arts education.

Dramatis Personae

Possible and desirable though it may be, breaking the Aristotelian barrier entailed—and still necessitates—a move beyond one's education and upbringing, since we are all circumscribed by social, political, economic, and cultural conditions that govern who knows what and who does what. Moreover, generally speaking, most educational institutions preserve the Aristotelian barrier. As d'Alembert pointed out, those apprenticed in an artisan's workshop do not necessarily know how to write. Conversely, even today, those who get a liberal arts education are not trained to become automobile mechanics. Concisely, race, class, gender, sexuality, occupation, and education are performed within roles that are not easily refused. To find alternatives to our assigned roles, we need to imagine *dramatis personae* that blend, divide, or diverge from conventional roles. This is a suggestion inspired by philosopher Gilles Deleuze.¹³

If we look carefully at the *dramatis personae* proposed respectively by d'Alembert and Babbage, we can see that they were catalytic in the creation of new institutions of knowledge and practice. D'Alembert acknowledges that the image of philosopher-as-midwife is at least as old as Socrates, yet even now, Socratic dialogue is explosive, if not revolutionary. As it was performed by Socrates, midwifery was a practice of intensively questioning someone's common sense, thereby birthing a new understanding of self.

Babbage's preface to *On the Economy of Machinery and Manufactures* evokes what at first glance seems to be a much less demanding role. Babbage seems to be describing a "gentleman mechanic" akin to the "gentleman farmer"—a persona that would require the gentleman to have some knowledge about how his wealth was produced but to acquire this knowledge as a form of leisure, not as a matter of necessity.

Babbage's preface tells his gentleman reader that he will reveal an entertaining diversion for his leisure time and, simultaneously, that the principles of the mechanical arts to be explained are not at all a diversion for him (Babbage) but rather should be seen as the very foundation of his intellectual life and the probable source of wealth for anyone who will benefit from the industrial revolution.¹⁴ Babbage's aspirations exceed entertainment. He wants to inspire his gentleman reader to become a manufacturer.

In a different essay, Babbage explicitly names the role he would have for his gentleman and all men: "It is not a bad definition of man to describe him as a tool-making animal."¹⁵ Babbage's *dramatis persona* is not *Homo sapiens*, the wise, rational, intelligent man. Neither is he what cultural historian Johan Huizinga has called *Homo ludens*, the man of leisure, man the player.¹⁶ Babbage's *dramatis persona* is *Homo faber*, man the maker.

Many philosophers, political theorists, and economists have elaborated on the cultural, social, economic, and political consequences of an ideology that places the

persona of *Homo faber* at its center. This trope can be elaborated by distinguishing between seemingly close variants. If we say that “man the maker” is a pivotal figure, we are pressed to consider just what it is that these men make and what kind of work they must engage in to make what they do. For instance, is the agricultural laborer fundamentally different from the construction worker, the factory worker, the office worker, or the researcher who tills the fields of knowledge? If so, is the distinction made according to how the work is done or according to what is made?

Using the definition of ideology discussed in chapter 2, it is possible to examine Baconian science, the arts and sciences of the *Encyclopédie*, and Babbage’s “science of operations” as distinct ideologies elaborated around their respective dramatis persona: husband, midwife, *Homo faber*.

Analogously, we can consider the brilliance and perspicuity of Turing’s 1936 article as resulting from his audacious move to put the modest dramatis persona of human computer at the center of a rethinking of mathematical work. Turing’s machines put the “low-level” work of calculation into the center of the “high-level” work of mathematics. In a phrase, Turing—like Bacon, Diderot, and Babbage before him—broke the “Aristotelian barrier.”

***Homo faber* and Work versus *Homo laborans* and Labor**

Many languages include at least two words for “work.” In English, we have “labor” and “work.” In French, the analogous terms are “travailler” and “oeuvrer.” In her book *The Human Condition*, philosopher Hannah Arendt points out that this double term exists not only in English and French but also in many other languages, including German, Greek, and Latin.¹⁷ Arendt hinges one of the main arguments of her book on this repeated difference, which philosopher John Locke references in his *Second Treatise of Civil Government*, where he writes about “the labour of our body and the work of our hands” (section 26).

Arendt points out that in ancient Greece labor was shunned and work was esteemed. This valuation lingers on in our everyday locutions, where we can talk about, for example, a “work of art” but not a “labor of art,” or, in English, borrowing from French, where an artist’s work can be referred to as the artist’s “oeuvre” but not the artist’s “travail” (which in English would mean laborious or painful effort).

According to Arendt, in ancient Greece, labor included those efforts made by women, slaves, and domestic animals to sustain and reproduce life and the necessities of life. Work was the production of free men in public for public, rather than private, purposes. The private realm was considered a position of privation, and labor

was considered the activity that took place in private. Work was an act of honor and renown that took place in public. Arendt's distinction describes the circumstances in which some forms of effort, production, and reproduction are unseemly or hidden from view and other forms of work are highlighted, highly valued, and given center stage. Furthermore, class and gender strictly regulated the differences between labor and work, private and public. Arendt refers to those men engaged in work as *Homo faber*. Those engaged in labor are *Homo laborans* or, following Arendt, *Animal laborans*.

Arendt contrasts this ancient Greek valuation of work over labor (and thus workers over laborers) with political economist Karl Marx's idea that labor (and thus laborers) should be central to and thus at the top of all valuation.¹⁸ So one can see that entire ideologies can be elaborated around images of work and who does what kind of work.

Work Languages and Machine Languages

To articulate various kinds of work and who or what does what kind of work (or labor), I introduce two constructs of my own design. One I call "work languages," and the other I term "machine languages." I define "work language" to mean the language—the text and talk—employed to describe the processes and products of work. So, for instance, one might scrutinize Benjamin Franklin's writings about work—"Early to bed and early to rise makes a man healthy, wealthy, and wise"¹⁹—in order to argue that contemporary business practices (e.g., as inscribed in documents of corporate mission, legal contracts, legislation, or employee manuals) are still tied to Protestant ethics in a variety of ways.²⁰ Each age, each culture, each industry, and each economy has one or more work languages. By examining differences and similarities between these languages, one can interrogate what work is here and now and how it contrasts with work as it was there and then.

Central to today's work are the almost performative qualities of "machine languages," a subset of work languages employed in the design and analysis of machines. To adequately describe how a machine works is tantamount to demonstrating the work to be done in exacting detail. When a machine is designed to replace a human in a work process, when work is automated, the actions performed by the human must be translated into a machine language.

Two work languages are central to this chapter. The first is a work language of physics that begins as a language of construction and evolves into a language of information. This first work language is descriptive of what Arendt calls "labor." The second is a work language of the arts that eventually becomes a language of computation. The

second is descriptive of some of the activities that Arendt calls “work.” The two languages are closely related but distinct.

A Work Language of Construction, Physics, and Information

The work language of physics is a language of calculation developed in the eighteenth century by a network of Enlightenment engineers, scientists, philosophers, and mathematicians, including French mathematician and scientist André-Marie Ampère (1775–1836), Swiss scientist and mathematician Daniel Bernoulli (1700–1782), French engineer and scientist Charles-Augustin de Coulomb (1736–1806), German scientist and mathematician Georg Simon Ohm (1789–1854), Italian scientist Alessandro Giuseppe Volta (1745–1827), and Scottish inventor James Watt (1736–1819). Originally, their work language was used to measure the activity of men and machines as heat or electrical charge. Thus, we have the quantitative measures of the watt, the joule, and the coulomb—all still used today.

French fortifications engineer Charles-Augustin de Coulomb stated at the beginning of his 1775 treatise (republished in 1821) what he took to be the fundamental unit of work. He uses this unit to compare the work of machines and the work of men: “We have just seen that the effect of a machine can always be measured according to a weight multiplied by the height to which it has been raised.”²¹ This measure of work—weight multiplied by the height to which it is raised—is still central to contemporary physics and engineering. It reduces what might be a set of very complicated movements to a single number labeled with a unit; specifically, the unit of foot-pounds. In Arendt’s terms, this is properly a language of labor and not a language of work, but in contemporary technical terms, a foot-pound force is defined to be a unit of energy or work, so in this section we will persist in calling it a work language.

The formalization of this language is defined in the unit of work named after James Prescott Joule (1818–1889), an English scientist and beer brewer.²² The definition of a joule in turn relates together the eponymous units of many of the participants of the network listed earlier—and also includes units named for Isaac Newton (1643–1727) and Blaise Pascal (1623–1662). One joule, usually written as J, is a unit of work equal to the expenditure of energy necessary to apply one newton—that is, to accelerate one kilogram of mass at the rate of one meter per second squared—through a distance of one meter. Alternatively, a joule can be defined as passing an electric current of one ampere—that is, one coulomb per second—through a resistance of one ohm for one second. We can also understand a joule to be the heat required to raise the temperature of one gram of water by 0.24 kelvin, a measure of temperature named after British physicist

and engineer Lord Kelvin (1824–1907). This definition can be written as an algebraic equation:²³

$$J = \frac{\text{kg} \times \text{m}^2}{\text{s}^2} = \text{N} \times \text{m} = \text{Pa} \times \text{m}^3 = \text{W} \times \text{s} = \text{C} \times \text{V}$$

This equation does far more than Coulomb's sentences of 1775. It succinctly relates not just weight and height but also heat and electricity, mechanics, thermodynamics, and electrodynamics—many of the fluxes and flows investigated independently in the eighteenth century.

This line of research was continued through the nineteenth century as thermodynamics, with practical application to, among other things, Joule's business of brewing beer, the construction of steam engines, and, eventually, internal combustion engines. The unit of one joule divided by kelvin (that is, a measure of work or energy divided by temperature) turned out to be pivotal for the development of thermodynamics: J/K is the unit of *entropy*, the measure of (dis)order! Who could have foreseen such a direct connection between work and disorder? Entropy is a measure of the number of ways in which a system may be arranged; that is, its measurement in a system is proportional to the number of possible states of the system.

In the middle of the twentieth century, Claude Shannon created a formal definition of information based on this definition of entropy. According to Shannon, entropy is equal to the average amount of information contained in a message.²⁴ This we know today as the basis for information theory.

This definition of information has its origins in the eighteenth-century problem of measuring how much work a common laborer accomplishes lifting and carrying loads at a construction site. Using Arendt's terms, one could say that the language of physics and information is a formalization of what is done by *Homo laborans*. Clearly, this language and its earlier formulations are apt for work in mechanics, thermodynamics, and electrodynamics, but they are not the languages of the arts and computation. They are inadequate when used to analyze the work of *Homo faber*. In Arendt's terms, the language of physics and information is the language of labor; in contrast, the language of computation is the language of skilled work.²⁵

Work Languages Have Limits

Clearly, the work language of physics and information has many uses and has been at the center of many innovations. Nevertheless, each work language has its limits when applied to activities for which it was not developed. Consequently, it is not surprising

that many students of introductory physics have been struck by the limits of its work language.

For example, let us imagine that you are a house builder's apprentice. Your name is "Sisyphus." In the morning, your duty is to take the builder's toolbox out of the truck and open it up. The builder climbs to the second floor of the house under construction. Whenever he calls for a tool—"Sisyphus, bring me a hammer!"—your job is to get it out of the toolbox, climb the ladder, give it to him, wait until he finishes the task for which he needed the tool, and then climb down the ladder again and put the tool in the toolbox.²⁶ According to the definition of work used in physics, at the end of the day, if you have performed your job well and returned all of the tools back to the box, you have done no work! You lifted certain weights in the form of tools to certain heights at the top of the ladder; that constitutes work. But you returned those same weights back to the toolbox on the ground; that constitutes negative work. Therefore, the total work completed by you is zero! Poor Sisyphus!

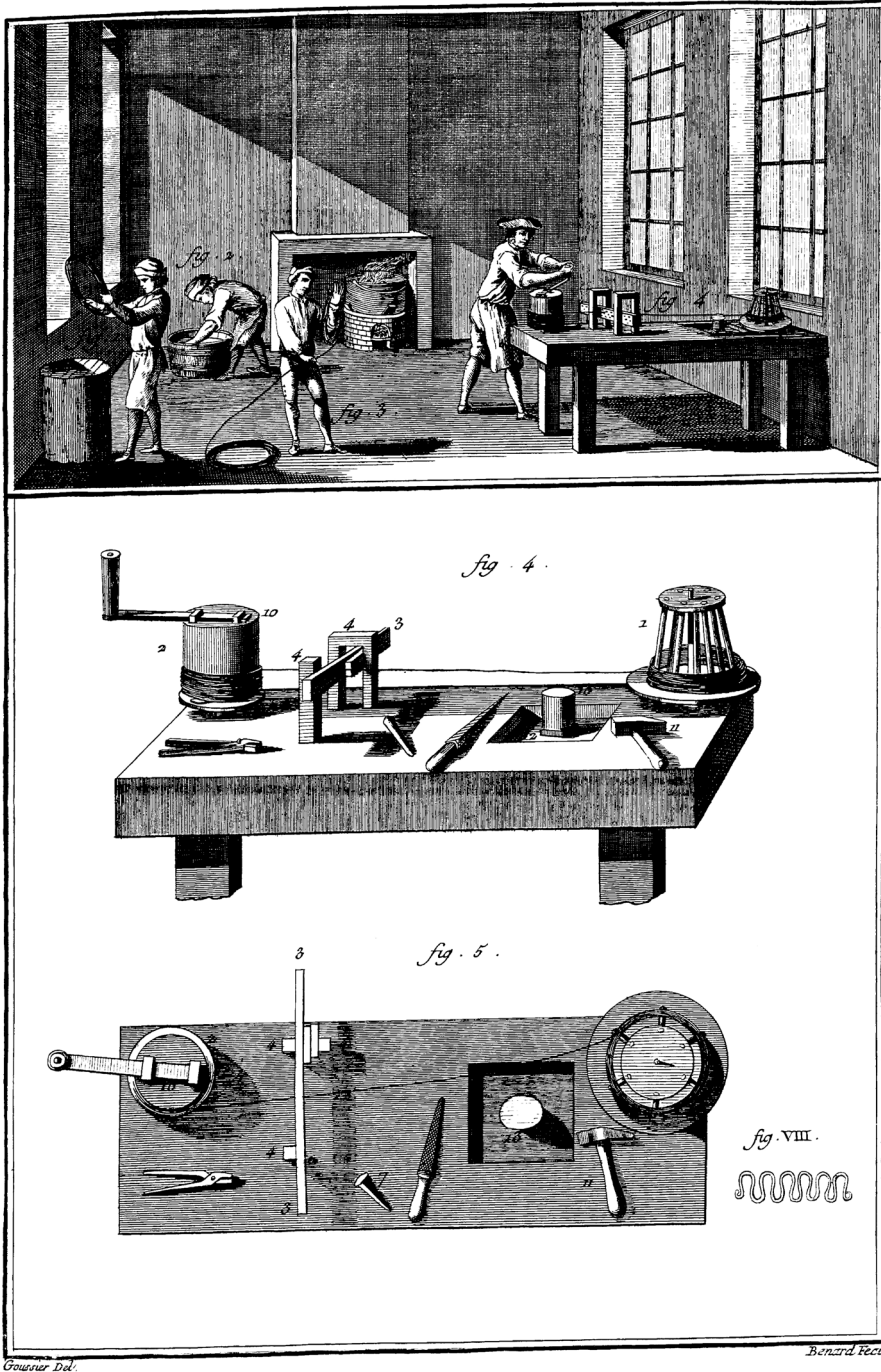
A Work Language of the Arts

To better describe the activities of Sisyphus and the house builder, one needs to use a work language of the arts. This work language is not the language of physics and information. Its origins can be seen in Diderot and d'Alembert's *Encyclopédie*.

Let us look at the *Encyclopédie*'s plates depicting the work of artisan pin makers (see figures 3.1, 3.2, and 3.3). Do you see men and machines lifting a lot of weight? No, right? So, even if the work language of physics and information is the right one for describing the labor of coal mining and construction sites, it is not the right one for describing the work of the mechanical arts. In fact, it is absurd when employed in the artisan's workshop.

What is the appropriate work language for describing what artisans, designers, and artists do? As it happens, a second work language was developed in the eighteenth century, and, curiously, this history starts at the same place with some of the same people as in the history of the joule. Unlike the work language of physics, this second language does not reduce the description of work to a single number (of joules). Rather, the work language of the arts can be employed to describe *how work is done*. The work language of the arts anticipates what we know today as computer programming languages.

Its history is referred to within the literature of computer science but rarely told in full. For example, one of the founders of the field of computer science, Herbert Simon, quipped in 1958 that "Physicists and engineers had little to do with the invention of the digital computer.... The real inventor was the economist Adam Smith."²⁷



Epinglier.

Figure 3.1

Plate I of the *Encyclopédie* entry for "Pinmaker."

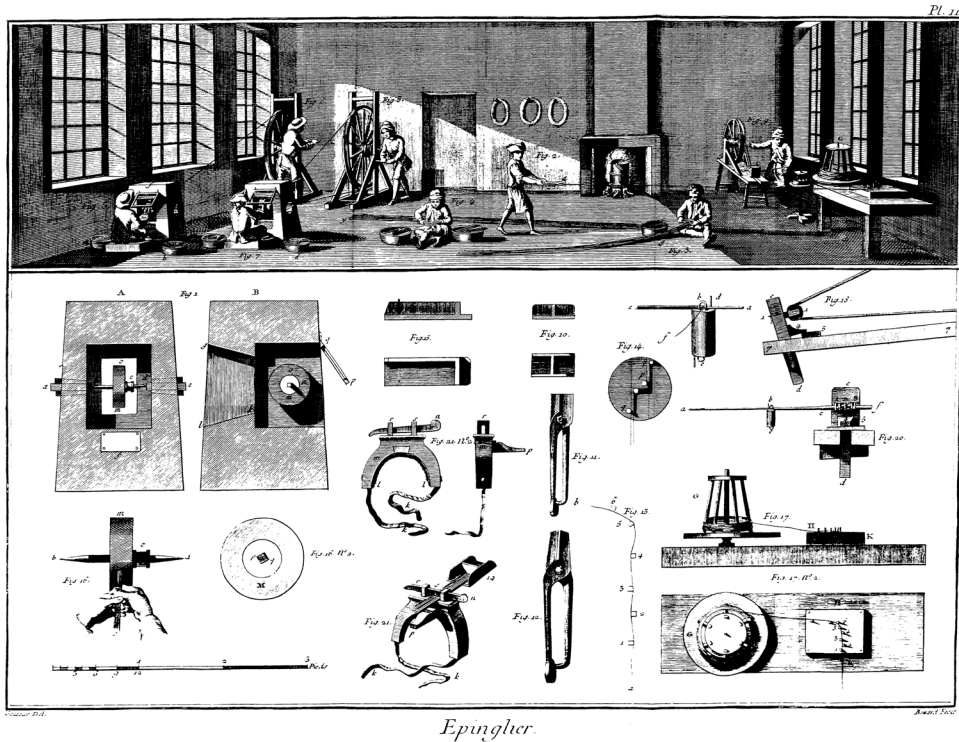


Figure 3.2

Plate II of the *Encyclopédie* entry for "Pinmaker."

What is Simon referring to here? Recall that book 1, chapter 1, of Adam Smith's best-known work, *The Wealth of Nations* (1776), is on the division of labor, specifically in the production of pins. Smith wrote, "The greatest improvements in the productive power of labor, and the greater part of the skill, dexterity, and judgement with which it is any where directed, or applied, seem to have been the effects of the division of labor." A division of labor is an organization of collaboration in which the work to be done is distributed between different people using a number of tools and machines. Herbert Simon is suggesting that we examine how work and the division of labor are at the core of the computer.

If we want to maintain some fidelity to the philosophical language of Arendt, we would say that when Smith describes a division of labor he is, in Arendtian terms, describing a division of work. This is because Smith's description—as we will see—draws on an entirely different kind of language than the work language of physics just

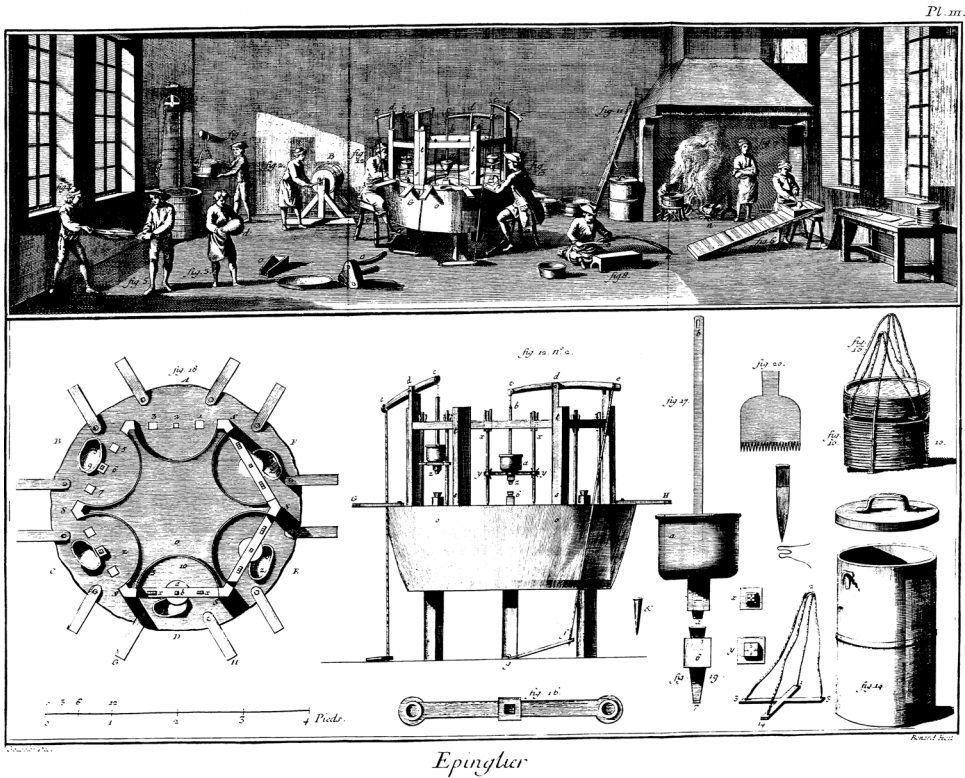


Figure 3.3

Plate III of the *Encyclopédie* entry for “Pinmaker.”

described. Adam Smith’s work language has its beginnings in a set of drawings detailing a workshop producing pins in a little town in Normandy: Laigle, France.

Engineer Jean-Rudolphe Perronet did the original observational work at this site. Let us call the observational work—anachronistically—ethnographic work, so that we can be reminded of the importance of contemporary human scientists’, especially ethnographers’, contributions to the design of software and hardware.²⁸ Trained in civil engineering, mathematics, and mechanics, Perronet joined the engineering corps of the Ponts et Chaussées in 1735.²⁹ Soon thereafter, he was appointed the chief engineer for the district of Alençon and was primarily concerned with the construction and paving of roads.

During the same period, however, Perronet also studied the workshops of artisans and craftsmen and wrote two manuscripts on the manufacture of pins at a workshop in the nearby town of Laigle.³⁰ While neither of these manuscripts was published

immediately, Perronet contributed to the entry for “Pin” (Épingle) in Diderot and d’Alembert’s *Encyclopédie*.³¹ Moreover, Perronet’s detailed descriptions of how the craftsmen manufactured the pins, how they used their machines, and how the machines were designed anticipated the work language of the *Encyclopédie*, a collection that incorporated many articles on contemporary methods of the mechanical arts.

Design historian Antoine Picon discusses the three main terms of this work language of the *Encyclopédie*—gestures, operations, and processes: “The common threads that connect the different articles devoted to the arts and crafts are the description of elementary gestures of production, how these movements are integrated and thereby define aggregate technical operations, and the logic of chaining together these operations to form processes organized according to a division of labor.... From individual movement to process chain, the thread that weaves them together is analogous to the overall aim of Diderot, D’Alembert, and their *Encyclopédie* collaborators: the integration of all forms of knowledge.”³²

For example, here are some extracts from the four-page *Encyclopédie* entry for “Pinmaker.” It summarizes in eighteen steps how straight pins were made: “A pin undergoes eighteen operations before it becomes a commercial commodity. 1. one yellows the brass wire... 2. one pulls the wire around the bobble... 3. one draws out the wire... 4. one cuts the wire... 5. one puts a point on it....”³³ Note that this looks like a recipe for making pins. Figures 3.1, 3.2, and 3.3 are the illustration plates for the entry. As we will see in chapter 4, on algorithms, algorithms are frequently compared to recipes. One might say that the *Encyclopédie* includes a set of recipes for making not just food but all kinds of different things.³⁴

Adam Smith’s example of pin making was inspired by his reading of d’Alembert and Diderot’s *Encyclopédie*.³⁵ A few years later, in 1791, Gaspard Prony—charged by the French government with producing a set of enormous and detailed logarithmic and trigonometric tables—borrowed back from Adam Smith this image of the division of labor, citing Smith and claiming he “could manufacture logarithms as easily as one manufactures pins.”³⁶ Prony organized a great number of working-class nonmathematicians to perform as a set of “computers” in order to calculate the tables.

There is, however, some sort of oedipal perversity in Prony’s claim that he was inspired by Smith, because, as we have seen, Smith’s source was Diderot’s *Encyclopédie*, to which Perronet contributed. And Perronet was not just Prony’s professor, mentor, supervisor, and eventual collaborator but also his predecessor as the first director of the École des Ponts et Chaussées. Prony succeeded him as director in 1798.

We might say instead that the real inventors of the computer were Perronet, Prony, and the encyclopedists and that, contrary to Herbert Simon’s attribution, the only

contribution Adam Smith made was to copy from the *Encyclopédie* so that it was ultimately cited by Prony. My point is that Prony could have received his information about the division of work and the production of pins directly from Perronet and that Smith was just an unlikely middleman. But this unlikely detour through Scotland—through the writings of Adam Smith—that connects the genealogy of computing from Perronet to Prony is the source of computer scientist and Nobel Prize-winning economist Herbert Simon’s quip that Smith was the inventor of the computer.

Babbage and the Translation from Manual to Machine Operations

A few years after Prony’s achievement, British mathematician, philosopher, and engineer Charles Babbage noted how Prony’s division of work could be incorporated as a machine. In my preferred terms, Babbage thus translated the work language of the *Encyclopédie* into a machine language. He achieved this in plan but not in physical form; his Analytical Engine was not completed in his lifetime.³⁷ Nevertheless, even on the drawing board, it became clear that the machine language he forged out of the *Encyclopédie*’s work language was from a very different family than logic or mathematics.

The differences appear clearly in Babbage’s drawings. Historian Mark Priestley tells us, “In the course of this work, Babbage found that the traditional method of using drawings to describe machinery was inadequate. A drawing could only represent the state of a machine at one instant, and so provided little assistance in understanding the sequences of movements involved in a complex mechanism or in working out the appropriate timing of the movements of its interacting parts.”³⁸ Consequently, Babbage was driven to invent new graphical notation for machines that combined textual annotation and the illustration of the structure of the parts of the machine with a novel means to describe the succession of movements that were to take place in the machine. (See figure 3.4.) In the terms of the *Encyclopédie*, Babbage had to develop a new means to diagram the gestures, operations, and sequences of movements and operations—that is, processes.³⁹

As Picon points out, operations were at the semantic foundations of the *Encyclopédie*’s work language. Soon after Babbage completed his design, it became clear that operations were central to his machine language, too. English mathematician Ada Lovelace argued, in elucidating the differences between the operations of Babbage’s machine and the functions of arithmetic and calculus, that Babbage’s machine would require a new field of research beyond mathematics, a field she called “a science of operations”: “The science of operations... is a science of itself, and has its own abstract truth and value; just as logic has its own peculiar truth and value, independently of the

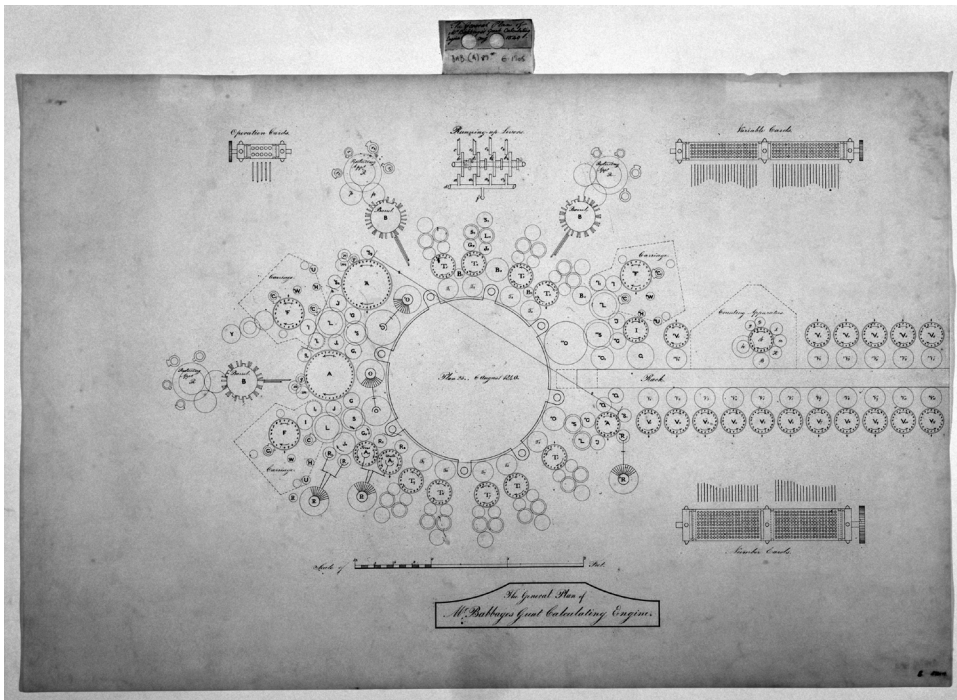


Figure 3.4

The general plan of Mr. Babbage's Great Calculating Engine, 1840. Reproduced with permission from Science Museum Archive/Science and Society

Picture Library: SSPL Image 10303657.

subjects to which we may apply its reasonings and processes.”⁴⁰ Because of her writings on Babbage's machine, Lovelace is acknowledged to be the first computer programmer, the first software designer *avant la lettre*, and indeed, key issues she identified in 1843 concerning the rendering and execution of operations are still concerns of computer science today.

Functions versus Operations

The language of labor, the language of physics, described previously, is a language of functions. In contrast, this second language is a work language of operations, the language of the arts. In other words, the latter is a work language of operations and not of mathematical functions. To underline Lovelace's point, computing is not mathematics.

What is the difference between a function and an operation? One can see, in the *Oxford English Dictionary* (*OED*) that prior to Leibniz, the term “function” was a very general term meaning, for example, “official duties” or “the kind of action proper to a person as belonging to a particular class.” These are quite general definitions applicable to all kinds of work.

After Leibniz, however, according to the *OED*, a new, more specialized and specifically mathematical definition is introduced: “A variable quantity regarded in its relation to one or more other variables in terms of which it may be expressed, ... This use of the Latin *functio* is due to Leibniz and his associates.” Thus, the language of labor quantified in joules (or joules per kelvin) is part and parcel of the eighteenth-century movement in engineering to recast engineering analysis and design into the language of Leibniz’s and Newton’s calculus.

Looking to the *OED* again for the definition of “operation,” we see that it, too, was—and still is—a general term applicable to the description of all kinds of work: definition 1.a. is “The exertion of force or influence; working, activity; a manner of working, the way in which a thing works.” “Operation” thus contrasts with mathematical “function.”⁴¹ As Antoine Picon emphasizes, “One must observe that although quantification and mathematical calculation could be considered as the quintessence of analysis, the analytical method [of the *Encyclopédie*] could very well remain purely qualitative.”⁴² In other words, the work language of functions is quantitative; the work language of operations can be purely qualitative.

The Work Language of the *Encyclopédie* Anticipates Computer Programming Languages

The *Encyclopédie* constantly testifies to a tale of matter, but this is also in a certain way a tale of “mind”: for the encyclopedist, the trajectory of matter is the progression of reasoning: the images of the plates have a logical function.... Here we find prophetically the very principle of cybernetic assemblages; the image of the machine depicted in the plate is in its own way a “brain”; in it one can see where matter is input and the organization of a “program.”⁴³

Let us now rush this history forward about a century (this time skipping Turing) to 1947, when Herman Goldstine and John von Neumann published *Planning and Coding for an Electronic Instrument*, a text that we might read today as the first-ever computer programming manual. Goldstine and von Neumann were trying to describe coding—that is, programming—for a readership that was completely unfamiliar with the notion.

They defined programming as the task of translating mathematical formulas into the language of the computer but were not entirely comfortable with the notion that it was a form of translation. They seemed to feel that the rewriting of mathematical formulas into computer language was much more difficult than translating from one language into another. They wrote, "The relation of the coded instruction sequence to the mathematically conceived procedure of (numerical) solution is not a static one, that of a translation, but highly dynamical: A coded order stands not simply for its present contents at its present location, but more fully for any succession of passages...through it."⁴⁴ In other words, here is yet another difference between these operations and mathematical functions: the operations can change their order, their number, or their kind as execution of the program proceeds.

The exposition of Goldstine and von Neumann hinges on their development of the then-newest graphical means of diagramming a machine: the flow diagram.⁴⁵ Software is still frequently designed in a graphical notation that bears a strong resemblance to Goldstine and von Neumann's flow diagrams. (See figure 3.5.) As in theirs,

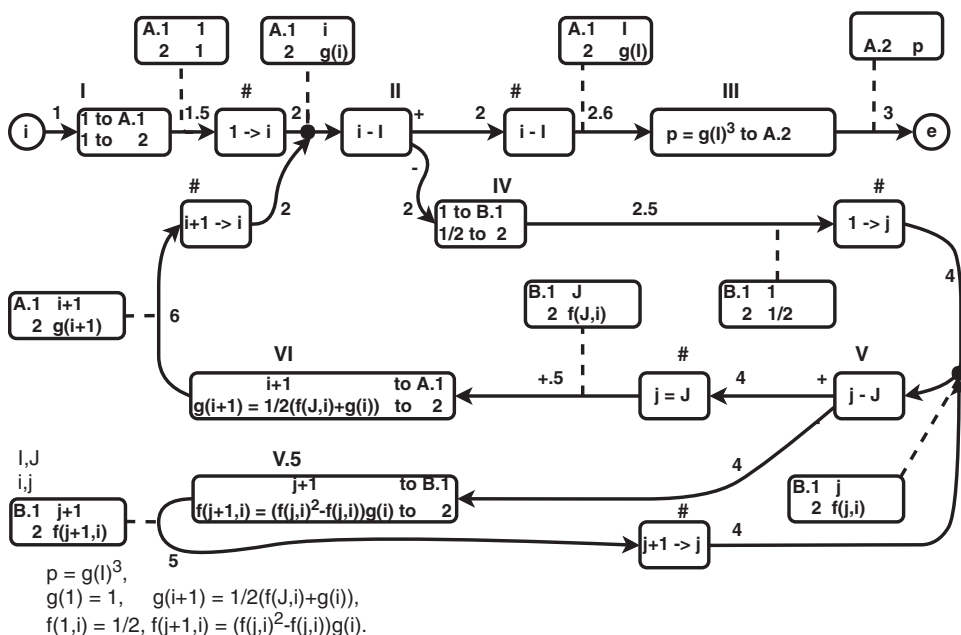


Figure 3.5

This flow chart was modeled on figure 7.2 from Herman Goldstine and John von Neumann, *Planning and Coding for an Electronic Instrument* (1947).

in contemporary flow diagrams, boxes describe operations and arrows denote the sequence in which the operations are to be performed.

There are no people depicted in Babbage's notations, nor are there any in Goldstine and von Neumann's flow diagrams. When we compare them to the *Encyclopédie's* engravings, this lack of people is striking.⁴⁶ Flow diagrams are a picture of work without workers. This picture is at the vanishing point of automation, where all workers have been ejected from the workshop and replaced by machines.

Something of the work language of operations was lost as it was translated through the centuries from Perronet, to Smith, to Prony, to Babbage, and then to von Neumann and Goldstine. What was lost in the language was the facility to include people; or, more specifically, what was lost in translation was an articulation of the interactions between people and between people and machines. As we will see in chapter 4, on algorithms, the loss of people was not by accident but rather by design. Babbage and then later von Neumann and others were especially keen to get people out of the loop.

Recall Antoine Picon's discussion of the three main terms of the work language of the *Encyclopédie*: gestures, operations, and processes. When one looks for the materialization of these three terms in contemporary computing, operations and processes are easy to see, because they constitute central terms or constructions in most modern computer programming languages. To see gestures in software, however, takes more effort.

Gesture recognition and gesture-based computing are, nevertheless, foundationally important to today's mobile platforms and game controllers. Microsoft's Kinect provides game designers with tools for automatically recognizing a large repertoire of human gestures and movements using techniques from machine vision.⁴⁷ Equally familiar to any regular user of Apple's iPhone or similar products are the embedded computational techniques deployed in the hardware of touchscreens and accelerometers; with handheld devices, we the users swipe, tap, tilt, and shake the mobile phone or tablet computer.⁴⁸ So, in some sense, gestures are a central construct for today's interface and user-experience designers.

But there is an apposite site in which gestures can be seen in contemporary computing: the site of the division of work. People began to disappear from the workshops of artisans and designers and then from factories and offices because their jobs had become automated. Automating a job entails breaking it down into component parts, dividing mental operations and physical gestures into tiny movements until they are so small or trivial that they can be performed by a machine. But this act of breaking down entails more than the phrase "division of work" communicates.

Division is, of course, an operation of arithmetic, but dividing work or labor is much more complicated than just plain arithmetic. It is not so much a question of finding a division of work as it is a matter of finding a grammar of work,⁴⁹ a grammar that includes complexities like doing operations again and again (iteratively or recursively); of chaining together sequences of operations—processes—and nesting them into powerful “black boxes” that have simple inputs and outputs even if they hide very complicated machines inside them; and of articulating together, in network topologies, these black boxes so that they mimic the relationships between workers we glimpsed in the workshop illustrated in the *Encyclopédie*.⁵⁰

Decomposing operations into complex assemblages of smaller operations requires more than division; it requires a grammar. Compare division to an ax, and compare grammar to a whole toolkit. An ax is a fine tool for splitting wood, but a carpenter needs a large array of tools to both cut and join wood in many diverse assemblages. For these reasons and others, I will follow a number of other theorists, especially Bernard Stiegler, and refer to grammars of work and efforts to distribute work into complex, recomposable, and reconfigurable units as efforts of “grammatization.” Grammar and grammatization will be more fully explored in chapter 7.

the behaviour of any machine. The myth has passed into the philosophy of mind, generally to pernicious effect.”

70. Stephen Hilgartner, “The Dominant View of Popularization: Conceptual Problems, Political Uses,” *Social Studies of Science* 20, no. 3 (1990).

71. Warren McCulloch, “Mysterium Iniquitatis of Sinful Man Aspiring into the Place of God,” *Scientific Monthly* 80, no. 1 (1955), 35–39, as cited in Petzold, *The Annotated Turing*, 335.

Chapter 3

1. Francis Bacon, *Novum Organum or True Suggestions for the Interpretation of Nature* (New York: P. F. Collier and Son, [1620] 1902), sec. 124.

2. Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven, CT: Yale University Press, 1995), 33–42.

3. The year of the publication of the *Novum Organum*, 1620, also seems to be the year that Bacon’s wife, Alice Barnham, met her lover, John Underhill, whom she married less than two weeks after Bacon’s death, in April 1626.

4. Francis Bacon, “Aphorisms—Book II on the Interpretation of Nature, or the Reign of Man,” in *Novum Organum*, sec. 31.

5. Jean Le Rond d’Alembert, *Preliminary Discourse to the Encyclopedia of Diderot*, trans. Richard N. Schwab (Chicago: University of Chicago Press, [1751] 1995), 123.

6. d’Alembert, *Preliminary Discourse to the Encyclopedia of Diderot*, 122

7. d’Alembert, *Preliminary Discourse to the Encyclopedia of Diderot*, 123.

8. Pamela O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2001), Kindle locs. 61–63.

9. Bernard Stiegler, *Technics and Time*, vol. 1, *The Fault of Epimetheus* (Stanford, CA: Stanford University Press, 1998), 3–4.

10. Charles Babbage, *On the Economy of Machinery and Manufactures* (Amazon Digital Services, [1832] 2011), https://www.amazon.com/dp/B004TS7610/ref=dp-kindle-redirect?_encoding=UTF8&btcr=1.

11. Babbage, *On the Economy of Machinery and Manufactures*, preface.

12. Babbage, *On the Economy of Machinery and Manufactures*, preface.

13. Writing about Deleuze, philosopher John Rajchman described it thus:

Deleuze was a philosopher who thought that philosophies are singular creations. Each philosopher creates a philosophy, indefinite enough for there to be others. The idea of philosophy is thus not fixed—there is no

one method, no one way of doing it. Rather each philosophy invents a distinctive *agon* with its own *dramatis personae*: in each we find what Deleuze comes to call an “image of thought,” even if the image is not always obvious.... Each of the “personae” through which a philosophy dramatizes its ideas suggests a manner in which philosophy is oriented and the kind of struggle in which it is involved.... Plato invents the *persona* of Socrates and his *agon* with the Sophists; Kant instead invents a Judge watching over the bounds of reason; Leibniz casts himself rather as a defense attorney for God in a world that seems to have abandoned him, ever adducing new principles, while Spinoza, in giving up even such a God, creates instead the *persona* of an Innocent, a “sort of child-player against whom one can do nothing.” In each case we have different ways the contest or “game” of philosophy is [played].

See John Rajchman, *The Deleuze Connections* (Cambridge, MA: MIT Press, 2000), 32, 42.

14. In chapter 19 of *On the Economy of Machinery and Manufactures*, Babbage goes further than just urging attention to the mechanical arts and arguing that the division of labor of the mechanical arts applies also to the liberal arts. The title of chapter 19 is “On the Division of Mental Labor.” In other words, physical labor and mental labor are both seen by Babbage to be equally amenable to division. Babbage attributes this insight to M. Prony.

15. Babbage continues like this: “It is not a bad definition of man to describe him as a tool-making animal. His earlier contrivances to support uncivilized life, were tools of the simplest and rudest construction. His latest achievements in the substitution of machinery, not merely for the skill of the human hand, but for the relief of the human intellect, are founded on the use of tools of a still higher order.” See Charles Babbage, “Calculating Machines, Chapter XIII, the Exposition of 1851,” in *Charles Babbage: On the Principles and Development of the Calculator and Other Seminal Writings by Charles Babbage and Others*, ed. Philip Morrison and Emily Morrison, eds. (Mineola, NY: Dover, 1961), 322.

16. Johan Huizinga, *Homo Ludens: A Study of the Play-Element in Culture* (Boston: Routledge & Keegan Paul, 1949).

17. Hannah Arendt, *The Human Condition* (Chicago: University of Chicago Press, 1958), 80 (footnote).

18. Hannah Arendt speculated that “The very reason for the elevation of labor in the modern age was its ‘productivity,’ and the seemingly blasphemous notion of Marx that labor (and not God) created man or that labor (and not reason) distinguished man from the other animals was only the most radical and consistent formulation of something upon which the whole modern age was agreed.” See Arendt, *The Human Condition*, 85–86.

19. See Benjamin Franklin, *Poor Richard’s Almanack* (Philadelphia: B. Franklin, 1735).

20. Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (New York: Routledge, [1930] 1992).

21. Charles-Augustin de Coulomb wrote,

Nous venons de voir que l’effet d’une machine avoir toujours pour mesure un poids élevé, multiplié par la hauteur à laquelle il est élevé. A présent, pour pouvoir comparer l’effet avec la fatigue que les hommes éprouvent en produisant cet effet, il faut déterminer la fatigue qui répond à un certain degré d’action.... Daniel Bernoulli, qui a discuté cette question, en ayant égard à la plus grande partie de ses éléments, dit que la fatigue des hommes est toujours proportionnelle à leur quantité d’action; en sorte qu’en n’outrant pas

pas leurs forces naturelles, l'on peut faire varier à volonté la vitesse, la pression, et le temps, et que, pour vu que le produit de ses quantités soit une quantité constant, il en résultera toujours pour l'homme un meme degré de fatigue.... [L]a quantité qui exprime le maximum d'action relativement à la fatigue doit être l'objet principal des recherches qui vont suivre.

Charles-Augustin de Coulomb, "Résultat de Plusieurs Expériences destinées à déterminer la quantité d'action que les hommes peuvent fournir pour leur travail journalier, suivant les différentes manières don't ils emploient leur forces," *Théorie des Machines Simples, en Ayant Égard au Frottement de leurs Parties et à la Roideur des Cordages* (Paris: Bachelier, 1821), 256–257.

22. One foot-pound is defined to be equal to 1.355818 joules.

23. Note that kg means kilogram; m means meter; s means second; N means newton; Pa means pascal (a unit of pressure defined as one newton per square meter); W means watt (a unit of power defined as one joule per second); C means coulomb (a unit of electrical charge defined as a constant current of one ampere in one second, or approximately 6.241×10^{18} electrons); and V means volt (a unit of electric potential difference and electromotive force defined as the electric potential between two points of a conducting wire when an electric current of one ampere dissipates one watt of power between those points).

24. Claude E. Shannon, "A Mathematical Theory of Communication," *Bell System Technical Journal* 27 (July and October 1948).

25. My proposal here, to distinguish information from computation by distinguishing the language of labor (i.e., the mathematical formulation of mechanics) from the language of skilled work (i.e., the computational formulation of operations and processes), is a response to a query posed by Arendt:

It is surprising at first glance, however, that the modern age—with its reversal of all traditions, the traditional rank of action and contemplation no less than the traditional hierarchy within the *vita activa* itself, with its glorification of labor as the source of all values and its elevation of the *animal laborans* to the position traditionally held by the *animal rationale*—should not have brought forth a single theory in which *animal laborans* and *homo faber*, "the labour of our body and the work of our hands," are clearly distinguished. Instead, we find first the distinction between productive and unproductive labor, then somewhat later the differentiation between skilled and unskilled work, and, finally, outranking both because seemingly of more elementary significance, the division of all activities into manual and intellectual labor.

See Arendt, *The Human Condition*, 85.

26. I introduce this particular example to allow readers of philosopher Ludwig Wittgenstein to compare it to the work language he discusses at the beginning of his *Philosophical Investigations*: "Let us imagine a language for which the description given by Augustine is right. The language is meant to serve for the communication between a builder A and an assistant B. A is building with building-stones: there are blocks, pillars, slabs and beams. B has to pass the stones, and in that order in which A needs them. For this purpose they use a language consisting of the words 'block', 'pillar', 'slab', 'beam'. A calls them out;—B brings the stone which he has learnt to bring at such-and-such a call.—Conceive that as a complete primitive language." See Ludwig Wittgenstein, *Philosophical Investigations* (New York: Macmillan, 1953), sec. 1.2.

27. Herbert A. Simon and Allen Newell, "Heuristic Problem Solving: The Next Advance in Operations Research," *Operations Research* 6, no. 1 (January–February, 1958): 1–10. Note that this quip was published in an article with "operations research" in its title and in a journal called *Operations Research*. I will return to the importance of "operations" for this second work and machine language. In a journal article published shortly before his death, Simon provides a short sketch of such a history that starts with Adam Smith and Voltaire (1694–1778), the French philosopher and contributor to Diderot and d'Alembert's *Encyclopédie*. See Herbert A. Simon, "Bounded Rationality in Social Science: Today and Tomorrow," *Mind and Society* 1, no. 1 (2000).

28. Now there is also a flourishing area of the social sciences—especially within sociolinguistics, sociology, and anthropology—devoted to detailed analyses of the language of work. The Work Practice and Technology Laboratory directed by Lucy Suchman at Xerox PARC in the 1980s was seminal in this area. The Association for Computing Machinery (ACM) Conference on Computer-Supported Cooperative Work (CSCW) is a venue where research of this kind is presented from the many sociologists, linguists, and anthropologists who now play a prominent role in information technology research in large corporations. The relevance of this area of the social sciences to the design of computer hardware and software is well represented within the field of CSCW and is highlighted by stars such as anthropologist Genevieve Bell, who was until recently vice president and fellow at Intel.

29. These biographical details are taken from Antoine Picon, *French Architects and Engineers in the Age of Enlightenment* (Cambridge: Cambridge University Press, 1992), 346–349.

30. Jean-Rudolphe Perronet, *Explication de la Façon dont on Réduit le Fil de Laiton à Différentes Gros-seurs dans la Ville de Laigle* (Manuscript 2384), ed. École Nationale des Ponts et Chaussées (Paris: Archives of the École Nationale des Ponts et Chaussées, 1739); Jean-Rudolphe Perronet, *Description de la Façon dont on Fait les Épingles à Laigle en Normandie* (Manuscript 2385), ed. École Nationale des Ponts et Chaussées (Paris: Archives of the École Nationale des Ponts et Chaussées, 1740).

31. Historian Jean-Louis Peaucelle points out that even though Perronet wrote his two treatises on the manufacture of pins by 1740, Perronet's contribution to the *Encyclopédie* was the second version of the entry "Épinglier." The first version of the entry was written by Alexandre "Delaire" Deleyre, who was sent by Diderot to investigate the manufacture of pins in Laigle in 1755. In a subsequent edition (1765), Perronet's text was published in place of Delaire's. In 1783, the entry on pins edited together the Delaire and the Perronet articles. Adam Smith's book *The Wealth of Nations* was published in 1776, yet, apparently, the version of the *Encyclopédie* that inspired him included Delaire's entry, not Perronet's. See Jean-Louis Peaucelle, "La division du travail: Adam Smith et les encyclopedistes observant la fabrication des épingles en Normandie," *Gérer et Comprendre, Annales des mines*, No. 57 (September): 35–51.

32. Antoine Picon, "Gestes ouvriers, opérations et processus techniques: La vision du travail des encyclopédistes," *Recherches sur Diderot et sur l'Encyclopédie, Société Diderot* 13 (1992): 143–144.

33. Alexandre Deleyre, "Épingle," in *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.*, ed. Denis Diderot and Jean Le Rond d'Alembert, University of Chicago Artfl

Encyclopédie Project (Chicago: University of Chicago, [1755] Autumn 2017), <https://artflsrv03.uchicago.edu/philologic4/encyclopedia1117/navigate/5/2993/>.

34. As noted, historian of science Pamela Long points out that how-to manuals and recipes from many of the mechanical arts have a very long history. But historian Sean Takats argues that by the middle of the eighteenth century in France, cooks especially had made considerable progress in theorizing their own profession and authoring an increasing number of books. Takats writes, “What had transpired in the decades before 1740 for cooking to stray from the purely mechanical to the intellectual? The transformation of *la cuisine* from place and action to knowledge resulted from a passionate campaign conducted by cooks to theorize their work.” See Sean Takats, *The Expert Cook in Enlightenment France*, Johns Hopkins University Studies in Historical and Political Science (Baltimore: Johns Hopkins University Press, 2011), Kindle locs. 1910–1912. By the 1740s, some cooks had become well-known authors. Consider, for instance, the publication by cook François Menon, *La Cuisinière Bourgeoise* (1746), which was reprinted in many subsequent editions and became the best-selling cookbook of the century. That the writing style employed in these increasingly popular cookbooks might have influenced Diderot and his collaborators seems more likely than not. Takats demonstrates the connection by citing Diderot: “Writing in the *Encyclopédie*, Diderot agreed: ‘insofar as our cuisine is concerned, it cannot be disputed that it is an important branch of chemistry.’ The *Encyclopédie*’s article on chemistry included a discussion of cooking, noting that ‘Panificium [breadmaking] is certainly in the domain of chemistry: cooking is a type of domestic chemistry.’ The argument that cooking had entered the world of science convinced booksellers to categorize the latest cookbooks under headings such as ‘Arts and Sciences. Medicine. Chemistry’ and ‘Pharmacopeia, Chemistry, and Alchemy.’” See Takats, *The Expert Cook in Enlightenment France*, Kindle locs. 2586–2591.

35. Armand Mattelart, *The Information Society: An Introduction* (London: Sage, 2003), 18.

36. As cited in David Alan Grier, *When Computers Were Human* (Princeton, NJ: Princeton University Press, 2005), 36. The original article by Prony is Gaspard-Clair-François-Marie Riche de Prony, “Notice sur les grandes tables logarithmiques et trigonométriques, adaptées au nouveau système métrique décimal, lue à la séance publique du 7 juin 1824” (paper presented at the Recueil des discours lus dans la séance publique de l’Académie Royale des Sciences, Paris, 1824).

37. As described for instance by Allan Bromley, the failure to build the Analytical Engine was partly the result of a falling out between Babbage and engineer Joseph Clement, who had worked with Babbage for years on his previous invention, the Difference Engine. See Allan Bromley, “Difference and Analytical Engines,” in *Computing before Computers*, ed. William Aspray (Ames: Iowa State University Press, 1990), 66–67.

38. Mark Priestley, *A Science of Operations: Machines, Logic and the Invention of Programming* (New York: Springer, 2010), Kindle locs. 1019–1022.

39. See Charles Babbage, “On a Method for Expressing by Signs the Action of Machinery,” in *Charles Babbage: On the Principles and Development of the Calculator and Other Seminal Writings by Charles Babbage and Others*, ed. Philip Morrison and Emily Morrison (Mineola, NY: Dover,

1961), 346–356. See also Charles Babbage, “Laws of Mechanical Notation,” in Morrison and Morrison, eds., *Charles Babbage*, 357–362. Babbage’s graphical notation is displayed and analyzed in a November 7, 2011 *New York Times* article at <https://archive.nytimes.com/www.nytimes.com/interactive/2011/11/07/science/before-its-time-machine.html>. The original image is archived at the Science Museum Archive/Science and Society Picture Library. Used by permission.

40. Ada Lovelace, “Sketch of the Analytical Engine Invented by Charles Babbage [by LF Menabrea, translated and appended with additional notes, by Augusta Ada, Countess of Lovelace],” in *Scientific Memoirs, Selected from the Transactions of Foreign Academies of Science and Learned Societies*, vol. 3 (London: Richard and John Taylor, 1843), 693, as cited in Priestley, *A Science of Operations*, Kindle locs. 1328–1330. Clearly, this is a key citation in Priestley’s book, since Lovelace’s phrase “a science of operations” is the title of his book.

41. In the history of science, one can find efforts to reconceptualize areas in terms of operations where, previously and institutionally, Leibniz’s calculus and functions reigned. Notable is the philosophy of physics—“operationalism”—proposed by Percy Bridgman. See Percy Williams Bridgman, “Operational Analysis,” *Philosophy of Science* 5 (1938), as discussed in Hasok Chang, “Operationalism,” in *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (Stanford, CA: Stanford University Press, 2009).

42. Picon, “Gestes ouvriers, opérations et processus techniques.”

43. Roland Barthes, “Les planches de l’Encyclopédie de Diderot et d’Alembert,” in *Nouveaux Essais Critiques* (Paris: Seuil, 1972), 99.

44. Herman Goldstine and John von Neumann, *Planning and Coding for an Electronic Instrument* (Princeton, NJ: Institute for Advanced Study, 1947), 2.

45. The development of the flow diagram is traced in Joseph Dumit, “Circuits in the Brain and How They Got There,” in *Plasticity and Pathology: On the Formation of the Neural Subject*, ed. David Bates and Nima Bassiri (New York: Fordham University Press, 2016).

46. See John Bender and Michael Marrinan, *The Culture of the Diagram* (Stanford, CA: Stanford University Press, 2010), for a fascinating discussion on the presence and absence of people in the plates of the *Encyclopédie*, especially those plates that concern the mechanical arts and the workshops of the artisans, such as the pinmaker workshop.

47. <https://developer.microsoft.com/en-us/windows/kinect>.

48. https://developer.apple.com/library/ios/documentation/EventHandling/Conceptual/EventHandlingiPhoneOS/motion_event_basics/motion_event_basics.html.

49. Philip Agre, “Surveillance and Capture: Two Models of Privacy,” *The Information Society* 10 (1994).

50. Specialists in the history and sociology of work are keenly aware of the simplistic understandings propagated by many influential but underinformed accounts of the “division of labor.” For example, rereading the texts of Delaire and Perronet written for the *Encyclopédie*, historian

Jean-Louis Peaucelle critiques Adam Smith's misunderstandings. In the texts from the *Encyclopédie* attention is paid to the fact that craftsmen performing different operations in a pin-producing workshop were paid different salaries: the more experienced, the more skilled, and those engaged in the more dangerous tasks received higher salaries. According to Peaucelle, the men who put the point on the pin were paid the most and were engaged in a terribly dirty job since the mill that was used threw steel dust into the air. These salary differentials were an important factor in the division of labor. Furthermore, Peaucelle argues that the division of labor in these workshops was not a consequence of the introduction of machines into the workshop—as Smith seems to have thought—but rather the inverse was the case. Examining the evidence from the firsthand accounts of Delaire and Perronet, the introduction of machines seems to have been the consequence of already existing divisions of the labor in the workshop. See Peaucelle, "La division du travail: Adam Smith et les encyclopedistes observant la fabrication des épingles en Normandie," *Gérer et Comprendre, Annales des mines*, no. 57 (September): 35–51.

Chapter 4

1. Donald Ervin Knuth, *The Art of Computer Programming*, vol. 1, *Fundamental Algorithms* (Reading, MA: Addison-Wesley, 1968), 27–29.

2. Tarleton Gillespie, "Algorithm," in *Digital Keywords: A Vocabulary of Information Society and Culture*, ed. Benjamin Peters (Princeton, NJ: Princeton University Press, 2016).

3. Antoinette Rouvroy and Thomas Berns, "Gouvernementalité algorithmique et perspectives d'émancipation: Le disparate comme condition d'individuation par la relation? Politique des algorithmes. Les métriques du web," *Réseaux* 31, no. 177 (2013); David M. Berry, *Critical Theory and the Digital* (New York: Bloomsbury, 2014); Tarleton Gillespie, Pablo J. Boczkowski, and Kirsten A. Foot, *Media Technologies: Essays on Communication, Materiality, and Society* (Cambridge, MA: MIT Press, 2014); Louise Amoore and Volha Piotukh, *Algorithmic Life: Calculative Devices in the Age of Big Data* (London: Routledge, 2016). Bernhard Rieder's article on the PageRank algorithm of Google is a rare and welcome exception in this literature. It is actually an analysis of an algorithm. See Bernhard Rieder, "What Is in Pagerank? A Historical and Conceptual Investigation of a Recursive Status Index," *Computational Culture: A Journal of Software Studies*, no. 3 (September 28, 2012), http://computationalculture.net/what_is_in_pagerank/.

4. Donald Ervin Knuth, "Section 1.3: MIX," in *The Art of Computer Programming*, vol. 1.

5. Donald Ervin Knuth, *The Art of Computer Programming*, fasc. 1, *MMIX* (Reading, MA: Addison-Wesley, 1999).

6. Knuth wrote:

Algorithms are concepts which have existence apart from any programming language.... I believe algorithms were present long before Turing et al. formulated them, just as the concept of the number "two" was in existence long before the writers of first grade textbooks and other mathematical logicians gave it a certain precise definition.... A computational method comprises a set Q (finite or infinite) of "states," containing a subset X of "inputs" and a subset Y of "outputs"; and a function F from Q into itself. (These quantities are

The Cybernetic Hypothesis

*I*ntrospection is often necessary in academic work, not simply concerning the objects of the mind but also the actual manner in which intellectual work is done. This typically comes under the heading of methodology. Yet the meaning of methodology is not always clear, particularly within the so-called theory disciplines that span Marxism, feminism, poststructuralism, psychoanalysis, and related fields. Some prefer the self-serving and somewhat vain conviction that theory and methodology are one and the same pursuit. Hence “doing theory” would seem to preempt the thorny exercise of methodological introspection, rendering it moot. Why speak of method when theory is nothing but method? Why worry about other tasks when theory is king?

Yet the reality of higher education contradicts such pat conclusions. In fact, academic halls are teeming with a vast array of different research methods, from the positivistic expediency of quantitative investigation, to the staging of ethnographic interviews, to the narrative reductions of historiography, to the various instrumentalized strains of hermeneutics such as the Marxist reading, the feminist reading, or the psychoanalytic reading.

In other words, methodology today has a distinctly liberal profile. For every taste, there is a method to match. For every predilection, there is a satisfaction to be had. In order to be successful today, a student or scholar must internalize the many options and enact them appropriately given the task at hand; this method for that problem, followed by a new method for the next. In this sense, methodology today is often more a question of appropriateness than existential fit, more a question of personal style than universal context, more a question of pragmatism than unwavering conviction.

But appropriateness is a thorny business, and not everyone agrees on matters of taste. Many methodological discussions devolve into a sort of popularity contest. Who advocates what method and for what purpose? Which general equivalent trumps all others? Is it sexuality, or is it class, or is it the *logos*, the archive, the gaze, desire, play, excess, singularity, resistance, or perhaps life itself, elevating one methodological formation above all others in a triumphant critique (to end all future critique)?

A contradiction thus emerges: the historical forces that generate liberal ecumenicalism are the same forces that strive to canalize and entrain such heterogeneity under a single symbolic order. The liberal profile of contemporary scholarly methodology is thus a kind of method-effect in which diversity of method is simultaneously asserted and withheld.

The situation is even more puzzling, however, as many humanities disciplines have in recent years marked a shift away from qualitative methods, as diverse and multitudinous as they are, in favor of more quantitative and empirical research techniques. In an apparent rebuff to methodological ecumenicalism, the positivistic expediency of quantitative research has tended to outflank other methods within Western modernity, as today's debate around digital humanities again makes clear. Appeals to empirical verification, to the reduction of complexity into simplicity, to the principles of repeatability and objectivity, to the sequential logic of the syllogism or the deductive argument—appeals, in short, to the paradigm of Enlightenment reason handed down since the Baroque turn of Descartes, Kepler, Galileo, and Leibniz—have gradually edged out all the others. A liberal array of possibilities galvanized to a single methodological tendency—but why, and how?

Perhaps the very question of method refers to that moment in history when knowledge becomes production, when knowledge loses its absolute claims to immanent efficacy, when knowledge ceases being intuitive and must be legitimized via recourse to some kind of metadiscourse. The ability to speak authoritatively is not a newfound right bestowed on humanity in the modern period, as recounted in the various narratives

around triumphant secularism, the death of God, and the rise of reason. Today, such authority is precisely the thing corrupted and debased into all manner of intellectual haggling. Method is already fragmented when it arrives; the apotheosis comes later.

So to observe that quantitative, rationalistic methods became dominant is not simply to claim that scientific positivism won the battle of wits, having transformed the nature of knowledge production and truth since the early modern period. It is also something else, for the liberal iteration of methodologies (in the plural) is itself a method-effect. The liberal iteration is precisely the only flavor available to anyone subscribing to the cult of scientific positivism in the first place.

What other mode could possibly be as efficient as pure suitability itself, pure individual appropriateness, the raw granularity of every body satiated by its own unique specificity? As with post-Fordism, what results is a field of infinite customization, where each thinker has a method tailored to his or her preferences. Such capacious liberalism takes great pride in the fact that no single methodological authority can ever truly be triumphant, whether that authority be God, *jouissance*, pragmatic reasonableness, or positivistic verifiability. In other words, even in the face of the seeming liberal fragmentation of the many methodologies, such liberalism nevertheless simultaneously enshrines the law of positivistic efficiency, for what could be more efficient than infinite customization? What better way to wrangle this rainbow coalition than to grant everyone in it the freedom to do what he or she will? Standardize the world and kill the spirit, but empower difference and the individual is unchained. In short, under post-Fordism, liberal ecumenicalism and positivistic efficiency share a special relationship.

For cultural workers, this presents something of a problem. The triumph of quantitative methods seems to devalue and exclude much of what cultural workers do. And the reverse is true as well, since many cultural workers often see little point in positivistic pursuits, regularly writing them off as wrongheaded, soulless, or myopic. Faced with such crises of method, some cultural workers prefer to withdraw into a more rigorous critical practice, not, as their detractors might claim, to cling to some sense of cloistered security granted to the armchair philosopher, but because of the newfound perspective gained from thinking in a way that is asymmetrical to the current state of affairs.

Yet humanists pursuing quantitative research methods face an additional challenge, for today's corporate titans consist of little more than highly evolved modes of quantitative research. An Internet search company's

page rank algorithm taps into a mass of intellectual labor performed in the field. It supplements this laboring mass with its own intellectual labor, the labor of data extraction, storage, and processing. So in many cases, what used to be intellectual work is now industrial work. When using quantitative methodologies in the academy (spidering, sampling, surveying, parsing, and processing), one must compete broadly with the sorts of media enterprises at work in the contemporary technology sector. A cultural worker who deploys such methods is little more than a lesser Amazon or a lesser Equifax.

A century ago, capital had a monopoly on the physical materiality of production. Now it has a monopoly on the immaterial sphere of informatic commerce. Industry has finally moved into the realm of intellectual labor, and by most reports it is excelling beyond all expectations. Many scholarly researchers must therefore face a startling fact: the corporate sector simply has far superior data reserves at its disposal. Thus, in the information society, the scholar of information will forever be trapped in a deficit of resources, playing catch-up behind the scads of mathematics PhDs on staff at Google. Never before in history have immaterial and informatic assets been so closely intertwined with capital.

But beyond the challenge of unequal talent and resources is the question of critical efficacy. Is it appropriate to deploy positivistic techniques against those self-same positivistic techniques? In a former time, such criticism would not have been valid or even necessary. Marx was writing against a system that laid no specific claims to the apparatus of knowledge production itself—even if it was fueled by a persistent and pernicious form of ideological misrecognition. Yet, today the state of affairs is entirely reversed. The new spirit of capitalism is found in brainwork, self-measurement and self-fashioning, perpetual critique and innovation, data creation and extraction. In short, doing capitalist work and doing intellectual work—of any variety, bourgeois or progressive—are more aligned today than they have ever been.⁴ Hence there appears something of a moral crisis concerning the very validity of scholarly methodologies. Such methods are at best underfunded and impotent cousins to the new algorithmic industries and at worst unknowing shills for that same system of canalization and debasement. The question is no longer “can we use the master’s tools to take down the master’s house?” Today the question is “can we still use our own tools now that the master has taken them up?”

Beyond simply asserting or describing the existence of a certain social, cultural, and economic paradigm, beyond simply moralizing about it or fomenting some kind of reinvigorated “hermeneutics of suspicion” fashioned to debunk it, I wish to shift tone and provide a more detailed picture of the contemporary landscape. How and when were the seeds of the digital universe planted? What are the historical conditions that had to be developed in order for the concept of the *digital humanities* to make sense? When and how did the creation and recombination of knowledge gain its distinctly liberal profile in which each thinker may pursue his or her own autonomous goals? Why would such an arrangement be beneficial for the extraction of surplus-value? The aim here is thus to explore the history of digital society in classic Foucauldian fashion, to explore some of the “conditions of possibility” for cybernetic society. Norbert Wiener invented the science of cybernetics, of course, but what conditions of possibility had to have been invented in years prior for him to be able to innovate? Claude Shannon put forth a new model of information science, but what conditions of possibility had to exist already for the world to be conceived as information in the first place? Thus I offer a slightly different history of cybernetics not to overturn the existing histories, but to extend and reorient them. This supplementary history starts earlier in the twentieth century (with important additional precedents in the nineteenth that we must skip for the moment) and continues to the present day, relying on sources drawn from media, culture, technology, and philosophy.

The basic argument I wish to propose here is that the liberal hue of contemporary methodology—with quantitative positivism serving as the “governor” of the rainbow coalition—is chiefly due to a single historical phenomenon that has taken place over roughly the last century. Taking a page from the French collective Tiqqun, we might label this historical phenomenon the *cybernetic hypothesis*. Such a hypothesis refers to a specific epistemological regime in which systems or networks combine both human and nonhuman agents in mutual communication and command. Along with the many related fields that parallel cybernetics—network sciences like ecology, systems theory, and graph theory; the sciences of economic decision such as game theory and rational choice theory; information science and signal processing; behaviorism, cognitivism, and the post-Freudian sciences of the subject—the cybernetic hypothesis has come to dominate the production and regulation of society and culture.² Tiqqun views the cybernetic hypothesis as a new kind of social management involving both human and nonhuman assets. “[A]t the end of the twentieth century the image of steering, that is

to say management, has become the primary metaphor to describe not only politics but all of human activity as well” (44).

Indeed, in the last few decades we have witnessed the fulfillment of the cybernetic hypothesis with the rise of computers and media in both academia and society at large. This has produced a number of contentious debates around the nature and culture of knowledge work. Perhaps the most active conversation concerns the status of hermeneutics and critique, or “what it means to read today.” Some assert that the turn toward computers and media destabilizes the typical way in which texts are read and interpreted.³ The discussion often hinges on the rise of digital media and the way in which it seems to destabilize the stalwart critical and interpretive techniques of reading. Some argue that digitality shifts the focus away from things like style, symbol, and allegory, and toward things like technique, materiality, and the archive. As Stephen Best and Sharon Marcus have recently argued, computers are “weak interpreters” that produce “more accurate knowledge about texts” and hence jibe well with a new kind of reader characterized by “minimal critical agency” (17). Franco Moretti’s argument in *Distant Reading* is similar: computers are useful readers because they improve empirical accuracy by performing kinds of research that are difficult for humans, such as reading vastly larger corpuses, identifying emergent phenomena via clustering algorithms, and mapping numerous data points spatially (fig. 1). Many of these scholarly exchanges are still quite active today, and among a number of important references I will merely cite Alan Liu’s thorough description of the current state of digital humanities (2013) and Elizabeth Weed’s response to Best and Marcus in defense of a certain kind of criticality (2012). Indeed, the present special issue of *differences* has been designed with precisely this debate in mind.

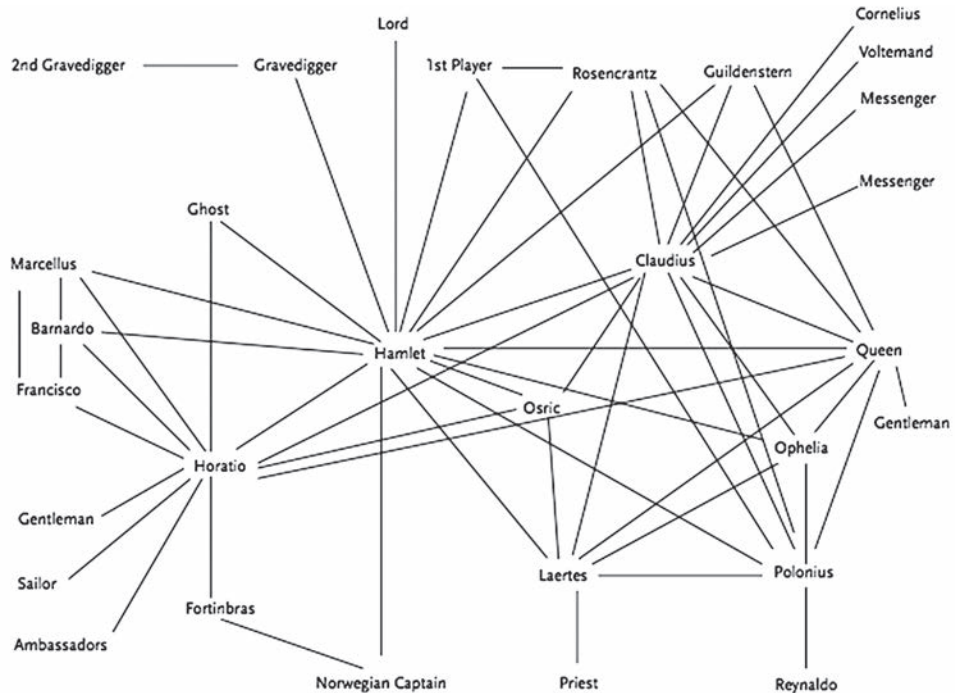
By labeling it a hypothesis, Tiquun meant to stress the provisional nature of cybernetics and the computational and media society it entails. They meant that cybernetics is a technological proposal and thus, like any experimental hypothesis, subject to ratification or indeed refutation. Like Tiquun, I also wish to historicize this digital universe, describing it less as our collective fate than as a series of specific shifts in the foundations of knowledge and culture.

The cybernetic hypothesis may be defined broadly or narrowly. In the most narrow sense, cybernetics comes from the work of Wiener and his important research in the years immediately following World War II.⁴ Yet in a more general sense, cybernetics refers to any kind of regulatory system in which human and nonhuman agents are connected in networks

Figure 1

Network graph illustrating character relationships in Shakespeare's *Hamlet*. Each character is displayed as a discrete entity within a network; characters are connected according to specific protocols such as whether or not they speak lines together on stage at the same time.

Source: Moretti 215



of control and communication. Because of this, cybernetics is often credited with inaugurating a particular historical relationship between subject and world. Specifically, cybernetics refashions the world as a *system* and refashions the subject as an *agent*.

A system is an aggregation of things brought together to form a complex whole. Cybernetics aims to view the world as one or more systems. The systems may be arranged and linked laterally or stacked orthogonally as system, subsystem, and super system. Here I will assume a network model for systems, meaning an architecture of nodes and links in which interaction and communication may pass from one point in the system to another. Indeed, an important characteristic of cybernetic systems is an internal message loop in which messages originating within the system also effect the operation of the system. This results in dynamic change, and, as a result, systems use feedback in order to mitigate imbalance and pursue homeostasis. Given their overall complexity, cybernetic systems also require a high level of control. Thus such systems require a subsidiary mechanism for overall organization and management. Given these qualities, systems are also best understood as “algorithmic,” which is to say operational or executable rather than static or descriptive, in that they prescribe a set of possible

behaviors and then facilitate the step-by-step execution of those behaviors according to dynamic variables originating from within the system.

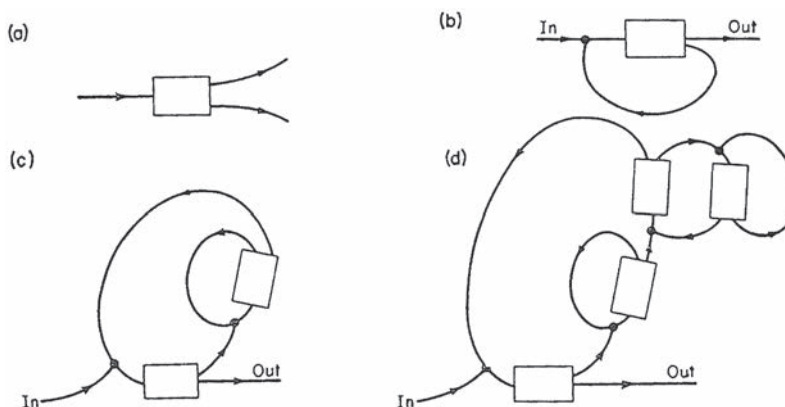
An agent is an entity capable of carrying out an action. Cybernetics assumes that an agent may be either animal or machine, human or nonhuman. Thus an aircraft pilot may be an agent, but so too are the dials and controls in the cockpit, since they carry out the actions of collecting and distributing vital information such as altitude and speed. Together the pilot and the aircraft form a cybernetic system. Agents in such systems are assumed to be autonomous to themselves and arranged on “equal footing” vis-à-vis the system as a whole. What this means is that, while agents may be wildly different in their relative size and power, each agent is endowed with the power of local decision according to the variables and functions within its own local scope. Thus while the pilot and instruments are not equal in power or type, they interoperate as equal peers to the extent that each may accommodate inputs and outputs and each may influence the outcome of the overall system. Agents are thus understood as more or less autonomous and equal at the level of their systematicity. In fact, agents are nothing more than subsystems within the super system. Given the existence of multiple agents, systems also display the quality of self-organization, meaning that no external metaphysics defines or dictates the behavior of the system. Systems are thus self-determining and rely on a high degree of reflexivity and self-referentiality in order to work properly.

This kind of agent infrastructure produces a few important results, the first having to do with the agents themselves, and the second having to do with the kind of messages that flow between them. First, while cybernetic systems do not require digital message encoding per se (analog signals work just fine in a thermostat, for example), such systems are digital at the level of infrastructure due to a necessarily atomistic architecture. Like the lines and boxes on a flow chart, discrete entities are separated by communications links (fig. 2). This is sometimes called an object-oriented infrastructure because it describes a system of objects (of whatever kind) that may connect or communicate. It results in a regular, discrete structure—similar to crystals—in which cells function like black boxes and interact diagrammatically rather than hierarchically.

Second, it is necessary to consider the messages themselves that propagate through cybernetic systems, not simply the agents that send them. Cybernetic systems are understood in terms of the sending, receiving, and processing of information. And such information is by definition highly encoded so that it may propagate and interface with agents in

Figure 2

Illustration from the Herman H. Goldstine and John von Neumann paper “Planning and Coding Problems for an Electronic Computing Instrument” (1947), an influential 1947 text that helped solidify conventions in computation and programming around principles of systematicity, diagrammatic flow, and encapsulation or “black boxing.”



predictable ways. At the same time, such information is often uncoupled from a human observer, given that information may be gathered, processed, and re-sent by instruments regardless of human intervention. Thus, just like the agents within the system, information also gains a relative autonomy when deployed within a cybernetic environment because it may directly effect certain outcomes without the intervention of a human actor.

The words *media* and *cybernetics* are not synonyms, of course, despite the insinuations thus far. And one should acknowledge the important technical and sociohistorical distinctions that separate the two terms. Yet it is clear that, considered in the most general sense, cybernetics treats the world as if it were a system of mediation. Where metaphysics deals with the bilateral expressions of essence and instance, cybernetics assumes a baseline multilateralism across broad swaths of different instances interacting and influencing one another. Where phenomenology addresses itself to the relationship between subject and world, cybernetics concerns itself with systems of multiple agents communicating and influencing one another. Thus, the cybernetic hypothesis begins from the elemental assumption that everything is a system of mediation.

But where did the cybernetic hypothesis come from? What are the historical conditions of possibility that gave rise to it? Without duplicating the important work of historians and critics like Katherine Hayles or Lily Kay, I wish to revisit a couple of moments from the history of computation and cybernetics in order to shed more light on the present conjuncture. By returning to the work of Lewis Richardson, Warren Weaver, John von Neumann, and Paul Otlet, I hope to show the emergence of a new conception of society and culture, one that revolves around three basic trends: 1) an *atomist's* conception of the world as an array of discrete entities; 2) an

occasionalist's conception of a pervasive media apparatus to interconnect these many entities; and 3) a *royalist's* conception of a sovereign or regulatory function necessary to manage and administrate the system as a whole.

Crystalline Space

In 1922, through what he labeled a strictly “numerical process,” the English mathematician Lewis Richardson proposed a massive chess game to span the continents, a system to predict weather via a cellular space of distributed meteorological sensors (fig. 3). He used the term *lattice* to describe this new device, borrowing a word from crystallography. Then, making a dramatic conceptual leap that would later influence John von Neumann and the science of cellular automata, Richardson proposed that these many sprawling intercontinental cells coordinate to form a single computational system.

[W]e take a piece of paper ruled in large squares, like a chess-board, and let it represent a map. The lines forming the squares are taken as meridians and parallels of longitude—an unusual thing in map projection. Next, we lay down the convention that all numbers written inside a square relate to the latitude and longitude of its center. [. . .] It is seen that pressure and momentum alternate in a pattern, which is such that, if a chessboard had been used, the pressures would all appear on the red squares, and the momenta all on the white ones, or vice versa. (Richardson 5)

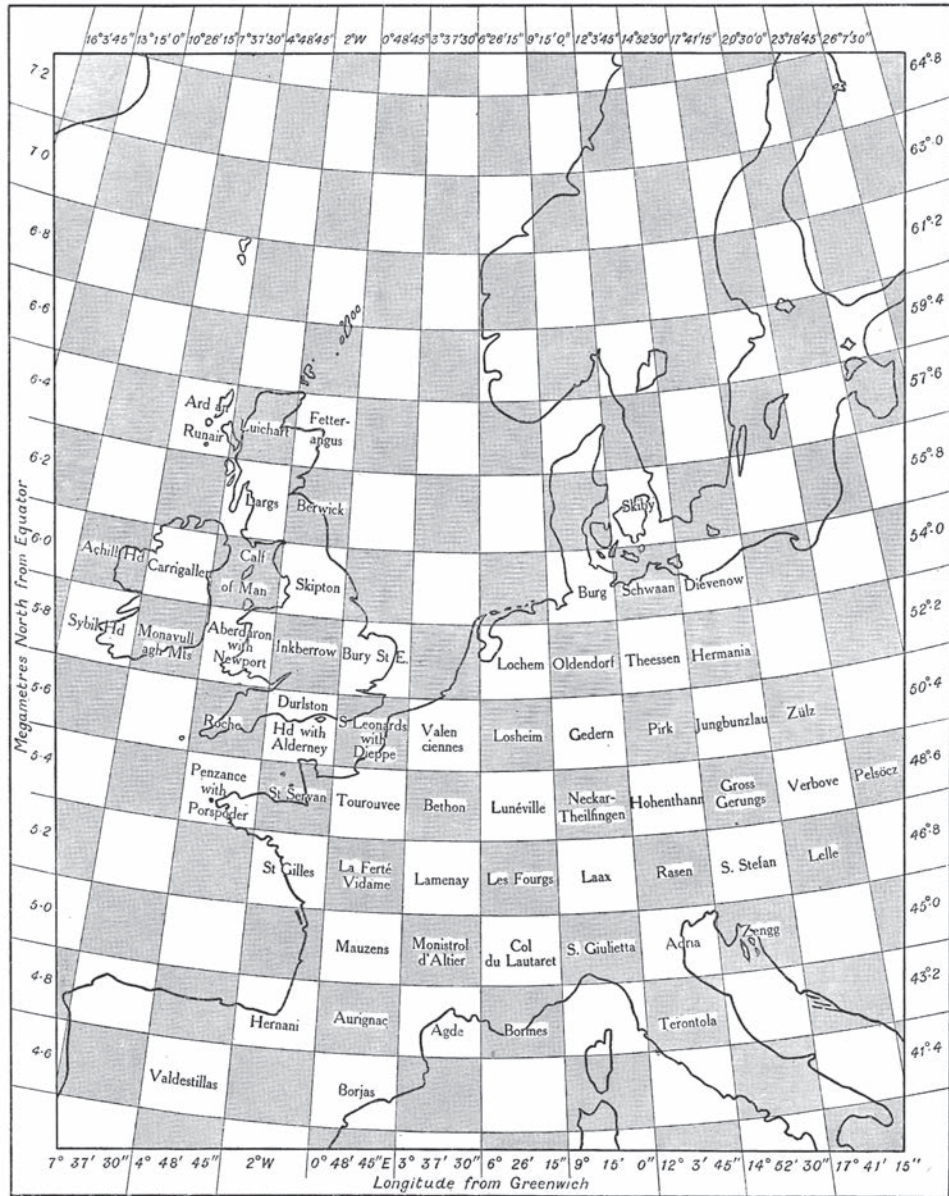
The computational framework extends vertically too, rising through four distinct atmospheric layers.⁵

His language is that of complex and nonlinear systems, borrowed, in particular, from thermodynamics. It is the language of eddy movements, laminar stresses, air viscosity, turbulence, heat flows, and conductivity. Using the same discourse that would later influence theorists like Gilles Deleuze and Félix Guattari, Richardson includes a whole section on “heterogeneity” and speaks in terms of the “molecular” and “molar” levels. He discusses the complexity of interactions between layers and the turbulence that results. Then, with a wink, Richardson adds a little rhyme to help remember it all: “We realize thus that: big whirls have little whirls that feed on their velocity, and little whirls have lesser whirls and so on to viscosity” (66).

Figure 3

"An arrangement of meteorological stations designed to fit with the chief mechanical properties of the atmosphere. Other considerations have been here disregarded. Pressure to be observed at the centre of each shaded chequer, velocity at the centre of each white chequer."

Source: Richardson frontispiece.



Simply overlaying a grid on a map is not the attraction of Richardson's system for the present investigation. For in Richardson's case the grid is not primarily a spatial technology. In fact while the grid exists in an entirely abstract geometric space oblivious to national borders or geographic features, as does the system of latitude and longitude, it is, more importantly,

a *latticework of parallel calculation*. Each square is represented by a number that feeds into an overall algorithm for modeling atmospheric phenomena.

As the cyberneticists would later discover, the establishment of this kind of lattice or crystalline space requires the encapsulation and obfuscation of each individual crystalline cell, a technique that scientists call “black boxing.” The phenomenon is quite evident in Richardson even though he was researching and writing several years prior to the invention of cybernetics proper. With each square represented by a single number located on the map at the coordinates of its center, the square is effectively black boxed. No subsquare information is necessary in Richardson’s system. Once the lower bounds of the grid’s granularity are determined, each cell essentially becomes an atom: uncuttable, impenetrable, and invisible. Its functionality is purely an outward relation to the lattice as a whole, never inward toward any kind of microcosm or interiority. In today’s parlance, the cell has a “surface” or “interface” that may be read, yet any sort of deeper investigation beyond the interface is unnecessary.

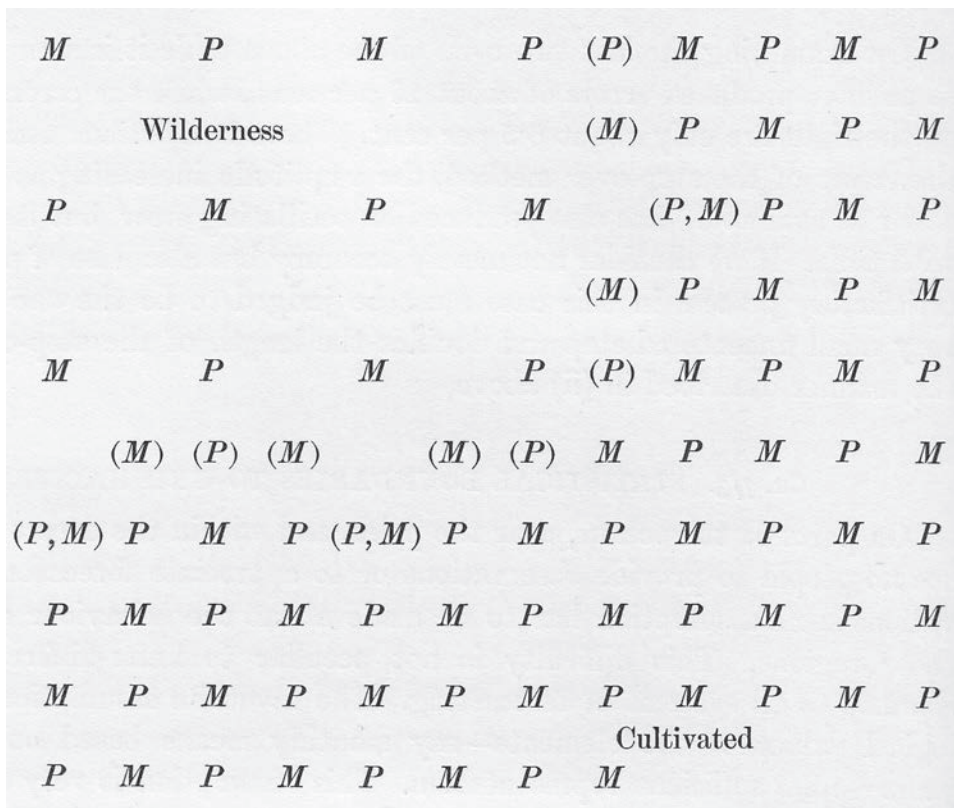
Richardson proposed to test his system by way of pen and paper calculations. “Let us now illustrate and test the proposals of the foregoing chapters by applying them to a definite case supplied by Nature and measured in one of the most complete sets of observations on record” (181). His goal was to reproduce the same framework that was empirically measurable, or in his words, to enact a “lattice-reproducing process.” “The initial data are arranged in a pattern which, by borrowing a term from crystallography, we may call a ‘space-lattice.’ Wherever in the lattice a pressure was given, there the numerical process must yield a pressure. And so for all the other meteorological elements. Such a numerical process will be referred to as a ‘lattice-reproducing process’” (156). In this way, Richardson’s “process” is a kind of writing system in which multiple cells are written in parallel based on a set of complex nonlinear computations. In essence, his goal was to inscribe, in parallel, a matrix framework that corresponds to actually observed measurements.

But Richardson was also aware that his lattice would necessarily be internally complex, that it would require bringing together heterogeneous elements. He referred to this as variations in the “density” of the lattice (fig. 4). Just as an open ocean or a remote wilderness would likely have fewer meteorological sensors, the grid in that zone would have to be spaced wider apart, whereas a heavily populated part of the land mass would have a surplus of sensors and therefore a tightly interwoven framework. Grid systems of course do not breed consistency and equality, as is often

Figure 4

Map showing weather pressure (P) and momentum (M) spanning the interface between a sparsely inhabited sector marked “wilderness” and a densely inhabited sector marked “cultivated.”

Source: Richardson
154



erroneously thought. Grid systems are technologies of structured inequality. So, reflecting the so-called asymmetry principle of networks—the principle that networks are always internally asymmetrical—Richardson developed a technique for dealing with unequal density resolutions that by necessity must be “interfaced” or integrated into the same overall map. He called these thresholds “joints.” Such joints must be established between the low resolution zones of the wilderness or the open ocean and the high resolution zones of the cultivated areas and the land masses (as opposed to the sea). This is not dissimilar to the way in which a digital communication network will interface high-volume “backbone” channels with low-volume “capillary” channels.

On parts of the oceans, near the poles, and within the desert tracts of land there are no people to provide observations or to appreciate forecasts. [. . .] [T]here are other portions of the globe, especially the seas, where some rough sort of forecast might be possible and desirable if it could be carried out with a much opener

network than that in use where population is dense. But the two networks must be united on the computing forms in such a way that air, represented by numbers, can flow across the joint. (133)⁶

The cybernetic hypothesis is thus already evident in Richardson's work in the 1920s: the atomistic arrangement of a system of cells; the interconnection of such cells into coordinated action (be it computational or otherwise); and the robust management of differing and heterogeneous densities across the system as a whole.

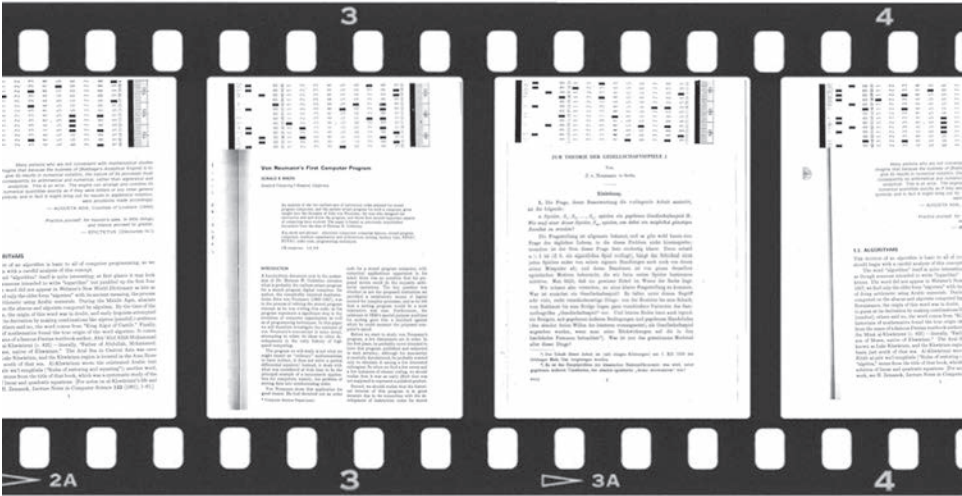
A Regular Discrete Framework

In early 1940, Warren Weaver and John von Neumann exchanged letters discussing a hypothetical invention that would use film photography to organize an archive of mathematical articles. The goal of the device was "the coding of mathematical literature and the application of a photographic high speed selection process to hunt out all of the mathematical literature bearing on a certain topic" (29 Mar. 1940). A run-of-the-mill digital humanities project by today's standards, Weaver's proposal was unusual for the time. Here is the device as envisioned by Weaver:

Suppose that someone has photographed, on very long strips of movie film, abstracts of all the mathematical articles which have appeared since, say, 1900. Each abstract might require one exposure of "frame" of the film; and in the margin of the film there would be recorded a complex code symbol which, according to some flexible system, characterizes the nature of the article. A research mathematician might be interested in locating all the articles which treat (or indirectly bear on) some certain topic. He appeals to the library or other organization which has the above-mentioned film record. This film is placed in a machine, the operator adjusts the machine so that it will select only those abstracts which (making use of the code symbols) treat of or bear on the topic in question. The film is run through this machine with extreme rapidity (1,000 frames or abstracts a second, say) and the machine automatically photographs these desired abstracts and passes the others by. Thus in an incredibly brief time each individual abstract is, so to speak, examined for its possible interest to this particular mathematician and problem, and the ones really of interest are photographed and delivered to the person making

Figure 5
A hypothetical recreation of what Warren Weaver’s “bibliographic aid in mathematical research” might have looked like.

Credit: Alexander R. Galloway



the inquiry. With this complete list of abstracts in his possession, it is presumed that he would look them up, if he is located near a suitably extensive library, or would make further use of film procedures by sending to some central bureau for photographic copies of the articles. (31 Jan. 1940)

Weaver’s proposal, which he mailed simultaneously to a number of colleagues in addition to von Neumann, predates by five years a similar device proposed by Vannevar Bush in a famous article from 1945.⁷ The implications of Weaver’s proposal are quite stunning. Both Weaver and von Neumann were influenced by what we might call the Turing paradigm for information machines, which is to say the notion that the best way to process data is by way of a long strip of tape fed through a central machine.⁸ “What is an automaton in the Post-Turing sense? It is one of the proverbial ‘black boxes’ which has a finite number of states which we may number 1, 2, . . . , *n*. [. . .] The change [in state] takes place by an interaction with the world outside the automaton which is considered as being a tape” (Goldstine 274). Here the “tape” comes in the form of movie film (fig. 5). But while the strips of film were linear in nature, the user of such a device would be able to follow threads through the archive in a nonlinear fashion: the researcher “proceeds to follow this thread wherever it leads him,” wrote Weaver in a follow-up note to von Neumann. “[T]his thread frequently cuts across all pre-existing lines of subject classification” (29 Mar. 1940).

Such microfiche databases had been proposed before, perhaps most vividly by Paul Otlet around the turn of the twentieth century. Otlet,

a Belgian lawyer and the inventor of the universal decimal classification system (which he hoped would alleviate some of the shortcomings of Dewey's system), was an innovator in the area of library and archival science. A utopian and global thinker, Otlet organized the International Institute of Bibliography in 1895, which aimed to synthesize all the different systems that existed for classifying the printed word. "By 1900 there were some 17 million cards organized along the lines of Melvil Dewey's system [. . .]. By 1908 Otlet had floated the notion of a [*sic*] international central library, with support of some 200 organizations. By 1910 he had held the first meeting of the World Congress on Bibliography" (Katz 327).

Around that same period, circa 1906–7, Otlet developed, with Robert Goldschmidt, a "projected book" called the *bibliophote*, a coinage combining the terms *biblio* (book) and *photography* (Levie 107). As in the subsequent proposals by Weaver and Bush, Otlet's bibliophote was a system for photographing books and then reproducing them via projection. The technique of microphotography was already known at the time and had, in fact, been used during the siege of Paris in 1870, when thousands of letters were reproduced in miniature on film and sent via carrier pigeon, as depicted in a famous painting hanging in the Musée Carnavalet in Paris. Otlet's innovation was simply the scale of his ambition, as he sought to unify the totality of all human knowledge, photographed and filed and easy to access. With the bibliophote as building block and in a culmination of his life's work, having enlisted Le Corbusier as chief architect and Nobel Peace Prize laureate Henri La Fontaine as collaborator, Otlet launched an ambitious initiative in 1910 called the *Mundaneum*, which although never realized was designed as a home for all the world's knowledge, classified and archived inside a massive library facility to be located on the shores of Lake Geneva (fig. 6). "Humanity has arrived today at the stage of globalization," he pronounced (Otlet and Le Corbusier 2).

Weaver's own "digital humanities" project was of course much more modest in scale yet, at the same time, more immediately realizable. Contrary to the conventions of cinematic film production, which aims to fuse successive frames together in linear sequence to achieve the illusion of movement, Weaver's proposal leveraged the inherently digital nature of film's discrete framework of successive frames to assemble a miniature archive that could be processed rapidly by computer (see fig. 5). There was to be no mediatic continuity between each cell in Weaver's film; continuity was to be achieved in other ways, via the recombination of cellular units into

- photography for storage, and rephotography for retrieval;⁹
- associative browsing of subject themes.

Weaver's "complex code symbols" are also notable. Guiding both the addressing and classification of each database entry, Weaver provided a kind of metalayer of pointers into this memory heap. One can assume that the system would have worked much like Herman Hollerith's tabulator and sorter, with binary holes designating different classification headings. All photographic cells marked with an appropriate dot in the "nonlinear differential equations" box would be rephotographed and returned in response to a query of that nature, and so on, just as Hollerith's punch cards contained boxes for the different census categories. So the logic of classification is also a logic of selection. Putting all this together, Weaver envisioned a device that would make it more efficient to locate material in the archive, that would assist the researcher in his or her inferences, that would open up inductive and associative pathways through information, and that would in fact be disruptive of existing classification systems, placing the individual intellect at the heart of the informatic system.

Weaver fretted over a few things. Could it be built? Would his peers want to use it? And, ultimately more important, how could a coding scheme be flexible enough to describe all the nuances of each article accurately? How could stored articles be made forward compatible if the coding schema ever needed to be updated? The solution was found in the coding scheme itself: he advised von Neumann to use "at least 12" symbols, because that amount of combinatory latitude would certainly afford "a complete functional characterization" of the text in question (31 Jan. 1940).

Although Weaver's "bibliographic aid" was never built, it stands as a useful signpost for the new media systems being invented during and after World War II. It aggregates a whole series of techniques and approaches that would rise in importance in the second half of the twentieth century. Summarizing from this brief discussion of Richardson, Weaver, von Neumann, and Otlet, these techniques and approaches include:

- an epistemology rooted in arrays or systems containing discrete entities;
- the division of each entity into system and subsystem, in which the subsystem is encapsulated and obfuscated (or "black boxed");
- the opening of specific codified interfaces for each entity;
- the superimposition of a mediative layer to interconnect each entity in the system (via the entity's interface);

- the regularization of difference or asymmetry within the apparatus itself, be it semiotic asymmetry (index/content) or functional symmetry (command/execution).

These are some of the characteristics of the cybernetic hypothesis. The historical examples just offered are certainly not the only stories that could be told. They should not supplant existing histories and genealogies of cybernetic society or preclude newer discoveries from being made. I offer them as short historical snapshots of the general regime of the cybernetic hypothesis, as a way both to widen the historical window beyond the conventional locus of 1947–48 and to introduce a set of references that explicitly ties the cybernetic hypothesis to contemporary literary and humanities research. In other words, I view the cybernetic hypothesis not as a more or less neutral development merely limited to a few small scientific fields, but as a broad social and cultural ethos with influence across a number of fields and practices. From this perspective, recent developments in digital humanities appear not so much as radical or bold new innovations, but as a natural evolution stemming from several decades of historical momentum, a final period at the end of a very long sentence.

Problems and Proposals

The debate over digital humanities is thus properly framed as a debate not simply over this or that research methodology but over a general regime of knowledge going back several decades at least. Given what we have established thus far—that digital methods are at best a benign part of the zeitgeist and at worst a promulgation of late twentieth-century computationalism—let me end by itemizing a series of problems and challenges that anyone partaking in digital methods must consider.

Hegemony, Recapitulation, and Symmetry

Given the hegemonic status of computers in contemporary life—a position endorsed by everyone from Kevin Kelly and Thomas Friedman to Manuel Castells and Michael Hardt and Antonio Negri—to propose computer-centric research methodologies is to propose that the humanities follow a trend toward normalization with the dominant rather than of differentiation from it. This will present a problem to certain intellectual endeavors that value deviation over normalization, heterodoxy over orthodoxy.

Moreover, the problem of hegemony is not simply limited to a hierarchy of domination and subordination. It also implicates the types of utterances that are made within such a hierarchy, particularly whether or not certain claims about knowledge or reality are recapitulative or critical of the hegemonic position. The nature and role of criticism is at the heart of contemporary debates over the digital humanities, as many wonder if criticism is still necessary and interpretation still valid. It is thus obligatory to identify the changing fortunes of critique as a specific shift in the relative value of recapitulative versus contestational claims.

Given the problems of hegemony and recapitulation, we must also ask whether the role of humanities research is to be a symmetrical mirror of trends in larger society or an asymmetrical rethinking of those larger trends. When the social and economic infrastructure is structured in such and such a way, is it the role of humanities researchers to redesign their discipline so that it is symmetrical with that infrastructure? Google views society as a network of value-producing agents (whose unpaid labor generates immense profits); is it, then, the role of university English departments also to propose that society is a network of value-producing agents? Object-oriented computer languages propose that entities can be abstracted into “objects” with codified interfaces that perform certain measurable functions; is it, then, necessary for literary researchers to view novels or poems as objects with codified interfaces that perform certain measurable functions? The issue here is not simply recapitulation (speaking the same or speaking different), but a structure of symmetry versus asymmetry (the propagation and extension of regular structure).

Whether or not critique remains viable, we must still ponder the original Kantian question: is thought as such dictated by the regularity of an inherited structure, or is thought only possible by virtue of an asymmetrical and autopoitional posture vis-à-vis the object of contemplation? Having inherited the computer, are we obligated to think with it?

Ideology, Deskilling, and Proletarianization

A second cluster of terms reveals a different challenge faced by the digital humanities. Call it the *Zuhandenheit* problem: we live within the cybernetic universe without necessarily being conscious of it and we use these digital tools without necessarily reflecting on them. Of course, the naturalization of tools can be good and useful in certain contexts, and literature and art are admittedly inseparable from *techné* at a more fundamental level. But

the naturalization of technology has reached unprecedented levels with the advent of digital machines. Nature likes to hide itself, and it's no different with computers. One must be dispassionate about this infrastructure of obfuscation, identifying when and how it is beneficial and when and how it is not.

Ever since Kant and Marx inaugurated the modern regime of critical thought, a single notion has united the various discussions around criticality: critique is foe to ideology (or, in Kant's case, not so much ideology as dogma). Hence a new challenge to the digital humanities: if there is indeed an increase in naturalization and a corresponding decrease in criticality, does this entail a concomitant rise in the power of ideology? Digital methods tend to naturalize the process of data discovery. Do they also at the same time embolden an ideological infrastructure?

Yet, beyond these more heady inquiries into the relative validity of knowledge, a more prosaic challenge also appears: the deskilling problem, or what Best and Marcus call the "minimization of agency" (17). The digital humanities assume certain things about human subjects. While seeming to embed scholars and students more firmly in data, digital tools tend to do the opposite. Highly codified interfaces reduce the spectrum of possible input to a few keywords or algorithmic parameters. Those who were formerly scholars or experts in a certain area are now recast as mere tool users beholden to the affordances of the tool—while students spend ever more time mastering menus and buttons, becoming literate in a digital device rather than a literary corpus.

Thus while Best and Marcus praise the minimization of agency—a spectacular reversal from the 1980s and 1990s when agency was all the rage in theoretical circles—we might be wise to acknowledge the "dark side" of a dissipated human agency. Low-agency scholars are deskilled scholars, proletarianized thinkers denuded of their authority to make claims (at least claims that haven't been culled directly from a measurement device). Low-agency scholars are adjunct workers with precarious economic roles to play in the university, their standing diminished relative to the increased power of academic administrators, presidents, chancellors, and trustees. Critique is foe to ideology, but, particularly in Marx's case, critique is also a necessary technique for revealing the conditions of proletarianization. As the Marxist tradition has persuasively demonstrated, capital itself thrives most when the proletariat identifies positively with the very structure of its own debasement.¹⁰ Thus the tools and trinkets we find so seductive, digital or otherwise, are the same devices that fragment and reorganize social life around specific economic mandates.

What I hope to suggest with these challenges and provocations is not so much a doom and gloom view of digital humanities, but rather a sober assessment of the problems faced by the academy and a view, provisional at best, of the kinds of solutions that might be possible. Scholars must make their own assessments of the challenges posed by digital humanities. How does the advent of the computer change humanistic research? How will it be possible to use computers while avoiding the difficulties just itemized, the epistemological challenges around hegemony, recapitulation, and symmetry and the more political challenges of ideology, deskilling, and proletarianization? Speaking as a programmer who has been writing and releasing software for several years both within and without the research context, I hope to ally myself with those innovating technical research methods, as they exist now and as they might exist in the future. Personally, my own efforts have followed a multimodal strategy of producing academic writing concurrent with software production, the goal of which being not to quarantine criticality, but rather to *unify* critical theory and digital media around the technique of allegory. Others will find an approach that is most appropriate to them.

This is not to advocate for some kind of rote digitization of the humanities, not to say that every child must be given a laptop. Few things will cripple the humanities more than the uncritical “adoption of tools” or the continued encroachment of positivistic research methods borrowed from cognitive science, neuroscience, computer science, or elsewhere. One should be very skeptical of the Googlization of the academy.¹¹

Rather, we might follow the lead of someone like Richard Rogers, with his Digital Methods research initiative, or the pioneering research techniques invented by artists like Natalie Jeremijenko or Trevor Paglen. These and other approaches exhibit the kind of creativity and care necessary for understanding and responding to the growing industrialization of mind and body.

As humanist scholars in the liberal arts, are we outgunned and outclassed by capital? Indeed we are—now more than ever. Yet as humanists we have access to something more important. We have access to what François Laruelle calls the “weak force” of persons in their generic humanity. The goal, then, is not to challenge the data miners at their own game, for we will always be underfunded and understaffed. The point is to withdraw from the game altogether and continue to pursue the very questions that technoscience has always bungled, beholden as it is to specific ideological and industrial mandates. The weak force grants us access to the generic

commonality of history and society and the various aesthetic and cultural phenomena that not only populate this history but, as its flesh and blood, are history itself.

ALEXANDER R. GALLOWAY is Associate Professor of Media, Culture, and Communication at New York University. His books include *The Interface Effect* (Polity, 2012), *Protocol: How Control Exists after Decentralization* (Massachusetts Institute of Technology Press, 2004), and *Gaming: Essays on Algorithmic Culture* (University of Minnesota Press, 2006).

Notes

- 1 For three spectacular yet rather different testimonials to this effect see Boltanski and Chiapello; Fraser; Liu, *Laws*.
- 2 A number of accounts have helped fill out this history, including Geoghegan; Turner.
- 3 For some of the basic contours of this debate, itself complex and divergent, see Best and Marcus; Latour; Love. The various discussions around “close reading,” “distant reading,” “surface reading,” and “descriptive reading” also clash and intermingle with the existing art historical discourse on close viewing and distant viewing, or what Aloïs Riegl called the tactile and optical qualities of art.
- 4 Norbert Wiener’s landmark text, *Cybernetics: Or Control and Communication in the Animal and the Machine*, was originally published in 1948.
- 5 Richardson elaborates:
It is desirable to have one conventional dividing surface at or near the natural boundary between the stratosphere and troposphere [. . .]. Secondly, that to represent the convergence of currents at the bottom of a cyclone and the divergence at the top, the troposphere must be divided into at least two layers. Thirdly, that the lowest kilometre is distinguished from all the others by the disturbance due to the ground. Thus it appears desirable to divide the atmosphere into not less than 4 layers. (16–17)
- 6 Richardson even goes so far as to work out the numbers for an optimal interface between these two unequal networks. “It is seen that the ninefold reduction gives a neater joint than the fourfold, in the sense that the latter involves more interpolations” (153). By experimenting with a ninefold or fourfold reduction, Richardson was discovering what numbers would fit best, in order to avoid “a violent change in the lattice” (155). Nevertheless, it should be noted that he was not advocating an overall reduction in the disparity of cellular density between differently classified zones. Thus the asymmetry principle that governs networked relations is demonstrated even here in embryonic form.
- 7 One might also compare Weaver’s device to the so-called Zuse palimpsest, the film stock used by Konrad Zuse to encode binary data for his z3 computer, completed in 1941. As Zuse recounts, “During the war I couldn’t get ordinary commercial punched-tape machines, which were then already in use in the telephone business for 5-track punched tape. I built my own punching and reading devices and used normal filmstrips—[Helmut] Schreyer’s idea. They were punched with a simple manual keypunch” (63). Of course

Zuse's filmstrips had no direct relationship to photography or cinema; the image on the filmstrip was unimportant, a mere trace of the medium's former life.

- 8 Such a paradigm has a much longer history, by way of Joseph Marie Jacquard's industrial weaving system at the dawn of the nineteenth century, which featured a strip of digitally encoded input (the "software") feeding into a central processing device (the "hardware"). Likewise, even Jacquard's loom had important antecedents in other looms made by Brösel circa 1680, Basile Bouchon in 1725, Jean Philippe Falcon in 1734, and other kinds of devices either built or proposed by Jacques de Vaucanson in 1750, not to mention some of the musical devices in Athanasius Kircher's *Musurgia Universalis* (1650).
- 9 The use of rephotography for retrieval might sound odd, yet in the 1940s, there were essentially no printers in existence, at least

not as we think of them today. A common technique for "printing" on early computers was to take a photograph of the computer's oscilloscope screen, assuming it had a screen at all, and then develop the photograph. So Weaver's suggestion that the "search results" would be rephotographed is in keeping with the media conventions of the time.

- 10 Jameson's "Reification and Utopia in Mass Culture" is an important touchstone in such a tradition.
- 11 My home institution, New York University, announced an agreement with Google in the fall of 2010 that migrated much of the university's data flow to Google Apps for Education, including e-mail, calendaring, document sharing, and collaboration tools. The recent revelation that Google has for several years been sharing its data stream with the National Security Agency only adds to the moral complexities of this type of industrial outsourcing.

Works Cited

- Best, Stephen, and Sharon Marcus. "Surface Reading: An Introduction." *Representations* 108 (2009): 1–21.
- Boltanski, Luc, and Ève Chiapello. *The New Spirit of Capitalism*. Trans. Gregory Elliott. London: Verso, 2005.
- Bush, Vannevar. "As We May Think." *Atlantic Monthly* July 1945: 101–8.
- Fraser, Nancy. *Fortunes of Feminism: From State-Managed Capitalism to Neoliberal Crisis*. London: Verso, 2013.
- Geoghegan, Bernard Dionysius. "From Information Theory to French Theory: Jakobson, Lévi-Strauss, and the Cybernetic Apparatus." *Critical Inquiry* 38 (2011): 96–126.
- Goldstine, Herman. *The Computer from Pascal to von Neumann*. Princeton: Princeton UP, 1972.
- Goldstine, Herman, and John von Neumann. "Planning and Coding Problems for an Electronic Computing Instrument, Part II, Volume 1." *Papers of John von Neumann on Computing and Computer Theory*. Ed. William Aspray and Arthur Burks. Cambridge: MIT P, 1987. 151–222.
- Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: U of Chicago P, 1999.
- Jameson, Fredric. "Reification and Utopia in Mass Culture." *Signatures of the Visible*. New York: Routledge, 1992. 9–34.

- Katz, Bill. *Cuneiform to Computer: A History of Reference Sources*. London: Scarecrow, 1998.
- Kay, Lily. *Who Wrote the Book of Life? A History of the Genetic Code*. Stanford: Stanford UP, 2000.
- Kircher, Athanasius. *Musurgia Universalis*. Rome, 1650.
- Laruelle, François. *Introduction aux sciences génériques*. Paris: Pétra, 2008.
- Latour, Bruno. "Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30.2 (Winter 2004): 225–48.
- Levie, Françoise. *L'Homme qui voulait classer le monde: Paul Otlet et le Mundaneum*. Bruxelles: Impressions Nouvelles, 2006.
- Liu, Alan. *The Laws of Cool: Knowledge Work and the Culture of Information*. Chicago: U of Chicago P, 2004.
- . "The Meaning of the Digital Humanities." *PMLA* 128.2 (2013): 409–23.
- Love, Heather. "Close but Not Deep: Literary Ethics and the Descriptive Turn." *New Literary History* 41 (2010): 371–91.
- Moretti, Franco. *Distant Reading*. London: Verso, 2013.
- Otlet, Paul, and Le Corbusier. *Mundaneum*. Brussels: Union des Associations Internationales, 1928.
- Otlet, Paul, et al. *Cent ans de l'Office international de bibliographie: 1895–1995*. Mons: Mundaneum, 1995.
- Richardson, Lewis. *Weather Prediction by Numerical Process*. Cambridge: Cambridge UP, 1922.
- Riegl, Aloïs. *Late Roman Art Industry*. Trans. Rolf Winkes. Rome: Bretschneider, 1985.
- Rogers, Richard. *Digital Methods*. Cambridge: MIT P, 2013.
- Shannon, Claude, and Warren Weaver. *The Mathematical Theory of Communication*. Champaign: U of Illinois P, 1971.
- Tiqqun. "L'Hypothèse cybernétique." *Tiqqun* 2 (2001): 40–83.
- Turing, Alan. "On Computable Numbers, with an Application to the *Entscheidungsproblem*." *Proceedings of the London Mathematical Society* 42 (1937): 230–65.
- Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: U of Chicago P, 2008.
- Weaver, Warren. Letter to John von Neumann. 31 Jan. 1940. ms. John von Neumann Papers. Library of Congress, Washington, DC.
- . Letter to John von Neumann. 29 Mar. 1940. ms. John von Neumann Papers. Library of Congress, Washington, DC.
- Weed, Elizabeth. "The Way We Read Now." *History of the Present: A Journal of Critical History* 2.1 (2012): 95–106.
- Wiener, Norbert. *Cybernetics: Or Control and Communication in the Animal and the Machine*. Cambridge: MIT P, 1965.
- Zuse, Konrad. *The Computer—My Life*. Berlin: Springer, 1984.

The Cultural Functions of Computation

THIS book is not about computers. It is instead about a set of widespread contemporary beliefs about computers—beliefs that can be hard to see as such because of their ubiquity and because of the power of computers themselves. More specifically, it is about the methods computers use to operate, methods referred to generally as *computation*. Computation—as metaphor, method, and organizing frame—occupies a privileged and under-analyzed role in our culture. Influential new concepts often emerge alongside technological shifts—they emerged alongside the shifts to steam power, electricity, and television, for example (see, e.g., Marvin 1988). Like enthusiasts during these other shifts, computer enthusiasts suggest that their bedrock principle is *the* one people need to use to resolve our most pressing social problems. To a greater degree than do some of those earlier concepts, computing overlaps with one of the most influential lines in the history of modern thought, namely the rationalist theory of mind. This may account in part for the strength of computing's influence in contemporary culture. I argue that the current vogue for computation takes this old belief system—that something like *rational calculation* might account for every part of the material world, and especially the social and mental worlds—and repurposes it in such a way so as to give every appearance of its being something very new.

This book foregrounds the roles played by the rhetoric of computation in our culture. I mean thereby to question not the development of computers

themselves but the emphasis on computers and computation that is widespread throughout almost every part of the social fabric. In this way, despite its critical orientation, I do not suggest that computers are useless, that we should discard them altogether, or (in the spirit of some recent popular commentators) that computers are destroying the fabric of expert reason and judgment on which our society supposedly rests. To the contrary: my concern is that belief in the power of computation—a set of beliefs I call here *computationalism*—underwrites and reinforces a surprisingly traditionalist conception of human being, society, and politics. In other registers, we might imagine these views to have long been abandoned, in large part because their faults as part of a total account of human being have been long ago demonstrated conclusively.

Like all the other things human beings build and discover, computers can only be understood productively when they are seen as part of the cultural and historical contexts out of which they emerge—when, to put it in a colloquial and potentially misleading manner, they are read like texts. The primary goal of such an investigation is not to understand computers, though it may have the effect of providing new analyses of them in context. The primary goal is to understand our own culture, in which computers play a significant but not decisive role. As such, the guiding argument of this book is not and cannot be that our society and human beings are in the process of being *fundamentally* transformed by computers, if by fundamentally we mean that we are becoming something categorically unlike ourselves as-we-are and as-we-have-ever-been—in Katherine Hayles’s (1999) term, “posthuman.” Of course, our society and human beings are changing, but they are also always changing. Change that is so fundamental as to redefine altogether what it is to be human and what it is to participate in a society therefore must be either that same kind of change to which we are always subject, or a kind of transcendence of the human lifeworld that arguably we cannot comprehend, because it is by definition beyond our human understanding.

Too often the rhetoric of computation, especially that associated with so-called new media, suggests that we are in the process of experiencing a radical historical break of just this millennial sort.¹ My bedrock conviction in this study is that whatever the range of historical and cultural difference may mean, it does not entitle us to posit such radical breaks lightly. Until and unless evidence to the contrary presents itself, and with reference to other significant and in their way world-changing technologies, we must assume that technological shifts are best seen as changes in degree and not in kind; that human beings remain what they are (however we decide to define such a vague concept), and that human societies, too, remain largely bound by much the same fundamental forces by which they have always been

characterized. In a time of the most extreme rhetoric of cultural change—which does not, at the same time, accompany a concomitant recognition of the possibilities for radical cultural difference—the need for resistance to the rhetoric of novelty seems especially pressing, not least when such claims are so often based on willful avoidance of the existence of analogous phenomena in the recent historical past. Networks, distributed communication, personal involvement in politics, and the geographically widespread sharing of information about the self and communities have been characteristic of human societies in every time and every place: a burden of this book is to resist the suggestion that they have emerged only with the rise of computers. In a familiar phrase whose import we sometimes seem on the verge of forgetting: the more things change, the more things stay the same.

The Circulation of Computational Discourse

This book focuses primarily on the ways in which the rhetoric of computation, and the belief-system associated with it, benefits and fits into established structures of institutional power. I investigate these benefits in two ways: first, by looking at those aspects of institutional power aided through belief in the superior utility of computerization as a form of social and political organization; second, by examining how the rhetoric of computerization circulates throughout our society, both inside of powerful institutions and outside of them, and then how that rhetoric entails beliefs about human subjectivity that endorse institutional power in a reciprocal manner. Because of its focus, this book is meant as a complement, rather than a direct contribution, to what is generally understood as the field of digital media studies. Computers and beliefs about them pervade our society through forms other than the ones usually designated by the term *media*; they are ubiquitous, playing vital roles in nearly every institution and nearly every product. “Digital media” names only a subset of the modes in which computers influence social formations; it must be the task of cultural criticism (as practiced by writers like Jameson 1981, 1991) to address all of these social forms and not confine itself to those that can legitimately be referred to as media.

I focus on the institutional effects of computing not merely to ensure that cultural criticism fully addresses our moment; rather, I am convinced both intellectually and experientially that computers have different effects and meanings when seen from the nodes of institutional power than from the ones they have when seen from other perspectives. If an unassailable slogan of the computing age is that “computers empower users,” the question I want to raise is not what happens when individuals are empowered in this

fashion (a question that has been widely treated in literature of many different sorts), but instead what happens when powerful institutions—corporations, governments, schools—embrace computationalism as a working philosophy. I am convinced that from the perspective of the individual, and maybe even from the perspective of informal social groups, the empowering effects of computerization appear (and may even be) largely salutary. But from the perspective of institutions, computerization has effects that we as citizens and individuals may find far more troubling. Here, computationalism often serves the ends of entrenched power despite being framed in terms of distributed power and democratic participation.

Too often, computers aid institutions in centralizing, demarcating, and concentrating power. It is not that individuals lack power to affect aspects of the computer system, or that new media art, hackers, and open source software are wholly ineffective; much the contrary is true. But it is a mistake to see these often beneficial effects as ameliorating the institutional effects of computerization, and it is also a mistake to give too much credence to the ways that the structures of capital and authority retreat in the face of relatively more democratic, resistant, and responsive public/individual uses of computers. A part of my argument is that this public existed well before the Internet did, and seeing public resistance too much in the context of computerization aligns too closely with the technological progressivism that conditions so much computational discourse.

Inside our existing institutions of power, computerization tends to be aligned with relatively authority-seeking, hierarchical, and often politically conservative forces—the forces that justify existing forms of power. This is true in academic disciplines (where it is especially visible in analytic philosophy, the subject of Chapter 3, and in linguistics, the subject of Chapter 4); it is true in corporations and the corporate monitoring and control of everyday life, including the worldwide spread of capital and accompanying surveillance known as globalization (Chapter 6); and it is true even in politics, despite the obvious utility of computers for communicating and political organizing (Chapters 8 and 9). It is those in power, and those who align themselves with existing structures of power, who are most often (but not exclusively) served by the advancement of computerization, and who make the fullest use of computers; it is they who endorse most fully the computational rhetoric and the computational beliefs that have become so widespread in our society. Following a line of criticism that extends at least as far back as Kant (at least on one interpretation of Kant's views), and that has recent avatars in figures as diverse as established scholars like Lewis Mumford (1934, 1964), Harold Innis (1950, 1951), Jacques Ellul (1964, 1980, 1990), Joseph Weizenbaum, Martin Heidegger, Norbert Wiener (1954,

1964), Terry Winograd, and Theodore Roszak (1986), and more recent writers like Langdon Winner (1977, 1988), Mark Poster (1990, 2000, 2006), Michael Adas, Philip Agre (1997), Christopher May (2002), Kevin Robins and Frank Webster (1999), Alison Adam, McKenzie Wark, Scott Lash (2002), Vincent Mosco, Dan Schiller, Lisa Nakamura, and others discussed below, I argue that computationalism meshes all too easily with the project of instrumental reason. Because of this commitment and its strength in our society, it seems problematic to put too much emphasis on computers in projects of social resistance, especially that kind of resistance that tries to raise questions about the nature of neoliberalism and what is (too often, disingenuously) referred to as free-market capitalism.

This book examines the ties between institutional power and the rhetoric of computationalism, in the hopes of helping to develop an even stronger political resistance to the power-effects of institutional computerization. In addition, therefore, to championing practices such as hacking (Wark 2004), network “exploits” (Galloway and Thacker 2007), transgressive computer art (Galloway 2004), resistance to overarching schemes of copyright (Benkler 2006; Lessig 2002, 2005; Litman 2001; Vaidhyanathan 2003), open source and free software (Stallman 2002), etc., I argue that we must also keep in mind the possibility of de-emphasizing computerization, resisting the intrusion of computational paradigms into every part of the social structure, and resisting too strong a focus on computationalism as the solution to our social problems. This study is written in the belief that computationalism aids some of the pernicious effects of institutional power; and that the best solutions to our pressing social problems lie in the social fabric itself and in social action, and less than we may imagine via computational transformation.

At the same time, I distance myself from certain lines of popular criticism of computers themselves, most especially that line of criticism that suggests that computers produce unsupervised interference with expert discourses and/or a crisis of legitimate authority with regard to the presentation of factual information. To begin with, I am less than persuaded that the democratizing effects of computers outweigh their tendency to centralize and concentrate power, as I discuss throughout this book; at another level, I endorse the demotion of expert opinion via tools like Wikipedia whose proliferation worries critics like Keen (2007). To a large degree, my concern is much the opposite: that the recent left-liberal adoption of computational evangelism (historically best documented and analyzed in Turner 2006) fails to offset the profoundly authoritarian bent of computationalism, so that radical democratization only appears likely if one avoids looking at the computational boon to centralized power. Thus both Keen and the wave of upbeat “democratization of information” writers (e.g., Shirky

2008; Surowiecki 2005; and Weinberger 2003, 2007) seem to look almost exclusively at what one might think of as the “good side” of the web, and in so doing nearly ignore the countervailing tendencies that undermine the movements they champion. These writers also endorse a radical populism that around the world only sometimes aligns itself with democratic social justice.

A second form of popular critique, this one having more exponents in academic circles, meshes more closely with my argument. This critique is often dismissed due to its first and best-known presentation in Birkerts (1994), where computerization is associated with a tendency to privilege the visual (a real worry, on my account), a decline in the ability to read (a real but more complex worry), and a decline in cultural standards that resembles the Keen (2007) attack on “amateurization” and lack of “expert oversight” of cultural production—phenomena that I would in fact find salutary if they were as widespread or as powerful as their advocates and their critics claim. Put simply, such critiques are elitist. But Birkerts also points to a line of critique that must be taken more seriously, which goes something like this: how do we guarantee that computers and other cultural products are not so pleasurable that they discourage us from engaging in absolutely necessary forms of social interaction? I see the current emphasis on the “social web” as not so much an account of a real phenomenon as it is a reaction to what we all know inside—that computers are pulling us away from face-to-face social interactions and in so doing removing something critical from our lived experience. While I am more skeptical about the implicit value of reading *per se* than Birkerts, the question of what that activity is being replaced with, raised more pointedly in Bauerlein (2008), must give anyone pause. In the Epilogue below I also discuss in some detail the pointed version of an allied critique offered by developmental psychologists, who examine the impact on personality formation of decreasing direct social interaction and unstructured play, as articulated by Adele Diamond (2006) and others (see Spiegel 2008a, 2008b).

This book is philosophical in form, but interpretive in method. Its form proceeds from one familiar throughout a number of philosophical traditions, in that it builds from discussions of the way people are constructed—via discussions of mind and then language—outward toward discussions of the consequences these particular notions have for culture and politics. Unlike some works in these traditions, my goal is not to articulate a philosophical system. Rather, and perhaps more in line with some recent works of this form, such those by Rorty (1979) and Putnam (1981a, 1992), it emerges from the conviction that there is no strong way to separate these kinds of issues, even if specialization might suggest otherwise. We are always talking about cultural politics, even when we appear not to be doing

so. More overtly than those works, however, I adopt Louis Althusser's post-structuralist conception of the project of philosophy: not a "demonstrative discourse" or "discourse of legitimation," but a "position on the philosophical battlefield: for or against such-and-such an existing position" (Althusser 2006, 256–7). My goal is not to articulate an alternative to computationalist presumptions about language, mind, and culture. It is to show the functions of that discourse in our society, to think about how and why it is able to rule out viable alternative views, and to argue that it is legitimate and even necessary to operate as if it is possible that computationalism will eventually fail to bear the philosophical-conceptual burden that we today put on it.

Computationalism

Computationalism is a word that has emerged only recently in the literature of analytic philosophy (see, e.g., Copeland 1996, 2002; Davenport 2000; Hardcastle 1995; Scheutz 2002; Wilson 1994, 1995). In that discipline, computationalism is used as a successor term to *functionalism*, notably deployed after the heyday of the doctrine, as discussed in detail in Chapter 3 below. Today, philosophers write about computationalism not as a view to be embraced directly, for the most part, but instead as a problematic doctrine which raises as many questions about philosophical practice as it does about its own putative subject matter. In its received (sometimes called its "classical") form, computationalism is the view that not just human minds are computers but that *mind itself* must be a computer—that our notion of intellect is, at bottom, identical with abstract computation, and that in discovering the principles of algorithmic computation via the Turing Machine human beings have, in fact, discovered the essence not just of human thought in practice but all thought in principle (see especially Kurzweil 1990, 1999, 2006).

Today, few philosophers can accept any of the straightforward versions of computationalism (although there are certainly exceptions to this rule), generally because, as Scheutz writes, "computation, assumed to be defined in abstract syntactic terms, necessarily neglects the real-time, embodied, real-world constraints with which cognitive systems intrinsically cope" (Scheutz 2002, ix). For Scheutz's cognitive systems we must read instead "human cognitive systems," since part of the failure of computationalism has been to show that we really cannot come to general conclusions about cognition per se—we are not even sure we know what that is. Defined this way, however, the recent reevaluations of computationalism pose a question that this volume seeks to answer: not merely why was computationalism so

attractive to philosophers—and why does it remain so attractive to many of them—but also what is at stake in the deep cultural commitment to this view, both inside and outside of philosophy?

In this sense, despite the widespread availability, indeed ubiquity, of computational systems throughout world culture today, I suggest that we must all the more urgently step back and ask questions that are not, in their essence, technological at all. In the terms used by Scheutz and other recent writers, it is clear that computationalism is not so much a commitment to the idea that our brains are fundamentally the same thing as personal computers (what would it mean, in this sense, for our brains to be “running programs” the way that computers run Microsoft Word or a web browser?) as it is a commitment to a set of views that are not at all new to Western or other imperial cultures in our history: views according to which cognition is a process of abstracting away from the embeddedness of material culture, and human beings can not merely be separated hierarchically from animals but also amongst themselves in terms of their cultural deployment of abstract rationality, of so-called “reason.” This is a view of human being that is familiar as what Deleuze and Guattari (1983, 1987) call “State philosophy” from as far back in history as we care to trace, although it reaches a certain apotheosis in at least one brand of European Enlightenment, especially the high rationalism associated with Leibniz—who has become, not coincidentally, a kind of patron saint for computationalism (Saul [1992] is a particularly trenchant historical analysis of rationalism in the sense I am using it here).

While philosophers use the term *computationalism* to refer to others of their kind who believe that the human mind is ultimately characterizable as a kind of computer, here I deploy the term more expansively as a commitment to the view that a great deal, perhaps all, of human and social experience can be explained via computational processes. While a great deal hangs precisely on the idea that cognition in particular is computational, in the world at large the belief that computers and human minds are converging entails a set of wider beliefs, namely that any number of real-world phenomena may not simply benefit from computerization but are ultimately “becoming” computerized (precisely due to a passive agency that is here a significant object of critique). In its benign forms, this kind of computationalism manifests in the belief not just that media like recorded music, books, television, and movies are being changed by and replicated on computers, but that they are at bottom fundamentally computational processes that will be transformed quite utterly, in a long term to which we seem to lack good access today, by accelerating computerization (for a skeptical counterpoint to such views, see in particular the writings of Paul Virilio, especially

Virilio 1983, 1989, 1997, and 2000). In more malevolent guises, computationalism manifests in messianic claims about sudden, radical, and almost always salutary changes in the fundamental fabric of politics, economics, and social formations: in claims that the world simply “is” becoming “flat” (to quote one particularly popular version of the view in circulation today; see Friedman 2005); in the belief that computers inherently create distributed democratic forms; and more abstractly, in claims that we can ignore any number of pressing social problems by dint of some kind of unnamable change, a change I see as being precisely messianic, one which computers are in the process of bringing into being. In this sense, by computationalism I mean something close—but not identical—to what Hayles (2005) rightly calls the “regime of computation”; I believe it is accurate to say that the regime of computation targets the combined effects of computational rhetoric and mass computerization; here, at least in great part, my effort is to separate these two phenomena, even if we often want to examine how they work in tandem.

In the most explicit accounts of Western intellectual history, mechanist views cluster on the side of political history to which we typically think of as the right, or conservatism, or Tory politics, or in our day, and perhaps more specifically relevant to this inquiry, neoliberalism. In some historical epochs it is clear who tends to endorse such views and who tends to emphasize other aspects of human existence in whatever the theoretical realm. It is figures like Leibniz who champion such views in European history, and skeptical figures like Voltaire and Swift who call them into question. There are strong intellectual and social associations between Hobbes’s theories and those of Machiavelli and Descartes, especially when seen from the State perspective. These philosophers and their views have often been invoked by conservative and neoliberal leaders when they want to consolidate power. This contrasts with ascendant liberal power and its philosophies, whose conceptual and political tendencies follow different lines altogether: Hume, Kant, Nietzsche, Heidegger, Dewey, James, etc. These are two profoundly different views of what the State itself means, what the citizen’s engagement with the State is, and where State power arises. Resistance to the view that the mind is computational is often found in philosophers we associate with liberal or radical (usually, but not always, left) views, despite a significant amount of variety in their views—for example, Locke, Hume, Nietzsche, Marx. These thinkers put both persons and social groups in the place of mechanical reason tend to emphasize social and relational duties rather than “natural right.”

The general tendencies of these two intellectual and political bodies are well known, but their connection with particular understanding of the

nature of human being is something we discuss much less often today than we did in the 1650s. The immense proliferation of scientific specialties leaves most people arguably without even a frame from which to conceptualize a view of human nature sensitive to the vast literature on cognition. More precisely, each side of the debate continues with its tacit understanding of what is vital to human being, while technological changes subtly influence the social field out of which broad political opinion is formed. The idea that the person is somehow in essence a digital thing, especially via the sense that the mind is a computer—with no more detail than that metaphorical equation—appears to be “loose” in contemporary culture. This idea fits well with capitalist rationalism and literalist evangelical Christianity, and in some important ways meshes well with associated beliefs of both dogmas.² It conflicts with the traditional views of the left, but it is intriguing enough and its contradictions are far enough *sub rosa* that many there take it up as a matter of course, where computationalism has today gained a surprisingly strong foothold.

Just in order to take advantage of what Deleuze and Guattari (1982, 1987) call the “war machine,” and then subsequently as a method of social organization in general, the State uses computation and promotes computationalism. This is precisely because “the modern State defines itself in principle as ‘the rational and reasonable organization of a community’ . . . The State gives thought a form of interiority, and thought gives that interiority a form of universality.”³ Interiority qua universal subjectivity emerges from numerical rationality applied as an understanding of human subjectivity, and not vice versa. This is not to reject the idea of subjectivity outside of rationalist modernity: it is rather to suggest that the particular and elaborated form of interiority we associate with present-day modernity underwrites an unexpected and radical mechanism. This mechanism does not seem radical if we associate it with a word like *rationalism*, because we are not accustomed to understanding rationality as a mechanical function, though that is exactly what its definition suggests. It is rationalists themselves who take the term most literally, seeing in the creating of ratios—of weightings, largely of the more and less powerful force—the characteristic computation of modernity. While Descartes himself did not subscribe to this understanding of psychology, through Hobbes in particular we associate the modern State’s conception of the “free” rational individual with absolute sovereignty and natural right. Because each citizen has the power to reason (to *calculate ratios*, or in our terms to *compute*) for himself, each citizen has access to the know-how (Foucault’s *savoir*) of State sovereignty.⁴ Each citizen can work out for himself the State philosophy: “Always obey. The more you obey, the more you will be master, for you will only be obeying

pure reason. In other words yourself . . . Ever since philosophy assigned itself the role of ground it has been giving the established powers its blessing, and tracing its doctrine of faculties onto the organs of State power.”⁵

To submit a phenomenon to computation is to striate otherwise-smooth details, analog details, to push them upwards toward the sovereign, to make only high-level control available to the user, and then only those aspects of control that are deemed appropriate by the sovereign (Deleuze 1992). In this sense, computers wrap the “legacy data” of the social world in formal markup, whose purpose is to provide the sovereign with access for post-hoc analysis, and secondarily to provide filter-style control. Computation can then be used, at sovereign discretion, as part of instruction, as a way of conditioning subjects to respond well to the computational model. From this perspective, it is surprising to hear prominent academics like Nicholas Negroponte state that the “digital age” is distinguished by “four very powerful qualities that will result in its ultimate triumph: decentralizing, globalizing, harmonizing, and empowering.”⁶ Without any consideration of arguments to the contrary, Negroponte asserts that “the traditional centralist view of life will become a thing of the past,” that “in the digital world, previously impossible solutions become viable,” that

The harmonizing effect of being digital is already apparent as previously partitioned disciplines and enterprises find themselves collaborating, not competing. A previously missing common language emerges, allowing people to understand across boundaries. Kids at school today experience the opportunity to look at the same thing from many perspectives. A computer program, for example, can be seen simultaneously as a set of computer instructions or as concrete poetry.⁷

It is no surprise that Negroponte’s “optimism comes from the empowering nature of being digital. . . . As children appropriate a global information resource, and as they discover that only adults need learner’s permits, we are bound to find new hope and dignity in places where very little existed before.”⁸ It is also no surprise that Negroponte now spearheads a worldwide effort to distribute computers to children (the One Laptop Per Child program, or OLPC) that can also be seen as realizing a desire to propagate computationalism, and in this mode emerges not from a prior base of interest in the social and economic problems of the world’s most marginalized people, but instead from the intuitions of computer users and developers about what it is like to engage deeply with the machine.⁹

The closing words of Negroponte’s best-selling book completely lack exemplary support, and with good reason. Their staging of an artificial, pre-computerization past where things like collaboration as opposed to

competition existed seems purely ideological, and the observation that computers alone teach a kind of perspectivalism instanced in the ability to read code as poetry is nothing short of bizarre. "Lessons" about perspective might be thought one of the main goals of any sort of humanities education, and easily obtainable from the whole world of cultural objects—a world which, in many worlds of education, exactly requires no particular "missing common language," especially not the monolingual majority languages of computing.

Just as importantly, it is critical not to accept *a priori* the idea that computation as such refers only to the operations of the particular physical objects we understand as computers. Arguably, the major function that computers perform routinely in our society is calculation.¹⁰ Calculation has a long history in civilization, especially in centralized, bureaucratic administrations, and in empires. Calculation is especially important for warfare, where it is deployed in a manner that must be understood as simulation, even if the simulation is represented entirely via mathematics. Turing, von Neumann, and other early developers of physical computers relied just as much on what were then named computers as they did on the machines for which we now use that name, and warfare was their main purpose.¹¹ As David Alan Grier has recently shown, along lines that have become accepted throughout the small field of computer history, since at least the late-19th century many sorts of institutions routinely employed rooms of human calculators, often women, and precisely enabling the exercise of administrative power to which the workers lacked access.¹²

These human computers were in fact the first operators of electronic and mechanical computers, regardless of whether they were built for analog or digital functions. In the administrative scheme, computing acts as a slave to the powerful human master, and it is always the task of imperial administration to amplify computational power. Following historians like Adas, Crosby, Headrick, and Mattelart and no less poststructuralist thinkers like Deleuze and Guattari, Virilio, and Derrida, we can see how uneven are the benefits of computational power in more aspects of their distribution than might be ordinarily supposed. This is no mere fantasy: on even cursory examination, one can easily see how many of the 20th century's most famous and infamous institutions depended heavily on computational practices. These are the accomplishments of computing, the ones its internal advocates trumpet, today more loudly than ever, as if they were devoid of politics. For a materialist study of computing to follow its predecessors, it must look not (or not only) to what computers may someday present to us, whether in the form of a genuinely "new" medium or not; it must look to what computers are doing in our world, from the implementation of widely

distributed identification and surveillance to the reduction of all the world's cultures for profit.

Computers come with powerful belief systems that serve to obscure their real functions, even when we say we are acutely aware of the consequences of our technologies. The thought surrounding issues like global climate change and genetics (and, in an earlier time, research into atomic physics) suggests that technologies have strong inherent destructive potentials, even when we don't see them. The fact that computers empower users is not in doubt; what is in question is what power it gives which users, how, and why. In a world where corporations already inhabit an ideal personhood (exported uniquely from an Anglo-American model) that obscures what we understand as human being (not least because the humans who inhabit them are rarely held accountable for a corporation's actions), and as with commercials for detrimental technologies like always-on wireless connectivity, it is all the more necessary to articulate the ideological operations of the computational tropes as they come into being, rather than afterwards. We need to find a way to generate critical praxis even of what appears as an inarguable good. What historicist and poststructuralist writers like Foucault and technological skeptics like Ellul and Innis share is the view that social transformations emerge anywhere other than political movements, even when their overriding trope is technological. The lesson from that work that this book deploys is that we have to learn how to critique even that which helps us (much as computers help us to write books like this one, among many other things). It would be better not to have computers, in that sense, than to live in a world where many more people come to believe that computers by themselves can "save us," can "solve our problems."

For at least one hundred years and probably much longer, modern societies have been built on the assumption that more rationality and more *technē* (and more capital) are precisely the solutions to the extremely serious problems that beset our world and our human societies. Yet the evidence that this is not the right solution can be found everywhere. This is not to suggest that rationality is wrong or misguided or that we should eradicate it (arguably figures like Derrida and Foucault follow the counter-Enlightenment tradition of Voltaire and Swift, none of whom altogether dismiss the value of rationality); it is to suggest that our societies function best when they are balanced between what we will call here rationalism and whatever lies outside of it. To some extent this is a perpetual tension in all societies, not just in ours or in so-called modern ones; what is distinctive about our society, historically, is its emphasis on rationalism and its terrific adeptness at ruling out any discourse that stands against rationalism. In

other societies and places just the opposite might be true, in a way that our own rationalist moment makes difficult to see. There is no doubt that societies have existed and do exist where there is so much emphasis on power without the appearance of rational rule that rationalism is precisely what they need to undo long histories of despotism.

Here I argue that the opposite has become the case for us. The computer, despite its claims to fluidity, is largely a proxy for an idealized form of rationalism. This book shows how the rationalist vision could be mutated into something like a full articulation of human society, despite the obvious, repeated, *a priori* and *a posteriori* reasons that this could never and will never be the case. On this view, the main reason figures like Kant, Hegel, Plato, Hume, the late Wittgenstein, and even Derrida and Spivak look odd at all to us is precisely because of the sheer power held by the rationalist vision over so much of society. It seems conceivable that someday they will be seen (again) as offering what is at least a plausible articulation of human social formation. At that point, this moment will look to be one in which we were possessed by a kind of extreme rationalist vision that carries with it at least two repressed historical formations: the absolutist leader whose will in fact transcends all rational calculation, and disdain for the “illogical” historical and social fabric of the human world.

The Deconstruction of Computation

Despite its rigid formal characteristics, in part because of them, then, computationalism is in every sense what Foucault calls a discourse, one that we are actively creating and enabling, and among whose fundamental principles is the elaboration of centralized power. Its deployment is in no way new in our world; as even computing’s advocates insist, at least since Leibniz, it has been well understood that a form of mathematical calculation could be made to represent propositions that are not themselves mathematical. There is little more to understanding computation than comprehending this simple principle: mathematical calculation can be made to stand for propositions that are themselves not mathematical, but must still conform to mathematical rules.

Yet the nature of Leibniz’s personal commitment to computation as a cognitive principle only demonstrates the degree to which it is culturally situated. Even orthodox computer histories have trouble making Leibniz sound like anything other than a product of the Western intellectual history of which he is a part, possessed by a belief system to which he subscribes for reasons we would today see as political at least as much as they are properly

scientific. The computer historian and logician Martin Davis calls the computer “Leibniz’s Dream,” and leaves us in no doubt that the dream is no simple anticipation of the machines we see today: it is a full-blown wish for the elimination of everything that is imprecise or ambiguous in human social practice. Thus in one of his fullest statements about the potential of computation, Leibniz writes to his friend Jean Gallois that he is

convinced more and more of the utility and reality of this general science [i.e., computation], and I see that few people have understood its extent. . . . This characteristic consists of a certain script or language . . . that perfectly represents the relationships between our thoughts

The pursuit of this “perfect relationship between our thoughts,” while not exclusive to computationalists or rationalists, nevertheless has persistently informed a central strand of Western thought about language and subjectivity. It emerges from a terrible anxiety about exactly the ambiguity that characterizes human experience; and it points toward a seemingly perfect world in which “it will be impossible to write . . . chimerical notions such as suggest themselves to us. An ignoramus will not be able to use it, or in striving to do so, he himself will become erudite.”¹³

For hundreds of years, sentiments such as this one were considered a kind of pipe-dream, the sort of stuff of which acerbic and highly rational anti-rationalists like Jonathan Swift could make merciless fun, with some confidence that the dreams would never be realized, on grounds that are philosophical, discursive, and empirical. Yet more recently, despite the strong philosophical and conceptual tradition that raises questions not about the reality of computation as a powerful praxis—its raw power should be of no question to anyone, especially today—but precisely about the conceptual underpinnings on which rest views about the general utility of computation as a form of something close to what we can call, as shorthand, “human thinking.”

Few writers have doubted the importance of rational calculation in the operation of human thinking. What is in question is the degree to which that sort of calculation explains all the facts of cognition, all the effects of culture, and all that is possible in the realm of culture and cognition. Thinkers who try to construct a rationalist line extending from Leibniz through Descartes to Boole and Frege (the 19th-century logicians most relevant to computing) must conveniently put aside the most famous dissenters from the view that computation is everything, which includes figures of note such as Hume, Hegel, and Kant; and no less the 20th-century thinkers, themselves quite close culturally and personally to the birth of modern computers, like Russell and Wittgenstein, all of whom raised the most profound

conceptual questions about the extent to which logical calculation could, in fact, represent all or even much of human cognitive practice.

The most thorough and most critical of these perspectives, and the one least addressed by contemporary computationalists, is the one offered by Immanuel Kant. Kant fully understood the power of logic and calculation, but he was famously not persuaded by the work of rationalists before him that this was the correct model for what humans do with their brains. Even this argument, clear enough in the main run of Kant's arguments, has started to become lost on us; today Kant looks in departments of Anglo-American analytic philosophy as if he is at least fairly close to a full-blown rationalist on the Leibniz model. Yet as one of Kant's most careful contemporary readers, Gayatri Spivak, has shown repeatedly, Kant argued that "mere (rather than pure) reason is a programmed structure, with in-built possibilities of misfiring, and nothing but calculation as a way of setting right" (Spivak 2005, 93). "Mere" reason, for Kant, is not like the two major categories of cognition, "pure" and "practical" reason, specifically because in its quest for exactness it actually eliminates the possibility of human agency in cognitive practice. Like mathematical equations, formulae that are "merely" reasonable admit of unique, univocal solutions. No thought is necessary to compute that 2 plus 2 equals 4; one can of course come to this conclusion through general thought, or through memorization, or exemplar, or through sheer calculation. But as is characteristic of such computational facts, no human being or human thought is actually necessary to determine that 4 is the unique solution to the question "what is the sum of 2 plus 2?"

It is no accident that Spivak uses the term *programmed* to describe the kind of thought that Kant did not think encompasses all of human reason, precisely the kind of cognitive practice that would eliminate the ambiguity that so troubled Leibniz and others. Jacques Derrida, who himself suggested some of the views of Kant on which Spivak elaborates, is often thought of as a thinker who teaches us to reject handed-down distinctions, showing why and how, for example, much thinking in the Western tradition has relied on an implicit and at times explicit distinction between writing and speech that is philosophically much less tenable than it may appear on the surface. At the same time, in a way that has not been so well understood by his readers, Derrida does not want to deny, exactly, that some societies, especially modern cosmopolitan and imperial societies, are everywhere characterized by writing and printing, while other societies, including the Nambikwara discussed by Claude Lévi-Strauss in the *Tristes Tropiques* and elsewhere, have historically had less formal systems of writing and have relied less on fully articulated systems of writing and printing.

Despite the efforts of pro-computer writers like George Landow to make hypertext sound like the realization of Derridean dreams of a language without binding or hierarchical structures (Landow 1992), in fact from his earliest writing Derrida has been concerned precisely with the difference between human language and something like computer code. *Of Grammatology* (1976) announces this concern in the deliberate use of the morpheme *gram* in its title, and Derrida cannily indicates that this term, associated for his purposes primarily with a history of writing proposed by the Egyptologist I. J. Gelb in his *Study of Writing* (1952), points at a more general and contemporary problematic that has been insufficiently thematized, even as he calls into question the distinction between so-called writing and other forms of inscription:

we say “writing” for all that gives rise to an inscription in general, whether it is literal or not and even if what it distributes in space is alien to the order of the voice: cinematography, choreography, of course, but also pictorial, musical, sculptural “writing.” One might also speak of athletic writing, and with even greater certainty of military or political writing in view of the techniques that govern these domains today. All this to describe not only the system of notation secondarily connected with these activities but the essence and content of these activities themselves. It is also in this sense that the contemporary biologist speaks of writing and *pro-gram* in relation to the most elementary processes of information within the living cell. And, finally, whether it has essential limits or not, the entire field covered by the cybernetic *program* will be the field of writing. If the theory of cybernetics is by itself to oust all metaphysical concepts—including the concepts of soul, of life, of value, of choice, of memory—which until recently served to separate the machine from man, it must conserve the notion of writing, trace, *grammè*, or grapheme, until its own historico-metaphysical character is also exposed. (Derrida 1976, 9)

This is not the work of someone who wants to dispose of the distinction between computer program and language. One detects, despite Derrida’s suspicion of all true messianism and distinctions that are too neat, a certain wariness that “the concepts of soul, of life, of value, of choice, of memory” may be overwhelmed by a mechanistic view of language (Harris 1987) and cognition that, heedless of Kant, substitutes “mere” reason for all the complex of human reasoning that philosopher knew must characterize our experience and most especially our moral and political actions and choices.

Derrida is no Luddite, and no one would be more suspicious than he of the view that one technology or another was leading us down a royal road to monstrous disaster—far from it. But the computer in particular is a technology that caused him great concern, for precisely the reason that it offers to substitute for the flux of experience an appearance of certainty that

cannot, in fact, adequately represent our experience. Marian Hobson, a critic who knew Derrida quite well personally, writes:

The information embodied in the digital series cannot be summarized to any useful extent. A summary which can be raised to the level of theme, of next-level program, is simply not possible. Such types of binary series suggest that the much more variegated strings of signifiers in natural language may likewise not be summarized without loss, by imposition of law-like program or summary equation one to another of different scales of detail and signification—what can be generally called “thematization.” The elements in the series can only be taken at the level of singulars.

For Derrida, a philosophic or fictional text is neither a code which is interpreted, nor a program which is “run.” (This stance takes the form of occasionally explicit resistance to a commentator in *Jacques Derrida* [Bennington and Derrida 1993] and is one of the sources of humor there.) (Hobson 1998, 194)

Hobson is right to point us to codes and programs as precisely the things which texts are not, despite Derrida’s putative disregard for analytic distinctions, and it is no surprise to hear Hobson report that the notion of a “deconstruction computer program” struck Derrida as profoundly troubling, nor to read in the introduction to Bennington’s “Derridabase”:¹⁴

The guiding idea of the exposition comes from computers: G.B. would have liked to systematize J.D.’s thought to the point of turning it into an interactive program which, in spite of its difficulty, would in principle be accessible to any user. As what is at stake in J.D.’s work is to show how any such system remains essentially open, this undertaking was doomed to failure from the start. . . . In order to demonstrate the ineluctable necessity of that failure, our contract stipulated that J.D., having read G. B’s text, would write something escaping the proposed systemization. (Bennington and Derrida 1993, 1)

Perhaps just as striking is the fact that Bennington does not even propose the creation of an actual computer program, and does not make it clear how the written text that follows—merely an ordered list of terms and concepts important in Derrida’s writing—might be made into something like a program. It seems to me that this hesitation on Derrida’s part show just how well he understood computer programs and how they differ from written texts.

Of course, “Derridabase” is well ordered, and for this reason it could easily be made part of a functioning computer application. But its concept of system is rudimentary. It is less elaborate than the kind of logical structure computer scientists call an *algorithm*, or at any rate forms one of the most basic types of algorithm, an ordered list (and it is not entirely wrong to think that an algorithm is the same thing as a very small computer program, and so as computation itself, the principle of letting mathematical formulae corre-

spond to logical ones; see Berlinski 2000). This helps to show the ways in which we have identified computers with every sort of logical system. This is because a computer can simulate or represent any logical system that can be precisely defined. In fact this is the definition of computation. (The thing we refer to as a computer today is a particular kind of algorithm, commonly referred to as a Turing machine.) The power and universal applicability of computation has made it look to us as if, quite literally, *everything* might be made out of computation (von Baeyer 2005; Wolfram 1994, 2002). This is meant literally: researchers have proposed, in the course of what must in part be nothing but normal scientific practice, that everything from DNA, to the interactions between subatomic particles, to the shape of space-time, might be constructed from the algorithmic passing of information in some abstract sense.

No doubt, at least some of these scientific theories will turn out to have a grain of truth to them, and no doubt others of them will fail. But what have proven to be of especially limited consequence, as this book shows, are theories that try to apply the universal representational capability of computation to the human world. The place where this is most visible is language, exactly because computers must partake of something like human language (called by computer scientists “natural language”) in order to be used by human beings at all. Programming languages, as Derrida knew, are codes: they have one and only one correct interpretation (or, at the absolute limit, a determinate number of discrete interpretations). Human language practice almost never has a single correct interpretation. Languages are not codes; programming “languages” like Basic and FORTRAN and scripting “languages” like HTML and JavaScript do not serve the functions that human languages do. The use of the term *language* to describe them is a deliberate metaphor, one that is meant to help us interact with machines, but we must not let ourselves lose sight of its metaphorical status, and yet this forgetting has been at stake from the first application of the name (see Chapters 2 and 4).

Of course, from the beginning of computation as a practice and in fact as part of it, writers have proposed that language itself might be subsumed by formal systems, eradicating the ambiguity that so troubles human society. As physical computers themselves came into being, scarcely a year has gone by when several corporate or governmental entities have failed to generate multiple press stories about computers that are about to speak—and only recently, in no small part because of the heated attention they receive, have we seen fewer claims that computers are about to start thinking. But it is a core commitment of this book that neither of these events is about to happen, soon if ever. The reason is not because we and our thought and language are

magical entities, beyond the science of computers; it is instead because we are material beings embedded in the physical and historical contexts of our experience, and it turns out that what we refer to as “thought” and “language” and “self” emerge from those physical materialities. Yes, we can easily build codes that are independent of our bodies; but we don’t even know how to conceive of what we call speaking and what we call thinking as independent of our bodies and selves. We can’t conceive that the destruction of identity that accompanies the “uploading self” fantasies of so much computer fiction has already and can always happen, because there is no self there to realize it or to feel it. Our selves can only stay where they are, in a singularity that has already happened—and is no nearer than it has ever been.

Discussions of the digital world and technology in general often are forced to hinge on conceptions of the human, and it would be easy enough to suppose that a poststructuralist perspective would have to rule out access to the concept of the human altogether. Nevertheless, like all writing including poststructuralism, cultural criticism of all sorts must inherently be concerned with something we can perhaps only vaguely call “the human world.” Arguably, we would not even know what our objects of study were without recourse to such a concept. We need, then, to distinguish between the concept *human* prior to poststructuralism and after it—to keep in mind the object of criticism Derrida and Foucault meant to target, while not jettisoning a robust enough conception of human life to sustain political and cultural reflection. The most narrow, and not entirely accurate, heuristic for making this distinction is to think about the term *human nature*: do we imagine that there are many substantive features of human nature, so that much of what it is to be human is invariant over time; or do we imagine that much of human nature is flexible and open to definition, so that what it means to be human can change depending on context? The former, substantive concept of human nature can be understood as that which the poststructuralists had most in mind, while the latter, flexible conception is the one with which poststructuralism is far more comfortable.

It would be inaccurate to say that we have passed beyond the notion of a substantive human nature in our own society; such a concept functions powerfully in popular discourse around gender, race, and sexuality, among other places. Contemporary geneticists and biologists, despite the power of DNA-based analysis, recognize that human beings are far more characterized by variability than they are by substantive qualities. Persons bearing XX chromosomes and typically classified “female” usually have less upper-body strength than does a typical male of similar height, weight, and age; but this statistical observation provides almost no information for predicting whether any specific human being will be more or less strong than an-

other. We have learned not to define women as “the weaker sex,” and not to disparage women with significant upper-body strength as failing to meet the substantive definition of their kind, just as many of us have learned to assign few characteristics to any individual based on his or her membership in any given group. In this sense contemporary views of human nature dovetail with poststructuralist views in rejecting the idea that “the human” is defined by the capability for rationality, or “man” is defined by bravery, sexual prowess, sportsmanship, and so on. Whatever our particular characteristics, we are all human, and we accept the fact that this term has little substantive content. As the philosopher of biology David Hull has put it, writing against the more substantive view of human nature adopted by sociobiologists, “if by ‘human nature’ all one means is a trait which happens to be prevalent and important for the moment, then surely human nature exists. Each species exhibits adaptations, and these adaptations are important for its continued existence. . . . But this adaptation may not have characterized us throughout our existence and may not continue to characterize us in the future” (Hull 1986, 9).

There is no essence to human nature, no particular set of traits or forms of life that make us human or make us inhuman. Human nature is highly malleable; the ability to affect what humans are and how they interact with their environment is one of my main concerns here, specifically along the lines that computerization of the world encourages computerization of human beings. There are nevertheless a set of capacities and concerns that characterize what we mean by human being: human beings typically have the capacity to think; they have the capacity to use one or more (human) languages; they define themselves in social relationship to each other; and they engage in political behavior.¹⁵ These concerns correspond roughly to the chapters that follow. In each case, a rough approximation of my thesis might be that most of the phenomena in each sphere, even if in part characterizable in computational terms, are nevertheless *analog* in nature. They are gradable and fuzzy; they are rarely if ever exact, even if they can achieve exactness. The brain is analog; languages are analog; society and politics are analog. Such reasoning applies not merely to what we call the “human species” but to much of what we take to be life itself, and it is notable that many animals (and even some plants) evidence behavior that falls under one or more of these headings. It is not even clear what the boundaries of “the human” might be in these regards; it is not at all intuitively clear what characteristics aliens would have to display for us to consider them roughly the same as humans, or even to be human. Presumably, the capacities to engage in thinking, language, social relations, and politics would go a long way in helping us draw this conclusion, but the problem is thornier than

some would like to admit; recent suggestions that animals might deserve something like “human rights” only goes to show the dense problematic sedimented into the term.

While human beings can surely engage in activities that resemble or are even equivalent to digital ones, it is their capacity to engage in analog activities—their propensity so far in history to engage most of the time in such activities—that are of signal concern in this study. Famously, Deleuze and Guattari write at length in the two volumes of *Capitalism and Schizophrenia* (1983, 1987) that much of human life and human society can be characterized in terms of machines; they go so far as to include much of everything we recognize as part of a “machinic phylum.” There is much to recommend this view, and it is not my purpose to put it under scrutiny here. But what is notable for our purposes is that these machines are generally analog: like most of our world, they are machines built for one or more specific functions, sometimes able to be repurposed for other uses, inexact, rough, fuzzy. They don’t choose between 1 and 0 to build up symbolic operations; rather, the machine of the animal elbow moves at any number of stretchable angles, which no part of the body needs to decompose into numeric approximations. While enough frames-per-second can make digital animations appear as smooth as analog ones, there is still a translation occurring inside the computer that the animal body does not need to make. There is no mystery here; analog machines are at least as old as digital ones and pose no conceptual obstacles (that they might is arguably a symptom of exactly the computational mania with which this book is concerned). Lawn mowers, toasters, drills, typewriters, elbow joints, pianos, and jaws may be mechanical, but there is no reason to suspect them of being digital (Derrida [1993] offers an excellent account of the machinic qualities of the organic world that nevertheless remain different from digital representation). That digital media can approximate their function should raise this suspicion no more than the existence of baseball or golf simulations makes us suspect that these games are digital.

Few theorists addressed the interconnection of politics, culture, and technology more closely than Deleuze and Guattari. In *A Thousand Plateaus*, Deleuze and Guattari develop a concept, *striation*, that arguably emerges in part from the growing emphasis on computerization that was evident even in the 1970s, but that has sometimes been overlooked by media theorists in favor of what is clearly a misreading of Deleuze and Guattari’s discussion of *virtuality* (see especially Lévy 2001). The term *virtual reality* emerged in wide use (popularized in particular by the computer evangelist Jaron Lanier) after Deleuze and Guattari’s pathbreaking work, and it is clear that Deleuze and Guattari intended the virtual to refer to a generic use

of the term rather than to a computer-based phenomena (see De Landa 2002; Massumi 2002; Shields 2003; and Wark 2004 for more accurate discussions of what Deleuze and Guattari mean by the virtual and how it relates to the computer). The idea that computers represent a better instantiation of “virtuality” than do the human brain or human society is a curious and curiously computer-centric notion, one that bespeaks the tremendous cultural power of computation itself.

Nevertheless, the emphasis on the virtual as Deleuze and Guattari’s chief contribution to the cultural study of computers has helped to obscure their much more sustained and meaningful ideas that center on the term *striation*, and that clearly have computation as an historical abstraction, and not just material computers, as their object of analysis. Striation is discussed throughout *Capitalism and Schizophrenia* (1983, 1987), principally in its second book, *A Thousand Plateaus*, but it receives thorough treatment in Chapter 14, “1440: The Smooth and the Striated.” It is important to remember that this is essentially the final substantive chapter of *Capitalism and Schizophrenia* and that the distinction implemented here builds on others Deleuze and Guattari work out throughout the two volumes. “Smooth space and striated space—nomad space and sedentary space—the space in which the war machine develops and the space instituted by the State apparatus—are not of the same nature” (474), Deleuze and Guattari write, despite the fact that in reality “the two spaces only exist in mixture.” Still, we can find examples that help us to distinguish the two principles. Smooth space, where “points are subordinated to the trajectory” (478), may be represented by the lifestyles of nomads, hunter-gatherers, navigation by “bearings” rather than maps, intuition, what Deleuze and Guattari call deterritorialization, rhizomatic organization, relatively anarchic and local forms government, and relatively mobile forms of life. Striated space, where “lines or trajectories tend to be subordinated to points” (478), is the space of the State, of firm bureaucratic and governmental orders, of the grid, of maps, coordinate orientations, of territorialization, tree-like (hierarchical) organization, settlement and agriculture (see Lunenfeld 2000, xvi-xviii, for a more laudatory but, for its closeness to contemporary computing practice, all-the-more telling account of the importance of grids; Crosby 1997, Scott 1999, and Wright 2005 touch on the importance of certain views of quantification to the State-based conception of progress that are closely tied to striation).

Schematized in this way, it is clear that most of the thought and practice surrounding computers promotes striated over smooth space. It is remarkable, then, how much of the cultural-political discussion of computers uses the rhetoric of smooth space while simply not addressing issues of

striation—of territorialization rather than deterritorialization. As in the case of language, computers are found on the side of culture in which people move to metropolises and then stay in them, commit to hierarchical organization, grow increasingly reliant on technologies and politics of organization and settlement, and see the world as an already-comprehended object that is available for exploitation; at the same time what is left behind is a space of relative smoothness and (although it may be heavily constrained by the pressures of global capital) mobility. While the rhetoric of computation looks for those places in which the network allows for smooth practices, arguably this is not because the computational infrastructure is itself hospitable to such practices. Rather, it is because we simply do not want to admit how overwhelming are the forces of striation within computers and computation, and we grasp at precisely those thin (but of course real) marks of smoothness that remain as computers grow ever more global in power. Of course computers contribute in some ways to what is arguably a vitally necessary resistance to global striation; but if our goal is truly to participate in such resistance, we need to see with clear eyes just how deeply computers are implicated in striation to begin with. Given the pervasive insistence of computers on State power and striation, there is perhaps no more relevant technology of which one can say, with Audre Lorde, that “the master’s tools will never dismantle the master’s house” (1984, 110).

Politically, the goal of this study is to expand on a cultural opening that generally has been discounted in public discourse. In today’s left, political analysis of computation largely focuses on one of two political possibilities. The first, expressed in liberal writings like those of Joseph Trippi and Markos Moulitsas, comes close to a kind of technological determinism: it suggests that the Internet is inherently democratizing, and we simply need to have faith that global computerization will produce democracy as a necessary side-effect. Trusting that the computer makes our political efforts qualitatively different from earlier ones, advocates of this position suggest that computer-based tools for fundraising, organizing, and citizen journalism will have a transformative effect on the public sphere: because the old media conglomerates will inevitably dissolve in the face of ubiquitous Internet access, we need do little more than use the computational tools engineers provide for us—as well as, no doubt, creating a few of our own—to effect significant, anti-authoritarian political change. In its best form—McChesney (2007), for example—this position embodies an admirable vision of citizen participation in the creation of the polis, something like a genuine liberal position. In its worst form—say, Friedman

(2005)—a similar position can degenerate into something very close to techno-progressivist neoliberalism, in which the computer is inherently effecting such massive social changes that we are virtually powerless over them, and at the same time need not worry about them, since they are almost inevitably going to make society more egalitarian, more resistant to authoritarian control and centralization.

A second view, more prominent within academic and creative thought about computing, suggests that there actually are problems inside of the contemporary computing infrastructure, but that it is “*through* protocol that one must guide one’s efforts, not against it” (Galloway 2004, 17). Adumbrating this position, Galloway and Wark, especially, describe the actions of hackers, artists, creative writers, and programmers who work diligently to exploit gaps in the system and to re-use the system, especially the computational system, for anti-authoritarian ends. Wark’s “hacker class” is wider than just those (e.g., Kevin Mitnick) understood to be hackers in the most literal sense; nevertheless, Wark writes that “*A Hacker Manifesto* is among other things an attempt to abstract from the practices and concepts” of “groups, networks, and collaborations such as Adilkno, Ctheory, EDT, Institute for Applied Autonomy, I/O/D, Luther Blisset Project, Mongrel, Nettime . . .” (Wark 2004, n.31). These artists and creative programmers (and mailing lists and critical communities) are extremely diverse entities, but it is fair to say that they generally adhere to Galloway’s dictum: “through protocol, not against it.”

This, too, is a laudatory goal, perhaps even more so than the first form of resistance articulated above; but I wonder what authorizes Galloway’s prohibition: “*not* against” protocol. I am all for resistance through protocol; what I want to articulate is the case precisely for resistance *against* what Galloway calls protocol, and what is more generally thought of as comput-erization. My point is not to simply raise a kind of Luddite anti-technologism according to which we should simply dispose of all computers; my point is to raise the question whether the shape, function, and ubiquity of the computing network is something that should be brought under democratic control in a way that it is not today. I do not think computing is an industry like any other, or even a communications medium like any other; rather, it is a name for the administrative control and concentration powers of our society—in a sense, precisely what Foucault would call our governmentality. It seems more than reasonable to insist that such governmental powers must remain in the hands of a widespread citizenry, one that encompasses both majorities and minorities, communities and individuals. It is not exactly the “concentration of media ownership,” but the concentration of computing

power within institutions, to which I am encouraging resistance. Thus to Galloway's dictum I offer this simple emendation: resistance "through protocol, *and* against it."

In this way the goal of this study is to point out how pervasive the discourse of computationalism has become throughout our powerful institutions, especially where these touch on the third rails of true political authority. Trying to broaden the space from which informed leftist thought can insist that the question of how much computer technology is used, and how and where it is used, raises questions that must be open to the polis and not simply decided by technocrats. To a degree, this position has started to be articulated with regard to legal notions of intellectual property and even, perhaps to a lesser extent, to the kinds of knowledge generated within medical fields and biological research (where the question of who owns and who has access to genetic information is becoming more and more heated).

I don't think we can know at this historical juncture which of these modes of resistance might or might not be successful; nor do I see any reason to suppose they are anything but complementary, even if there is no doubt that differences will exist among them. But I will confess to being concerned about just where (because he does not say) a writer like Galloway derives the imperative in his statement that we *must not* resist against what he calls protocol. Again, resisting through protocol is a laudable goal; actually working to democratize media and information technology is a laudable goal (as for example in democratized projects like Wikipedia, and open source and free software, etc.); but it seems to me we can leave it to technocrats and capitalists to insist that we as the citizenry have no right or power to determine how technologies change, adapt, and function in society. No doubt there are a whole range of technical questions that can be left to specialists. The ubiquity of computer technology is not one of them.

It can be no coincidence that the computer emerges at just a moment when the public ideology of human enslavement has been changed by intense social effort. We address computers as our slaves, and never think of the power and satisfaction we feel precisely in knowing how perfectly the machine bends to our will. We exercise and intensify mastery over the machine at the individual and the social levels; we experience frustration when the real world fails to live up to the striated and rigid computational model. Yet we continue to look to the computer for solutions to this problem, itself largely created and intensified by the computer. We don't see people who use computers extensively (modern Americans and others around the world) breaking out everywhere in new forms of democratic action that disrupt ef-

fectively the institutional power of capital (see Dahlberg and Siapera 2007, Jenkins and Thorburn 2003, and Simon, Corrales, and Wolfensberger 2002 for close analysis of some of the more radical claims about democritization), yet our discourse says this is what computers bring. Our own society has displayed strong tendencies toward authoritarianism and perhaps even corporate fascism, two ideologies strongly associated with rationalism, and yet we continue to endorse even further tilts in the rationalist direction. This book is written in the hope that this historical imbalance between rationalism and “anti-rationalism” has gone about as far as it can go in the rationalist direction. Perhaps, despite appearances, there is a possible future in which computers are more powerful, more widespread, cheaper, and easier to use—and at the same time have much less influence over our lives and our thoughts.

Notes

Chapter 1 The Cultural Functions of Computation

1. For the most overt rhetorical presumptions of the newness of new media, see Hansen (2004), Manovich (2001), and the editor's commentaries in Wardrip-Fruin and Montfort (2003). Gitelman (2006) and some of the essays and commentary in Chun and Keenan (2003) and Gitelman and Pingree (2004) raise critical questions about the utility (though not as often the purpose) of this rhetoric.
2. See, e.g., Mosco (2005).
3. Deleuze and Guattari (1987), 375.
4. For the *savoir/connaissance* distinction, see Foucault (2000), especially "Truth and Juridical Forms."
5. Deleuze and Guattari (1987), 376.
6. Negroponte (1995), 229.
7. Ibid., 230.
8. Ibid., 231.
9. See OLPC (2009).
10. Agre (2002) and Sloman (2002) provide convincing typologies of current computational practice that highlight the importance of "traditional" (if massive) computation and the relative and surprising unimportance of Turing machine-style algorithmic processing to contemporary computational practice.
11. See, e.g., Campbell-Kelly and Aspray (2004); Hayles (1999).
12. Grier (2005). See also, e.g., Campbell-Kelly and Aspray (2004).
13. Gottfried Wilhelm Leibniz, letter of December 1678 to Jean Galloys. Quoted in and translated by Davis (2000), 16.
14. Marian Hobson, p.c.

15. In this sense the position I describe here is meant to be completely consistent with what is usually, but perhaps misleadingly, called antihumanism in post-structuralist theory; see, in addition to the Derrida and Foucault material cited elsewhere in this chapter, Althusser (2003, 221–305), and Badiou (2001, 4–17).

Digital materiality? How artifacts
without matter, matter

by Paul M. Leonardi

Abstract

It sounds rather odd to say that digital artifacts — like software — have material properties because people generally think of materials or materiality as physical substances such as wood, steel, and stone. Yet scholars increasingly talk about the “materiality” of digital artifacts. What do they mean? In this paper, I explore two definitions of the adjective “material” — practical instantiation and significance — in addition to its normal connotation as matter. I argue that treating materiality as the practical instantiation of theoretical ideas (like policies that allow women to vote help make material the idea that sexes are equal) or as what is significant in the explanation of a given context (like material evidence in a courtroom trial) provides a more useful framework for understanding how digital artifacts affect the process of organizing. I contend that moving away from linking materiality to notions of physical substance or matter may help scholars of technology integrate their work more centrally with studies of discourse, routine, institutions and other phenomena that lie at the core of organization theory, specifically, and social theory more broadly.

Contents

[What is “materiality?”](#)

[From “matter” to “practical instantiation” and “significance”](#)

[Why focus on different definitions of material?](#)

If someone asked you to point your finger at an organization, at what would you point? Would you point at a person? A group of people? What about the sign reading “XYZ Corporation” carefully placed on the lawn in front of an office building? How about the office building? Would you point your finger at desks? Computers? Conveyor belts? You might answer that no one thing alone is an organization and you would argue instead, as theorists have been doing recently (Fayard and Weeks, 2007; Orlikowski and Scott, 2008; Pentland and Feldman, 2007), that organizations are made up of people doing work with material artifacts. Following such a definition you’d likely point to both people and the technologies (both of which might be broadly called “artifacts”) they use to do their jobs.

Despite the fact that artifacts occupy a central role in the process of organizing, organizational theorists have spent the last few decades managing to carefully avoid pointing their fingers at them. Beginning with the importation of micro-sociological concepts such as the performance (Goffman, 1961), the contract (Garfinkel, 1967) the negotiation (Strauss, 1978) the practice (Bourdieu, 1977) and structuration (Giddens, 1979) into the field of organization studies in the 1970s and 1980s, organizational researchers have increasingly pointed their fingers at the space between things. Drawing on these influences, authors such as Van Maanen (1975), Weick (1979), Smircich (1983)

and Barley (1986) began to advocate an approach that treated organizing as a process created, perpetuated, and changed by patterns of interaction between people. The decidedly agentic perspective that accompanied this approach has focused many researchers' attention on how those patterns of interaction catalyze networks, crystallize into routines, and concretize as institutions.

Although procedural views of organizing successfully highlight the importance of human interaction in organizational dynamics, they often refrain from looking at those artifacts around which such interaction occurs. As Orlikowski [1] notes: "A quick perusal of much organization literature reveals the absence of any considered treatment or theorizing of the material artifacts, bodies, arrangements, and infrastructures through which practices are performed." Orlikowski and others (Schatzki, 2005; Suchman, 2007) have thus called for more theorizing about the artifacts people use in organizations, suggesting that the *materiality* of those artifacts is consequential for our understanding of the organizing process. This notion of materiality seems to separate the physicality of artifacts like bodies, chairs, staplers, filing cabinets and drill presses from the more conceptual nature of discourses, routines, and institutions. While some authors argue that the boundaries between the physical and the conceptual are not fixed but rather constantly negotiated in practice (Latour, 2005; Orlikowski and Scott, 2008; Suchman, 2007), they usually submit, without protest, to the idea that the physical and the conceptual are phenomena of different orders. The physical (obviously) can be touched while the conceptual cannot. Physical things are made up of materials like flesh, bone, wood, glass, steel, and plastic — each one with its own matter. These material properties offer certain opportunities and constraints that simply cannot be overcome — you cannot see through wood or light glass on fire. Although the content of an institution or the contours of a routine may seem as difficult to change as the arrangement of polymers in a plastic, the conceptual offers a particular freedom of improvisation and re-creation that the physical does not — simply because it lacks matter.

Were there only physical artifacts and conceptual innovations it would be relatively simple to define materiality as physical matter and to specify how the properties of those artifacts enable and constrain people's actions in ways that are distinct from how people act in response to norms and rituals. Today, organizing is frequently accomplished with the aid of software-based digital artifacts. A digital technology like a word processing program or a finite element solver is an artifact that is not comprised of matter and cannot be touched or, in the case that it runs in the background on one's computer, even pointed to. Although it has no physical properties, software clearly does not exist in the conceptual domain because it provides hard constraints and affordances in much the same way as physical artifacts do. Indeed, many researchers suggest that software, intangible though it may be, can be described in terms of its materiality (Hutchby, 2001; Jackson, 1996; Leonardi, 2007; Orlikowski, 2007; Suchman, 2000; Volkoff, *et al.*, 2007). Yet as digital artifacts, software-based information technologies are not built of materials, *per se*. Thus, as Leonardi and Barley [2] note: "because most information technologies are software rather than solid physical objects, it may seem odd to say that information technologies have 'material properties'."

In this paper, I pose the question "Can digital artifacts have materiality?" In exploring an answer, I consider three definitions of materiality taken from the *Oxford English Dictionary*: Materiality as (1) matter; (2) practical instantiation; and, (3) significance. I argue that if materiality is defined simply as matter, that digital artifacts cannot be said to have materiality. However, when materiality is understood to represent the practical instantiation and the significance of an artifact, digital artifacts can clearly be seen to have materiality. In summary, I argue for using these two alternative definitions as lenses through which to understand the influence of "digital materiality" in the organizing process. I also suggest that using these alternate definitions can help researchers to integrate studies of digital artifacts with other types of intangible phenomena, such as routines and discourse, which are at the core of most all theories of the organizing process.

What is “materiality?”

In recent years, the term “materiality” has been cropping up in the works of authors in management, communication studies, and sociology, to name a few places. But what does this word mean. Let’s begin by taking a look at how it is used in context across a number of fields.

In the field of management, Orlikowski [3] has begun to make the argument that even though organizations are saturated with new digital artifacts, research “largely disregards, downplays, or takes for granted the materiality of organizations.” Although she does not explicitly define “materiality” in her paper, she makes the following association:

“Consider any organizational practice, and then consider what role, if any, materiality may play in it. It should be quickly evident that a considerable amount of materiality is entailed in every aspect of organizing, from the visible forms — such as bodies, clothes, rooms, desks, chairs, tables, buildings, vehicles, phones, computers, books, documents, pens, and utensils — to the less visible flows — such as data and voice networks, water and sewage infrastructures, electricity, and air systems.” [4]

Broadly, Orlikowski seems to define materiality as “stuff.” I say “stuff” because a definition of materiality as “object” would imply tangibility — tactile experience. To be sure, one need only open up any dictionary and look for the entry “object” to find a long list of items that can be touched. In Orlikowski’s definition, examples of clothes, tables, and books represent “tangible stuff”; they can be touched and are constructed of physical materials (they are “objects”). But data and electricity are not objects. They are “stuff” without a tangible character. You can’t touch data. You can touch the paper (an object) upon which data is written; you can touch the screen (an object) upon which data is displayed; but you can’t touch the data itself. Other “stuff” like voice networks are certainly comprised of both tangible and intangible “stuff.” You can touch the copper wires or fiber-optic cables over which voice is transmitted; you can touch the routers and switches through which the direction of voice is channeled, but you can’t touch the data packets in which the sounds of voice are encoded. For Orlikowski, tangibility — and thus matter — is clearly not a necessary component of the definition of materiality. Indeed, the empirical case that Orlikowski offers in her paper focuses on people’s “everyday engagement with the materiality of the Google search engine.” [5]

Ashcraft, *et al.* (2009) argue that the field of communication’s turn towards constitutive models of communication (models based on the premise that communication generates, as opposed to simply transmits, reality) has skewed researchers’ attention to the symbolic as opposed to the material. They argue that communication theorists must be “accountable to the materiality of organizing,” which they define as “objects, sites, and bodies” if they are to maintain relevance and theoretical and practical import [6]. At first glance, materiality seems to imply tangibility. You can touch objects, that exist within specific sites like desks, chairs, walls, computer monitors, etc. and you can touch bodies. Yet later the authors argue that “materiality entails ‘brute facts’ and ‘institutional facts’” [7] and they draw on the work of communication researchers like Fulk and colleagues (Fulk, *et al.*, 1996) who studied networked database software applications, Poole and DeSanctis (DeSanctis and Poole, 1994; Poole and DeSanctis, 1992) who studied group-decision support software, and Rice and Danowski (1983) who studied voice messaging software along with communication researchers. Whereas objects, sites, and bodies, make it easy to define materiality as having some tangible character, software does not.

Trevor Pinch [8] argues that traditional sociological studies “carve up the world ... such that sociologists deal only with social things. The world of objects, machines, and materials are left unanalyzed or considered the territory of others, perhaps scientists and engineers.” Pinch asserts that

sociology has not dealt with materiality, which he defines as “the world of objects and things” [9] and he provides numerous accounts drawn from sociological studies of how technologies are treated purely as symbolic as opposed to “material.” He suggests that some sociologists who have realized this lack of research into the “material” have begun to study “material practices.” In a characteristically cheeky way, Pinch rightly asks, “What exactly do [scholars] mean by the ‘material’ in ‘material practices’?” [10] After careful reflection, he notes,

“The word ‘material’ here seems to signify a practice that is grounded in the everyday, in the world of material things and may involve the exchange or manipulation of material things but by and large the materialness of the things does not itself figure in the analysis.” [11]

To move materiality to a more prominent position in sociology, Pinch reviews studies that chart the development and use of a number of “material artifacts” to show how they are fundamentally transformed by sociological practices and, subsequently, transform them. To make his case he draws on some material artifacts that are physical, like the bicycle (Bijker, 1995) and the car (Kline and Pinch, 1996), some that are digital, like electronic publishing software (Boczkowski, 2004), and some that are in-between like the synthesizer (Pinch and Trocco, 2002), which in its digital (as opposed to analogue) form consists of both hardware and software.

These three examples from management, communication, and sociology, limited though they are, demonstrate that scholars who have spent a good deal of time thinking about “materiality” have a hard time defining it. Most begin with some definition that references physical objects, but in providing empirical examples of “materiality” at play in the world they quickly begin to point to digital artifacts like software.

These examples seem to suggest that perhaps the physical matter out of which objects are constructed is not all that important when defining materiality. Following Pinch, perhaps a better strategy than attempting to define materiality (the noun) — since it seems so messy to do — is to look at how scholars use the adjective “material” when they refer to intangible artifacts, like software. Across a range of disciplines including management, communication, and sociology, but extending to human-computer interaction, science and technology studies, economics, and political science, authors increasingly write with the use of the adjective “material.” As just a few examples, Orlikowski [12] writes about groupware software that the technology embodies “particular symbol and material properties.” She provides several examples of the “material properties” of groupware, which include its features contained in menus embedded in the program. Volkoff, *et al.* [13] describe the enterprise resource planning software that they study as having “material aspects” such as algorithms that allow financial transactions and features that permit only certain people to authorize accounts and payments. Leonardi [14] documents use of a help-desk queuing software used by IT technicians and argues that its “material features” make possible activities such as assigning jobs or documenting what one did to solve a particular used problem.

In each of these examples, the adjective “material” seems to refer to some property of the technology (in these cases, software) that provides users with the capability to perform some action. Calling these properties out with the adjective “material” seems a ploy to remind the reader that the software-in-use does things that cannot be reduced to human intention or action. Pickering [15] expresses this idea quite succinctly: “I find it hard to imagine any combination of naked human minds and bodies that could substitute for a telescope, never mind an electron microscope or for a machine tool, or for an atom bomb.” In other words, calling something material emphasizes its performativity — the notion that it provides people with capabilities that they can use to accomplish their goals (Pickering, 2001).

Yet what are these capabilities, exactly? As we saw above, most authors who proffer either a direct or an associative definition of materiality link the term to matter — tangible stuff. But the empirical studies they offer are often focused on artifacts that have no physical matter — no tangible stuff. From this vantage point, it seems that the traditional view of materiality as “matter” is not appropriate, nor does it convey the importance of software’s role in organizing activities. It appears, then, that we have two options. The first is to drop the adjective “material” when discussing digital artifacts. If “material” means “matter” and software has no matter, we are best off to dispense with the inaccurate modifier. But if we think there is something important about software or other intangible artifacts that distinguish them in key ways from patterns of interaction, talk, or other social practices, and that the word “material” points to that distinction, a second option would be to consider how the adjective can be used to represent these differences. In the next section I turn to two alternative definitions of “material” that move the term away from definitions of “matter” and into territory that is more useful for describing what it is that intangible artifacts do for social interaction.

From “matter” to “practical instantiation” and “significance”

The *Oxford English Dictionary* provides three major definitions for the adjective “material.” They are:

1. Senses related to physical substance: *Formed by or consisting of matter*
2. Opposed to formal: *Designating the practical aspect of something as opposed to the theoretical aspect*
3. Having significance or relevance: *Of serious substantial import; significant, important, of consequence.*

Each of these definitions provides a different account of what it means for an artifact to be “material.” In what follows, I briefly explore each of these definitions and consider the consequences they have for the materiality of intangible artifacts.

1. Senses related to physical substance: *Formed by or consisting of matter*

To be sure, the definition of “material” as a physical substance is the most common. If you were to ask a friend to list the materials that make up an object — say a table — they would have little trouble pointing out the wood used for the flat writing surface, the metal used for the tracks upon which the drawers glide and the plastic used for the handles on those drawers. But, as discussed above, if you asked someone to list the materials that make up a piece of software like Microsoft Word, the task would not be so simple. One might argue that the keyboard upon which one types, the monitor upon which one looks to see the text, and the hard drive upon which the software is stored all have matter and that these tangible artifacts are part of interacting with or experiencing the software. Although critics would be correct that one cannot experience MS Word without a monitor, keyboard or hard drive, the software has no physical matter of its own (even though its code is mediated by electronic signals and it relies on physical artifacts such as disk drives and processors for its execution).

Over the years, researchers have shown that physical artifacts’ matter matters for the way people organize their work. Edwards (1979) documented how the introduction of conveyer belts into meat packing plants changed the way that employees conducted their work. The conveyor belt moved at a certain speed and the workers had no ability to change it. If they did not speed up the pace of their

work so as to assure that animal carcasses would not fall off the moving belts they would be fired. The belt was a physical force with which the workers had to contend. Barley (1988) illustrated that a newly implemented computed tomography scanner changed the ways that radiologists worked when performing patient scans. The scanners had new physical properties: a new set of cameras arranged in new layouts to take patient images, and new screens to see the results of the films shot by those cameras. As Barley documents, radiologists were not initially sure how to position patients and read films. The physical nature of the machine required a change to the way work was conducted.

In both cases above, workers had to contend with the physical matter of new technologies. These devices provided hard constraints on the way people worked. Yet authors such as Suchman have argued that the matter that comprises physical artifacts is not, in and of itself, important in shaping human action. Providing the example of a hammer, whose matter consists of steel and wood, Suchman [16] argues: “Although the durable materiality of the hammer supports the statement that it exists before and after the moments of its use, it is nonetheless clear that its status as a hammer rests on its incorporation into the practices of some form or carpentry.” Suchman’s argument is that the matter of a hammer is of little consequence until it is marshaled in the accomplishment of some human action. In other words, the physical matter of the artifact begins to matter only as one utilizes it to achieve a particular goal. Thus, to understand why the physical matter of Edwards’ conveyer belt mattered in the work of meat packers we would need to understand how it was taken up in their work. Similarly, to understand why the physical matter of Barley’s scanner mattered in the work of radiologists we would need to explore how it became embedded in their interactions with each other and with other roles at their hospitals.

One could easily substitute a compiler, or a spreadsheet, or a simulation software for the hammer in Suchman’s observation and reach the same conclusion: That they have effects on the way people interact only when they are incorporated into people’s actions. Consequently, perhaps what matters most about an artifact is not what it’s made out of, but what it allows people to do. In an effort to explain how animals perceive their environments, James Gibson, a perceptual psychologist, made a similar point. Gibson [17] observed that that people, surfaces, and objects all offered certain “affordances” for action:

“If a terrestrial surface is nearly horizontal ... nearly flat ... sufficiently extended ... and if its substance is rigid ... then the surface *affords* support It is stand-on-able, permitting an upright posture for quadrupeds and bipeds ... Note that the four properties listed — horizontal, flat, extended, and rigid — would be *physical* properties of a surface if they were measured with scales and standard units used in physics. As an affordance of support for a species of animal, however, they have to be measured *relative to the animal*. They are unique for that animal. They are not just abstract physical properties.” (emphasis in original)

In Gibson’s formulation, people do not interact with an object prior to or without perceiving what the object is good for. As he suggests, the physical matter of an artifact exists apart from the people who use it, but that physical matter is infused with meaning “relative to the posture and behavior of the animal being considered.” [18] Although the physical matter of an artifact is common to each person who encounters it, the affordances of that artifact are not. Affordances are unique to the particular ways in which an actor perceives materiality. To this end, Gibson [19] offers an explanation of the relationship between matter and affordances:

“The psychologists assume that objects are composed of their qualities ... color, texture, composition, size shape

and features of shape, mass, elasticity, rigidity, and mobility ... But I now suggest that what we perceive when we look at objects are their affordances, not their qualities. We can discriminate the dimensions of difference if required to do so in an experiment, but what the object affords us is what we normally pay attention to.”

Because matter can provide multiple affordances, it is possible that one artifact can produce multiple outcomes.

Gibson’s work has been most notably applied to discussions of technology by Norman (1990; 1999). Norman argues that good designers purposefully build affordances into artifacts to suggest how its material properties should be used. Norman [20] suggests that affordances are intrinsic properties of artifacts and that the role of design is to make affordances easily perceptible to would-be users. For Norman, affordances are “designed-in” properties of artifacts. The goal of an affordance is to signal to the user what the technology can do and how it is to do that thing. To do this, designers must make affordances easy to perceive: “The designer cares more about what actions the user perceives to be possible than what is true.” [21] Users are important to Norman inasmuch as they can identify a technology’s affordances; however, they play little role in creating affordances. Instead, affordances are created strategically by designers. In this formulation, Norman’s argument is different than Gibson’s in that Norman claims affordances do not change across different contexts of use; rather, they are always there waiting to be perceived.

Hutchby (2001) seeks a middle ground between these prior views by emphasizing the relational character of affordances. In his view, affordances are not exclusively properties of people or of artifacts — they are constituted in relationships between people and the materiality of the things with which they come in contact. Hutchby uses the term “materiality” as opposed to matter because he believes that people create affordances of both physical and digital artifacts. In this formulation, materiality exists independent of people, but affordances do not. Because people come to materiality with diverse goals (Pickering’s useful operationalization of human agency) they perceive a technology as affording distinct possibilities for action. For Hutchby, the affordances of an artifact can change across different contexts even though its materiality does not. Similarly, people may perceive that an artifact offers no affordances for action, perceiving instead that it constraints their ability to carry out their goals.

This discussion of affordances pushes us to ask whether physical matter really matters at all. If what is important about “material” artifacts is how they are perceived and subsequently used, as opposed to what they are made of, then using the adjective “material” to denote that an object has a physical substance would seem relatively unimportant for explaining the contours of social interaction. In other words, researchers who study digital materiality lose little by focusing on contexts in which there is no physical matter. Thus, when those researchers describe digital artifacts as having “material” properties, aspects, or features, we might safely say that what makes them “material” is that they provide capabilities that afford or constrain action.

2. Opposed to formal: *Designating to the practical aspect of something as opposed to the theoretical aspect*

A second definition of “material” emphasizes the practical instantiation of a theoretical idea. The *Oxford English Dictionary* suggests that this definition of material is used in mathematics when a person “designates a number or a number as applied to a specific set of objects rather than treated abstractly or formally in itself.” One might think of justice as an abstract or theoretical construct that is made material through the creation of laws or regulations. Or, one might think of a worth as a theoretical idea that is made material when an item is assigned a specific monetary value. When principles, beliefs, or values are made manifest in some way, they become material.

Consider the work of those who manage the design of new cars. These managers have to assure that engineers are designing all of the vehicle's subsystems in adequate ways. To do so, they might map out a series of procedures that engineers should follow to assure that all of the appropriate design steps have been taken. These procedures, and the relationships between them first exist in some manager's head, then move to talk between managers, and then, after some verbal revision, to a sheet of paper such as the one presented in Figure 1. This figure illustrates the process by which managers believe engineers should set-up a computer simulation model of a crash test. As the process chart illustrates, the engineers should begin by creating new geometry (shape) data or by utilizing existing FE (finite element) models and then move to building a preliminary model. After this, engineers follow steps in a specific sequence until they can measure section forces in the models (how much force a specific area of the model received during impact).

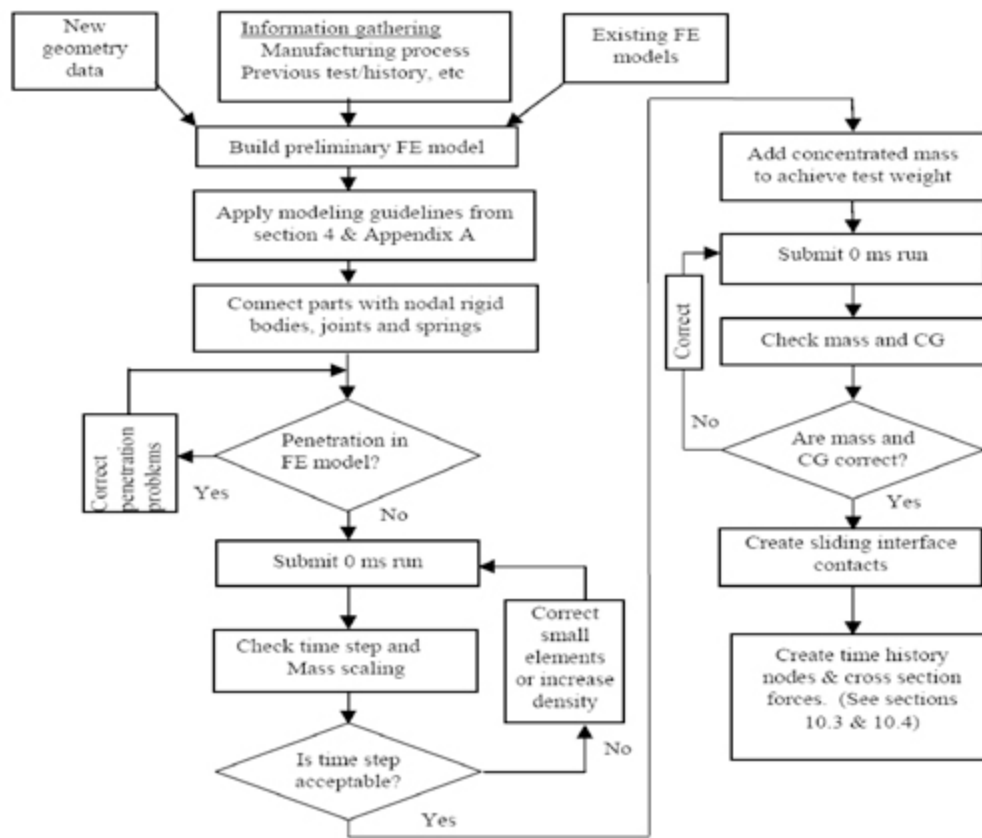


Figure 1: Abstract process for setting up a computer simulation for a crash test.

Although this process model is quite detailed, it is still abstract in the sense that the idea (or its inscription on a piece of paper) goes no distance to ensuring that the steps are actually completed as they are laid out. The idea has yet to become material. In order to give this idea materiality (instantiate it in some way), managers have a number of choices. They could establish a policy indicating that all computer simulations must follow these steps or the engineer's contract with the company would be terminated. They could refuse to look at any results of a simulation that were not generated by setting up the model with the process. Or they could create a piece of software that walks engineers through the process, thus ensuring that it is completed as was desired. Figure 2 provides an image of a piece of software created to make the abstract process material. This piece of

software, called a virtual crash laboratory, guides engineers through each of the steps in the abstract process. The software will not let them move to a new step without completing one that came before it. Consequently, the abstract process of setting up a computer simulation is made material through the software artifact.

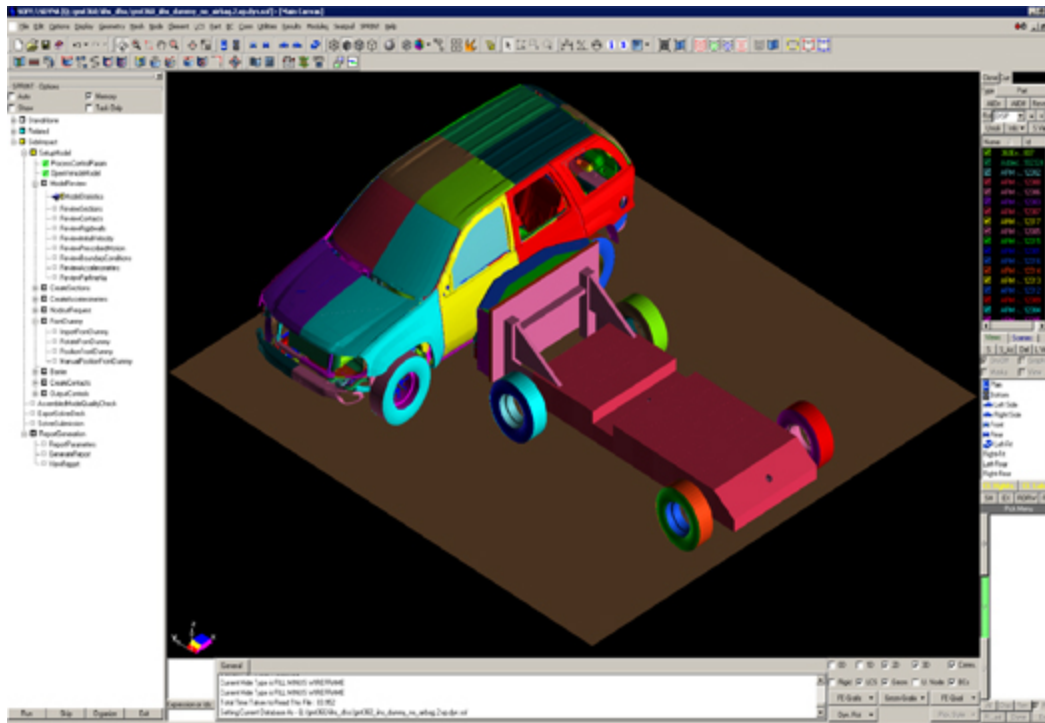


Figure 2: Material instantiation of process in software.

If material is defined as having physical matter, the software is not material. But under the second definition of material, the software clearly helps to instantiate the abstract idea of management. As alluded to above, the software was not the only medium through which the abstract process could become material; organizational policies or specific routines of refusing work could have served this function too. What these policies, routines, and software all have in common is that they exploit some type of social practice that compels people to follow the abstract plan. Thus, to say something is “material” in this definition would be to emphasize its ability to instantiate ideas in practice. Orlikowski’s groupware technology could be considered to have “material properties” if those properties permitted the execution of some abstract idea for collaboration. Volkoff, *et al.*’s ERP system would have “material aspects” if it provided facilities to enact inter-departmental coordination. And, Leonardi’s help-desk queuing system could be said to have “material features” if it allowed the desired knowledge sharing among technicians.

If one considers materiality using this second definition, it matters little whether an artifact has matter or not. Whether in physical or digital form, an artifact that translates idea into action is material. Of course, not all artifacts make this translation. Even those designed specifically to move thought into the realm of action often fail to do so because people reject them because they cannot understand what value they will bring to their work (Leonardi, 2009) or they use them, but appropriate them in unanticipated ways (DeSanctis and Poole, 1994). In this sense, one could look around at workplace at a number of artifacts, physical or digital, and claim that they are not “material” in the sense that they are not being used to translate some idea into action. This understanding of “material” may help to explain why it is that many software technologies used in

workplaces fail to bring about desired organizational changes (Markus, 2004). Only some artifacts are material, and it is not necessarily those with matter.

3. Having significance or relevance: *Of serious substantial import; significant, important, of consequence*

The third definition of “material” emphasizes significance. This sense of material is used in law to describe witnesses (“material witness”) or facts (“material facts”). Material, when used in this way, refers to only those things (*e.g.*, witnesses or facts) that are pertinent to the task at hand (*e.g.*, proving the defendant’s innocence). This sense of the term material is also used in accounting where it refers to the importance or significance of an amount, transaction, or discrepancy. In accounting, what is material is highly subjective, though, according to the Financial Accounting Standards Board a transaction is material if its “omission or misstatement could influence the economic decision of users taken on the basis of the financial statement.” [22] In short, this definition suggests that something is “material” if it makes a difference in the current situation.

It is not strange to think that, for a user, some features of an artifact might be material (significant) while others are not. Consider the many features in the photo-editing software Adobe Photoshop. As Figure 3 demonstrates, one can pick from any number of menus and discover a variety of features (*e.g.*, blur, sharpen, pixelate) that can be used at a given time. Some are extremely important to a certain set of users, while others are not. You might imagine that the “blur” feature is important for editors of high school yearbooks attempting to hide blemishes, while the “sharpen” feature is important for law enforcement professionals who are attempting to read the license plate numbers on a passing car. Conversely, if an amateur user is trying to touch up a night-time shot of the Burj Al Arab hotel from his vacation, it is possible that none of these features make a significant difference in his ability to accomplish his goal. Just like a material fact in a case, a piece of software can have certain material features — features that are “more significant” to the user than others. Of course, significance changes across populations of users, and may even change for one user over time. So, researchers should ask, when examining practices of use, which features are “material” (significant) for this user and how those features become significant for the type of work she does, for whom she interact with, or for maintaining control.

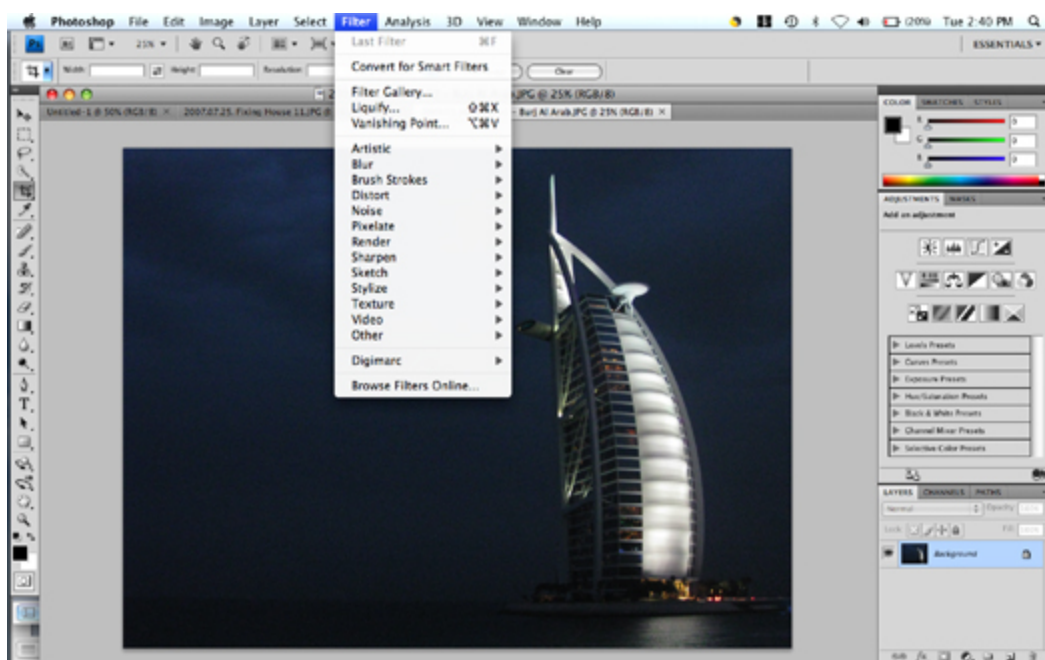


Figure 3: What features are “material” in a digital artifact?

In recent years, Orlikowski's (2000) notion of a technology-in-practice has become common in discussions of technology and organizing. Orlikowski distinguishes a technology-in-practice from a technological artifact. The artifact is the thing that people use. It is the same regardless of who is using it in whatever context. Technology-in-practice refers to the way the technology is used. In the physical realm a chair would be a technological artifact whose form does not change depending upon what office it is in, nor does the steel or wood it is made from. But as technology-in-practice, a chair can be used as a seat, as a ladder, or as a toy (to spin on, of course!). Digital artifacts can also be turned into technologies-in-practice. A user in Chicago who buys Photoshop from the college bookstore gets the same set of features as a user in Tulsa who buys the software from a stand at the local mall. But the same digital artifact can become very different technologies-in-practice as users employ the artifact's features for different purposes, such as those outlined above.

Such a conceptualization of "material" suggests that although an artifact may have many features, not all are equally significant to everyone. Further, not all features are significant for particular purposes. Adopting a definition of "material" as significant, would lead authors to use the adjective in a way that points to those features or aspects of a digital artifact that are significant for accomplishing certain types of work. For example, a pivot table might be a "material property" of MS Excel for a financial analyst while the regression function in Excel's analysis tool pack might be a "material property" for a market researcher. Under the first definition of "material" neither the pivot table nor the regression function would qualify because neither have physical substance. Under the second definition, one might be able to make the case that one or both of these features is an instantiation of a more theoretical idea (*e.g.*, the logic of charts or sampling distributions), but this link is at best, far removed, and at worst, tenuous. Given the third definition of material as significance, neither feature need qualify, but either can depending upon the context in which it is used.

Further, to define significance, one needs to ask, "significant for what?" A pivot table may be significant for persuading a client to invest in an IRA, but it may not be significant for changing the status hierarchy among analysts in a financial consulting firm. This third definition reminds us that a digital artifact, or its features, may be material in some ways, but not in others.



Why focus on different definitions of material?

Over the past decade, students of technology and organizing have labored to describe the relationship between artifacts and informal organizational structures in a theoretically adroit and empirically defensible way, seeking to find some middle ground between extreme positions of determinism, on the one side, and voluntarism on the other. Early work attempted to swing the pendulum away from theoretical explanations that emphasized the logic of determinism. To do so, they conceptualized technology as existing independent of structure, but lacking causal priority; in other words, technology was treated either as an occasion for people to enact new patterns of organizing (Barley, 1986; 1990), or as something that changed organizing practices and was changed by them (DeSanctis and Poole, 1994; Orlikowski, 1992). Both approaches allowed technology an important role in the organizing process while emphasizing the contingent and socially shaped nature of the changes it wrought.

Today, researchers continue to wrestle with the problem of incorporating the materiality of artifacts into voluntaristic theories of change. This problem appears to emerge, in large part, because practice theorists have adopted a definition of structure from structuration theory, which characterizes it as consisting of rules and resources. Moreover, Giddens [23] suggests that "structures refer to a virtual

order of relations,” thus, by implication, requiring rules and resources to be of a virtual order too. As Monge and Contractor (2003) suggests, it is easy to conceptualize organizing practices as virtual rules that guide people’s understandings of who they should communicate with and what they should communicate about. However, many researchers argue we consider artifacts to be resources that can be drawn upon to alter who people organize, it is not so easy to conceptualize them as having a virtual character because they are “material” (using the first definition) in nature; that is, they have a form and substance that transcends space and time. Thus, as Sewell [24] argues, it is “hard to see how such material resources can be considered as ‘virtual,’ since material things by definition exist in space and time. It is, moreover, only in particular times, places, and quantities that such material objects can serve as resources.”

To deal with this problem that organizing structures can have ‘only a virtual existence’ [25], but that artifacts have a material (substance) nature, practice-based approaches emphasize that only technologies-in-use, not technological artifacts, can shape organizing processes. In other words, although technologies are material artifacts, their materiality can only bring change if people recurrently enact them as technologies-in-use. Therefore, as Orlikowski [26] argues, it is the technologies-in-practice, not the technological artifacts, that ‘are the set of rules and resources that are (re)constituted in people’s recurrent engagement with the technologies at hand.’

Such debates over whether or not an artifact can be a resource that people use to change the organizing process are clearly based on a definition of ‘materiality’ as substance. Some critique this view out of hand because most of the artifacts that researchers today study are digital, not physical, and thus have no substance anyway (Leonardi and Barley, 2008; Vaast and Walsham, 2005). Others critique it instead for its ontological inconsistencies (Woolgar, *et al.*, 2009). But if materiality were to be defined in terms of practical instantiation or significance, voluntaristic theorists would likely have few qualms with it for ‘material’ would refer not to inherent properties of the artifact, but instead to the way that the artifact exists in relationship to the people who create and use it. These alternative, relational definitions move materiality ‘out of the artifact’ and into the space of interaction between people and artifacts. No matter whether those artifacts are physical or digital, their ‘materiality’ is determined, to a substantial degree, by when, how, and why they are used. These definitions imply that materiality is not a property of artifacts, but a product of the relationships between artifacts and the people who produce and consume them.

Researchers frequently lament that studies of the organizing process rarely consider the artifacts that people use when communicating and interacting with others (Fayard and Weeks, 2007; Orlikowski and Scott, 2008; Zamutto, *et al.*, 2007). Orlikowski and Scott [27] observe, for example, that artifacts are ‘missing in action’ in studies of the organizing process and Leonardi and Barley [28] argue that ‘even the most influential studies of organizations and information systems focus primarily on social dynamics or on how people interact with each other around the technology, rather than providing evidence of what specific material features people use.’ Pinch [29] perhaps makes the strongest claim when he notes that for traditional sociological studies of interaction and organizing ‘the material realm provides an object for signification processes to glob onto, but these processes are independent of the actual working or material composition of the object.’ All of these observers suggest that artifacts are overlooked in most research because organizational scholars from varying sociological perspectives all see the ‘social’ as their object of inquiry and the ‘material’ as the domain of scientists and engineers. Here, we again see the definition of ‘material’ as physical substance rearing its head. As Latour (2005) points out, social scientists often have a hard time understanding why they should study the physical when the social sciences spent so many years carving out a mandate for their existence by claiming unique expertise over ‘social’ and specifying the ‘social’ as something that exists independently and prior to the physical.

Whatever the reason, it seems true that organizational researchers have largely overlooked artifacts — physical and material — and continue to miss their importance in the organizing process. If it is the case that scholars are leery to journey into the world of the physical, defining “materiality” as

substance only widens the cleavage. But saying that artifacts have materiality in the senses of practical instantiation and significance may seem less strange because these are similar ideas that are used when describing other phenomena like discourse, routines, and institutions, which occupy a central role in organizational theory, specifically and social theory more broadly.

For example, authors such as Fairhurst and Putnam (2004) and Phillips, *et al.* (2004) argue that talk, or discourse with a “little d” brings ideology, or Discourse with “big D” into practice. That is, our everyday talk produces and reproduces ideologies that constrain and enable human action. While ideology exists in the world of theory, it can be practically instantiated in activity through the way people communicate. In this sense, discourse is “material” in the second definition in the same way as artifacts. As another example, Feldman and Pentland (Feldman and Pentland, 2003; 2005) argue that routines have both an ostensive and performative form. In their ostensive form, they are broad theories or plans for action. The ostensive aspect of a routine is instantiated in the world of practice through its performative character. Performing specific steps in the hiring routine activates and grounds the ostensive or theoretical guidelines that routines set forth. Were it not for their enactment in performance, routines’ ostensive character would be of little consequence for the organizing process. Put another way, routines are made material when their theoretical guidelines are transformed into specific performances.

Researchers who focus on discourse, routines, and institutions would also feel comfortable talking about their significance. Elsbach (2002) discusses how many institutions exist within organizations such as norms about seating arrangements or standards about acceptable dress, but that not all of them influence the way people perform their jobs. Only some institutions have significant impact, while most do not. In other words, not all institutions are “material” in the sense that they have an impact on people’s practices. Similarly, Mumby (1987) discusses that of the many different types of narratives circulating within organizational culture, only some are significant in shaping power relations and creating deference to authority. His analysis shows that not all talk is material in the sense that it can be used to shape action. Some talk is just talk without any particular effect.

As these examples illustrate, researchers who study phenomena central to organization theory, such as discourse, routines, and institutions expend great effort understanding how these phenomena become practically instantiated and theorizing the conditions under which they are significant in producing some type of stasis or change in the way work is organized. Scholars who attend to artifacts could join these conversations more easily if they worked from one of the latter two definitions of materiality instead of insisting that it is matter that matters. Especially in the case of digital artifacts, what may matter most about “materiality” is that artifacts and their consequences are created and shaped through interaction. 

About the author

Paul M. Leonardi is Assistant Professor of Communication Studies, Industrial Engineering and Management Sciences, and (by courtesy) Management and Organizations at Northwestern University in Evanston, Ill. where he holds the Breed Junior Chair in Design.
E-mail: Leonardi [at] northwestern [dot] edu

Acknowledgments

The author wishes to thank Bonnie Nardi and Jannis Kallinikos for recommending clarifications of the unconventional ideas presented herein. He hopes this paper will spark debate among scholars about how they should think about theorizing the materiality of things they can’t touch. A previous

version of this paper was presented at the 2009 meeting of the Academy of Management in Chicago, Ill.

Notes

1. Orlikowski, 2007, p. 1,436.

2. Leonardi and Barley, 2008, p. 162.

3. Orlikowski, 2007, p. 1,436.

4. *Ibid.*

5. Orlikowski, 2007, p. 1,439.

6. Ashcraft, *et al.*, 2009, p. 2.

7. Ashcraft, *et al.*, 2009, p. 24.

8. Pinch, 2008, p. 461.

9. *Ibid.*

10. Pinch, 2008, p. 463.

11. Pinch, 2008, p. 464.

12. Orlikowski, 2000, p. 406.

13. Volkoff, *et al.*, 2007, p. 843.

14. Leonardi, 2007, p. 816.

15. Pickering, 1995, p. 15.

16. Suchman, 2007, p. 21.

17. Gibson, 1986, p. 127.

18. Gibson, 1986, pp. 127–128.

19. Gibson, 1986, p. 134.

20. Norman, 1990, p. 9.

21. Norman, 1999, p. 39.

22. See the Financial Accounting Standards Board's (FASB) Auditing Standards number 47 "Audit risk and materiality in conducting the audit" for further elaboration.

23. Giddens, 1984, p. 304.

24. Sewell, 1992, p. 10.

25. Orlikowski, 2000, p. 406.
26. Orlikowski, 2000, p. 407.
27. Orlikowski and Scott, 2008, p. 434.
28. Leonardi and Barley, 2008, p. 163.
29. Pinch, 2008, p. 462.

References

- K.L. Ashcraft, T.R. Kuhn, and F. Cooren, 2009. "Constitutional amendments: 'Materializing' organizational communication," *Academy of Management Annals*, volume 3, number 1, pp. 1–64.<http://dx.doi.org/10.1080/19416520903047186>
- S.R. Barley, 1990. "The alignment of technology and structure through roles and networks," *Administrative Science Quarterly*, volume 35, number 1, pp. 61–103.<http://dx.doi.org/10.2307/2393551>
- S.R. Barley, 1988. "Technology, power, and the social organization of work: Towards a pragmatic theory of skilling and deskilling," *Research in the Sociology of Organizations*, volume 6, pp. 33–80.
- S.R. Barley, 1986. "Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments," *Administrative Science Quarterly*, volume 31, number 1, pp. 78–108.<http://dx.doi.org/10.2307/2392767>
- W.E. Bijker, 1995. *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*. Cambridge, Mass.: MIT Press.
- P.J. Boczkowski, 2004. *Digitizing the news: Innovation in online newspapers*. Cambridge, Mass.: MIT Press.
- P. Bourdieu, 1977. *Outline of a theory of practice*. Translated by Richard Nice. Cambridge: Cambridge University Press.
- G. DeSanctis and M.S. Poole, 1994. "Capturing the complexity in advanced technology use: Adaptive structuration theory," *Organization Science*, volume 5, number 2, pp. 121–147.<http://dx.doi.org/10.1287/orsc.5.2.121>
- R. Edwards, 1979. *Contested terrain: The transformation of the workplace in the twentieth century*. New York: Basic Books.
- K.D. Elsbach, 2002. "Intraorganizational institutions," In: J.A.C. Baum (editor). *Blackwell companion to organizations*. Oxford: Blackwell, pp. 37–57.
- G.T. Fairhurst and L.L. Putnam, 2004. "Organizations as discursive constructions," *Communication Theory*, volume 14, number 1, pp. 5–26.<http://dx.doi.org/10.1111/j.1468-2885.2004.tb00301.x>
- A.–L. Fayard and J. Weeks, 2007. "Photocopiers and water-coolers: The affordances of informal interaction," *Organization Studies*, volume 28, number 5, pp. 605–634.<http://dx.doi.org/10.1177/017084060606068310>

M.S. Feldman and B.T. Pentland, 2005. "Organizational routines and the macro-actor," In B. Czarniawka-Joerges and T. Hernes (editors). *Actor-network theory and organizing*. Malmö: Liber, pp. 91–111.

M.S. Feldman and B.T. Pentland, 2003. "Reconceptualizing organizational routines as a source of flexibility and change," *Administrative Science Quarterly*, volume 48, pp. 94–118.<http://dx.doi.org/10.2307/3556620>

J. Fulk, A.J. Flanagan, M.E. Kalman, P. Monge, and T. Ryan, 1996. "Connective and communal public goods in interactive communication systems," *Communication Theory*, volume 6, pp. 60–87.<http://dx.doi.org/10.1111/j.1468-2885.1996.tb00120.x>

H. Garfinkel, 1967. *Studies in ethnomethodology*. Englewood Cliffs, N.J.: Prentice-Hall.

J.J. Gibson, 1986. *The ecological approach to visual perception*. Hillsdale, N.J.: Lawrence Erlbaum.

A. Giddens, 1984. *The constitution of society: Outline of the theory of structuration*. Berkeley: University of California Press.

A. Giddens, 1979. *Central problems in social theory: Action, structure, and contradiction in social analysis*. Berkeley: University of California Press.

E. Goffman, 1961. *Encounters: Two studies in the sociology of interaction*. Indianapolis, Ind.: Bobbs-Merill.

I. Hutchby, 2001. "Technologies, texts and affordances," *Sociology*, volume 35, number 2, pp. 441–456.<http://dx.doi.org/10.1177/S0038038501000219>

M.H. Jackson, 1996. "The meaning of 'communication technology': The technology-context scheme," In: B. Burleson (editor). *Communication yearbook*, volume 19. Beverly Hills, Calif.: Sage, pp. 229–267.

R. Kline and T.J. Pinch, 1996. "Users as agents of technological change: The social construction of the automobile in the rural United States," *Technology and Culture*, volume 37, number 4, pp. 763–795.<http://dx.doi.org/10.2307/3107097>

B. Latour, 2005. *Reassembling the social: An introduction to actor-network theory*. Oxford: Oxford University Press.

P.M. Leonardi, 2009. "Why do people reject new technologies and stymie organizational changes of which they are in favor? Exploring misalignments between social interactions and materiality," *Human Communication Research*, volume 35, number 3, pp. 975–984.<http://dx.doi.org/10.1111/j.1468-2958.2009.01357.x>

P.M. Leonardi, 2007. "Activating the informational capabilities of information technology for organizational change," *Organization Science*, volume 18, number 5, pp. 813–831.<http://dx.doi.org/10.1287/orsc.1070.0284>

P.M. Leonardi and S.R. Barley, 2008. "Materiality and change: Challenges to building better theory about technology and organizing," *Information and Organization*, volume 18, pp. 159–176.<http://dx.doi.org/10.1016/j.infoandorg.2008.03.001>

M.L. Markus, 2004. "Technochange management: Using IT to drive organizational change," *Journal of Information Technology*, volume 19, pp. 4–20.<http://dx.doi.org/10.1057/palgrave.jit.2000002>

P.R. Monge and N.S. Contractor, 2003. *Theories of communication networks*. Oxford: Oxford University Press.

D.K. Mumby, 1987. "The political function of narrative in organizations," *Communication Monographs*, volume 54, pp. 113–127.<http://dx.doi.org/10.1080/03637758709390221>

D.A. Norman, 1999. "Affordance, conventions, and design," *Interactions*, volume 6, number 3, pp. 38–43.<http://dx.doi.org/10.1145/301153.301168>

D.A. Norman, 1990. *The design of everyday things*. New York: Doubleday.

W.J. Orlikowski, 2007. "Sociomaterial practices: Exploring technology at work," *Organization Studies*, volume 28, number 9, pp. 1,435–1,448.

W.J. Orlikowski, 2000. "Using technology and constituting structures: A practice lens for studying technology in organizations," *Organization Science*, volume 11, number 4, pp. 404–428.<http://dx.doi.org/10.1287/orsc.11.4.404.14600>

W.J. Orlikowski, 1992. "The duality of technology: Rethinking the concept of technology in organizations," *Organization Science*, volume 3, number 3, pp. 398–427.<http://dx.doi.org/10.1287/orsc.3.3.398>

W.J. Orlikowski and S.V. Scott, 2008. "Sociomateriality: Challenging the separation of technology, work and organization," *Academy of Management Annals*, volume 2, number 1, pp. 433–474.<http://dx.doi.org/10.1080/19416520802211644>

B.T. Pentland and M.S. Feldman, 2007. "Narrative networks: Patterns of technology and organization," *Organization Science*, volume 18, number 5, pp. 781–795.<http://dx.doi.org/10.1287/orsc.1070.0283>

N. Phillips, T.B. Lawrence, and C. Hardy, 2004. "Discourse and institutions," *Academy of Management Review*, volume 29, number 4, pp. 635–652.

A. Pickering, 2001. "Practice and posthumanism: Social theory and a history of agency," In: T.R. Schatzki, K. Knorr Cetina, and E. von Savigny (editors). *The practice turn in contemporary theory*. London: Routledge, pp. 163–174.

A. Pickering, 1995. *The mangle of practice: Time, agency, and science*. Chicago: University of Chicago Press.

T. Pinch, 2008. "Technology and institutions: Living in a material world," *Theory and Society*, volume 37, pp. 461–483.<http://dx.doi.org/10.1007/s11186-008-9069-x>

T.J. Pinch and F. Trocco, 2002. *Analog days: The invention and impact of the Moog Synthesizer*. Cambridge, Mass.: Harvard University Press.

M.S. Poole and G. DeSanctis, 1992. "Microlevel structuration in computer-supported group decision making," *Human Communication Research*, volume 19, number 1, pp. 5–49.<http://dx.doi.org/10.1111/j.1468-2958.1992.tb00294.x>

R.E. Rice and J.A. Danowski, 1983. "Is it really just a fancy answering machine? Comparing semantic networks of different types of voice mail users," *Journal of Business Communication*, volume 30, pp. 369–397.<http://dx.doi.org/10.1177/002194369303000401>

T.R. Schatzki, 2005. "The sites of organizations," *Organization Studies*, volume 26, number 3, pp. 465–484.<http://dx.doi.org/10.1177/0170840605050876>

- W.H. Sewell, 1992. "A theory of structure: Duality, agency, and transformation," *American Journal of Sociology*, volume 98, number 1, pp. 1–29.<http://dx.doi.org/10.1086/229967>
- L. Smircich, 1983. "Concepts of culture and organizational analysis," *Administrative Science Quarterly*, volume 28, pp. 339–358.<http://dx.doi.org/10.2307/2392246>
- A. Strauss, 1978. *Negotiations: Varieties, contexts, processes, and social order*. San Francisco: Jossey–Bass.
- L. Suchman, 2007. *Human–machine reconfigurations: Plans and situated actions*. Second edition. Cambridge: Cambridge University Press.
- L. Suchman, 2000. "Organizing alignment: A case of bridge–building," *Organization*, volume 7, number 2, pp. 311–327.<http://dx.doi.org/10.1177/135050840072007>
- E. Vaast and G. Walsham, 2005. "Representations and actions: The transformation of work practices with IT use," *Information and Organization*, volume 15, pp. 65–89.<http://dx.doi.org/10.1016/j.infoandorg.2004.10.001>
- J. Van Maanen, 1975. "Police socialization: A longitudinal examination of job attitudes in an urban police department," *Administrative Science Quarterly*, volume 20, pp. 207–228.<http://dx.doi.org/10.2307/2391695>
- O. Volkoff, D.M. Strong, and M.B. Elmes, 2007. "Technological embeddedness and organizational change," *Organization Science*, volume 18, number 5, pp. 832–848.<http://dx.doi.org/10.1287/orsc.1070.0288>
- K.E. Weick, 1979. *The social psychology of organizing*. Second edition. Reading, Mass.: Addison–Wesley.
- S. Woolgar, C. Coopmans, and D. Neyland, 2009. "Does STS mean business?" *Organization*, volume 16, number 1, pp. 5–30.<http://dx.doi.org/10.1177/1350508408098983>
- R.G. Zamutto, T.L. Griffith, A. Majchrzak, D.J. Dougherty, and S. Faraj, 2007. "Information technology and the changing fabric of organization," *Organization Science*, volume 18, number 5, pp. 749–762.<http://dx.doi.org/10.1287/orsc.1070.0307>

Editorial history

Paper received 4 May 2010; accepted 10 May 2010.

Copyright © 2010, *First Monday*.

Copyright © 2010, Paul M. Leonardi.

Digital materiality? How artifacts without matter, matter
by Paul M. Leonardi.

First Monday, Volume 15, Number 6 - 7 June 2010

<http://firstmonday.org/ojs/index.php/fm/article/download/3036/2567>



Chapter 3

COMPUTATIONAL ARTIFACTS

Technical artifacts are taken to include all the common objects of everyday life, such as chairs, televisions, paper clips, telephones, smartphones and dog collars. They are material objects, the engineered things of world that have been intentionally produced by humans in order to fulfill a practical function. In this regard, they differ from naturally occurring entities such as stars and rivers [240]. A central part of the analytic philosophy of technology aims to understand their nature, design, and construction, and it is from this perspective that we approach the artifacts of computer science.

3.1 Function and Structure

One of the claims of the philosophy of technology concerns the ontological status of technical artifacts: they are said to have a dual nature.

Technical artifacts are, at least *prima facie*, always physical objects, but they are also objects that have a certain function. Looked upon merely as physical objects they fit into the physical or material conception of the world. Looked upon as functional objects, however, they do not. The concept of function does not appear in physical description of the world; it rather belongs to the intentional conceptualization. Technical artifacts thus have a dual nature: they cannot exhaustively be described within the physical conceptualization, since this has no place for their functional features, nor can they be described exhaustively within the intentional conceptualization, since their functionality must be realized in an adequate physical structure. [135]

This insistence on the need for a purpose or function has led philosophers (eg. [135, 136, 138, 162, 216]) to argue that technical artifacts have a dual nature fixed by two sets of properties:

- functional properties
- structural properties.

For example, the purpose of a clock is to tell us the time, but how it does it, whether it is analog, digital, or based upon the sun's rays, is part of its structure. Likewise, the purpose of a car is transportation, but how it provides it, whether it is petrol, diesel or electric, is part of its structure. Structural properties present the artifact as a physical object or device. In engineering practice, the functional and the structural properties are often not separated in the description of an artifact. Nor, in the standard documentation associated with such artifacts, is there any indication of which is which. Nevertheless, from a logical perspective they constitute two very different forms of knowledge: one describes the physical characteristics of the artifact, and the other asserts what it is intended to do. Both are necessary components of the notion of a technical artifact: without one, it won't work; without the other, we don't know what working amounts to.

Moreover, the relationships between function and structure are central to our grasp of these concepts. Getting from function to structure is a creative activity; it is the crucial design stage of engineering. It requires the skill and expertise of the design engineer. It is also not possible to extract function from structure, but not because it is practically difficult and involves creativity; it is not possible for an entirely different reason. While by testing and experimentation we may be able to figure out what a device actually does, this may not be what it was intended to do: the design engineer may have got it wrong. A functional description must provide a black-box description that expresses what it is intended to do. While the structure determines what it actually does, the function is supposed to tell us what it ought to do. That is, the notion of function, while having a propositional content, is intentional in nature.

3.2 Design and Manufacture

The output of the design process is a structural description of an artifact, and there might be many structural forms that fulfill a given function. For example, in the case of clocks, one might be digital and the other analog, whereas in the case of computers, one might be a laptop and the other a desktop. The design process may itself be divided into several stages, where more informative structural descriptions emerge at each stage. Even so, the final description does not have to be a *complete* structural description in the sense that all the physical properties need to be included. In one sense this is obvious. A structural description of a bicycle frame might demand that it be blue and made of carbon fiber. But there are many different grades of the latter. We might insist that it be made of intermediate-modulus fiber where less material is required to get the same stiffness, and therefore a lighter structure. The degree and amount of detail vary from structural description to structural description.

But what governs such detail in practice? In simple cases the structural description is direct and close to a complete description of the artifact. For example, to describe a clock as made

of aluminum is to describe some of its physical characteristics. Other details might describe its internal mechanisms. However, some details may be left to the manufacturing process. This will be particularly pertinent to the kinds of artifacts found in computer science, where the distance between structural descriptions and physical devices is bridged by a complex process of implementation, and the input to this process may fall well short of a complete physical description. All that is required is that, relative to the implementation stage, there is sufficient detail to enable the production of the physical device; where detail is lacking, the implementation must supply it. So, what constitutes a structural description is relative to the state and sophistication of the implementation process. In some cases the latter is often automated, and involves no more input than the structural description itself. But this does not mean that there is no creative input in implementation. The latter is itself a complex technical artifact with a function and a structure. As such, it has associated design and implementation stages. The following schematic summarizes this view of technical artifacts:

$$\text{Function} \rightarrow \text{Design} \rightarrow \text{Structure} \rightarrow \text{Implementation} \rightarrow \text{Artifact}$$

This will be the perspective that we carry over to *computational artifacts* – the technical artifacts of computer science. Finally, notice that any manufacturing process generates instances of the design. The design of a Ford Focus does not correspond to one Ford Focus but to a *car kind*. In addition, the design might be parameterized for color or fuel type. So, when we use the term *artifact* we are actually referring to *artifact kinds*, where the actual physical objects are instances of these kinds.

3.3 Theories of Function

The duality thesis raises a crucial philosophical concern that is put in the following way by Kroes [136]:

Exactly how the physical and intentional conceptualisations of our world are related remains a vexing problem to which the long history of the mind-body problem in philosophy testifies. This situation also affects our understanding of technical artefacts: a conceptual framework that combines the physical and intentional (functional) aspects of technical artefacts is still lacking.

How do we relate the functional and the intentional? There are two standard theories that aim to address this question: the *causal* theories and the *intentional* ones. Causal theories insist that actual physical capacities determine function. Cummins's theory of functional analysis is an influential example: *no material object, no physical capacity, no technical function* [47]. The underlying claim is that, without the physical thing and its actual properties, there can be no actual artifact. There is an obvious truth here: without the physical device, there is no artifact and so there is no mechanism, and so no function is materialized. In particular, without a physical program running on an actual

physical machine there is no physical computation. But to conclude from this that the function is fixed by a physical device is to mistake a physical description for an intention.

To illustrate matters, consider a kettle. While it may boil water, it also, as a side effect, heats the material of the kettle itself. But what is it that determines that heat generation is a side effect and not part of the main function? More generally, how do we decide which physical properties form part of the function and which do not? On the simple-minded causal account of function, where the latter is fixed by the physical device itself, what the artifact actually does is its function, and so we cannot distinguish intended from accidental properties. If performance determines function, there is no notion of malfunction and correctness. The intentional aspect of function has been completely lost.

There has to be an intentional aspect, and the alternative theory embraces this: it puts agents and their intentions at the heart of any theory of function. The underlying assumption is that functions reflect the intentions of a designer. The theory begins with observations about everyday objects: for example, a television can serve as a doorstop or a toothbrush can serve as a cutlery cleaner. The fact that the same physical thing can serve many purposes has led some philosophers to suggest that the function of an artifact is dependent upon the decision of some agent – the one who decides it will be a toothbrush or a cutlery cleaner. It is agents who ascribe functions to artifacts. Good examples of this approach are [152, 201]:

[t]he function of an artifact is derivative from the purpose of some agent in making or appropriating the object; it is conferred on the object by the desires and beliefs of an agent. No agent, no purpose, no function [152].

But the introduction of agents and intentions brings some well-known problems. Where in this perspective, is the function located? On the naive intentional view, it is located in the mental states of the agent. Unfortunately, in their crude form, such theories have difficulty in accounting for how they impose any constraints upon the actual thing that is the artifact:

If functions are seen primarily as patterns of mental states, and exist, so to speak, in the heads of the designers and users of artifacts only, then it becomes somewhat mysterious how a function relates to the physical substrate in a particular artifact [138].

The problem with such mental theories is that we have lost all connection with the physical structure. As an agent, I can have all sorts of images in my head, but how do any such images connect with the structure of an artifact?

3.4 Computational Artifacts

How is the function expressed for computational artifacts, and how is the structure laid down? What is the relationship between the function and the structure, and between the structure and the actual

physical device? How are we to deal with the problems associated with the causal/intentional views of function in the case of computational artifacts? Somehow, the intuitions behind both theories need to be incorporated into any sensible theory. We need the insight that without the physical device there would be no materialized function, and without the perspective of an agent there would be no intention. In particular, two different kinds of intentional agents need to be addressed: designers and users. In general, engineers hold that it is the designer and implementer that play the critical role in determining the functions of artifacts, and we shall follow this perspective.

Answering these questions for the artifacts of computer science will not only put a great deal of flesh on the notion of a technical artifact, but also bring out some of the central properties and idiosyncrasies of the computational family. One aspect involves the role of formal languages. At both the functional and the structural level, computational artifacts employ formal languages for the expression of their functional and structural properties. And there is a rich and varied collection of these languages. This is one of the central features of the computational family: their descriptions, both functional and structural, are given in specially designed formal languages. Very largely, this is a consequence of the need for clarity and precision in their characterizing descriptions. These claims and observations will take a more concrete form as we proceed.

In the rest of this part of the book, concerned with ontology, we shall unpack and illustrate these ideas by reference to the central technical artifact kinds of computer science: computers, programs and software systems.

‘That which is lacking cannot be counted.’

(Ecclesiastes 1:15)

The Development of Normative Uses of Quantification

The notion of government has been simplified: numbers alone make laws and the law. Politics has been reduced to a question of arithmetic.

Alexis de Tocqueville, *The Old Regime and the Revolution*¹

SOME REMARKABLE HISTORICAL scholarship has been carried out over the last 30 years on the quantification of economic and social facts in the modern era,² showing the state's concern with perfecting instruments to measure its wealth and population. The most important of these instruments is *statistics*, a term derived from the German *Staatistik*, a 'science of the state' (*Staatswissenschaft*), but whose contents actually corresponded more to what in England was called 'political arithmetic'. The difference was that *Staatistik* sought to give an overall picture of the state without using quantification, whereas 'political arithmetic', or statistics, was entirely based on quantitative surveys.³ Although, in both cases, the normative uses of quantification seem to have the state as their central protagonist, in fact they were first developed in the private sphere, to assist in business management. We shall therefore start with this corporate sphere, before examining the much better known history of the rise of public statistics and calculations of probability. From the different uses of quantification, both private and public, we shall be able to tease out its four normative functions, as they developed historically: accounting; managing; judging; and legislating.

¹ A de Tocqueville, *The Old Regime and the Revolution*, Vol II, *Notes on the French Revolution and Napoleon* [1856], tr AS Kahan, ed and intr F Furet and F Mélonio (Chicago, University of Chicago Press, 1998) Ch 5, 57 [*tr mod*].

² cf F Bédarida, J Bouvier, F Caron, I Cloulas, Marec, Briand, Desrosières, et al, *Pour une histoire de la statistique*, Vol 1 (Paris, INSEE/Economica, 1987); P Cline Cohen, *A Calculating People: The Spread of Numeracy in Early America* [1982] (London, Routledge, 1999); L Daston, *Classical Probability in the Enlightenment*, 2nd edn [1988] (Princeton, Princeton University Press, 1995); A Desrosières, *La Politique des grands nombres. Histoire de la raison statistique* (Paris, La Découverte, 1993, 2000 (2nd ed)); TM Porter, *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life* (Princeton, Princeton University Press, 1995).

³ On these differences, cf A Desrosières, *La Politique des grands nombres* (ibid) 28ff.

I. ACCOUNTING

Accounting ledgers are doubtless the first modern expression of the link made between numbers and law, quantification and legal obligation. In its *Commercial Code*, French law defines the ‘financial obligations applicable to all traders’ in the following terms:

Article L 123-12—All natural or legal persons with the status of trader shall enter in their accounts the movements affecting the value of their company. These movements shall be recorded chronologically.

These persons must check the existence and value of the assets and liabilities of the company by means of an inventory at least once every twelve months.

They must prepare annual accounts at the end of the financial year in view of the entries made in the accounts and the inventory. These annual accounts shall consist of the balance sheet,⁴ the profit and loss account⁵ and an annex, all of which shall form an inseparable whole.

Article L 123-14—The annual accounts shall be honest and truthful and shall ensure a fair representation of the assets, financial situation and results of the company.

Where the application of an accounting requirement is not sufficient to ensure the fair representation indicated in this article, additional information must be provided in the annex.

If, in an exceptional case, the application of an accounting requirement proves to be unsuitable in order to ensure a fair representation of the assets, financial situation or results, an exception must be made to this. This exception shall be indicated in the annex and duly reasoned, with an indication of its effect on the assets, financial situation and results of the company.

In this definition, accounting operates within four legal parameters. First, *the obligation to prepare accounts*. Merchants must be able to account for their activities before third parties, and preparing accounts is part of this commercial liability, which is not solely to contracting parties but beyond this to the state and the public in general.⁶ The term ‘accountability’ precisely contains an idea of financial liability, requiring an *accountor* (who must render account), an *accountee* (to whom the accounts are submitted) and an *accountant* (who prepares the accounts). Today, accounting obligations are enshrined in law, but in the medieval period, when modern accounting was

⁴ The balance sheet shows the company’s assets at a particular moment, namely at the end of the accounting year.

⁵ This account shows the profit and losses for the accounting period, and justifies the overall result.

⁶ The concept of ‘commercial liability’ does not seem to have been studied for itself in recent doctrine. See the nomenclature of the tradesman’s responsibilities in Jacques Mestre, Isabelle Arnaud-Grossi, Laure Merland, Marie-Eve Pancrazi, Nancy Tagliarimo-Vignal, *Droit commercial*, 29th edn (Paris, LGDJ, 2012) 249ff, 236ff.

first invented, they were stipulated by the guilds, or what Berthold Goldman has called the *lex mercatoria*.⁷ Later, the Italian city states made book-keeping obligatory for merchants, as a system of proof and a way of preventing bankruptcy. Etymologically, 'bankruptcy' is the destruction of the bench; that is, the counter the bankrupt merchant had occupied in the marketplace. From the outset, then, keeping accounts was one of the merchant's responsibilities.

Secondly, accounting is a way of *accrediting a truth through an image*. The notion of 'fair view' (in French, '*image fidèle*'; a faithful image), which recurs in Article L 123-14 of the French Commercial Code (introduced via the European Directive no 78/660/CEE of 25 July 1978) is an abbreviation of the English formula, 'true and fair view'. The accounting image thus has the status of an icon: religious icons unite a community of the faithful around a religious truth, just as accounting images federate a community of merchants around a legally backed truth. With this shared faith in a divine guarantor for pledges made, merchants could obtain credit from one end of Europe to the other.⁸ As late as the nineteenth century, many industrialists placed their accounting books under the protection of God. And inversely, when the accounting image proves deceptive, such that it can no longer inspire collective belief, the whole community falls apart. This is what happened with the American company *Enron*. Having risen to stratospheric heights on the stock exchange, it crashed over a couple of weeks at the end of 2001, when the accounting ploys on which its apparent wealth had been based became known.⁹ The Sarbanes-Oxley Law passed by the American Congress in 2002 showed the lessons learnt: the law strengthened accounting regulations and attempted to break the collusion between companies and audit firms, but more importantly it reactivated the old religious principle on which the veracity of accounts is based, by obliging the heads and financial directors of quoted companies to certify their books under oath. Foreign companies trading on the US markets were under the same obligation, with stiff penalties for non-compliance.¹⁰ The accounts must be a true and a fair image because they are a vital pillar of the market system, a point of articulation of the true and the just. As such, accounting standards necessarily

⁷ B Goldman, 'Frontières du droit et *lex mercatoria*' in *Archives de philosophie du droit*, (Paris, Dalloz, 1964) 177; and, by the same author: 'La *lex mercatoria* dans les contrats et l'arbitrage internationaux: réalités et perspectives', *Clunet*, 1979, 475. P Lagarde, 'Approche critique de la *lex mercatoria*' in *Le Droit des relations économiques internationales. Études offertes à Bertold Goldman* (Paris, Litec, 1987) 125–50.

⁸ cf A Supiot, *Homo juridicus. On the Anthropological Function of the Law*, tr S Brown (London, Verso, 2007) 153ff. (With this shared faith in a divine guarantor for pledges made, merchants could obtain credit from one end of Europe to the other.)

⁹ See M-A Frison-Roche (ed), *Les Leçons d'Enron. Capitalisme, la déchirure* (Paris, Autrement, 2002).

¹⁰ See P Lanois, *L'Effet extraterritorial de la loi Sarbanes-Oxley* (Paris, Éditions Revue Banque, 2008).

refer to a certain representation of justice, and are not simply politically neutral technical norms. Only ignorance, or the wish to mask this political dimension, can have led the EU to entrust accounting standardisation to a private agency, the International Accounting Standards Board (IASB).¹¹

Thirdly, accounting is also the first modern system to have *conferred on numbers the value of a legally backed truth*. As the French Commercial Code states, the figures acquire probative force: ‘Article L 123-23—Duly kept accounts may be accepted by the courts in order to act as proof between traders in respect of commercial instruments’.¹² The way these figures were arrived at, and the many qualitative decisions taken to get there, simply fall away, unlike what occurs when a law has been passed or a contract has been signed. For whereas laws or contracts are expressed in a natural language and so remain open to interpretation, numbers are not accessible in this way. The dogmatic value assigned to numbers in certified accounts is not absolute, however. An Annex which ‘shall supplement and comment on the information given in the balance sheet and the profit and loss account’ confirms that the accounting presentation is true and fair, when this cannot be perceived from the figures alone.

Lastly, accounting is *the first technique to have made money into a universal standard of value*. Money makes different things commensurable.¹³ Its function as a unit of measurement is different from its function as a means of payment, and there is no reason why the two should be conflated, as we do today.¹⁴ In a barter economy, one should be able to exchange a consultation with a doctor for a certain number of bottles of wine, by referring each to the same unit of account. This unit would simply serve as a reference for both parties, and not as a means to dissolve the obligation, which is only done by handing over the bottles. The idea of separating these two functions of money recurs periodically. Keynes, for instance, tried to do this after the Second World War when he proposed an accounting currency which he called the ‘bancor’ as an international monetary reference, to protect the economy from national currency manipulation (and from the hegemony of the dollar—which is why Keynes’s proposal failed). More recently, the French statesman Jean-Pierre Chevènement proposed a similar uncoupling, in order to compensate for the evident design faults of the single European currency.¹⁵

¹¹ Regulation (EC) No 1606/2002 of 19 July 2002.

¹² French Commercial Code, Art L 123-23.

¹³ *cf* above, ch 4, pp 76–77.

¹⁴ Money has yet another distinct function, as a reserve currency, which raises other problems. On the legal analysis of these different functions, see R Libchaber, *Recherches sur la monnaie en droit privé* (Paris, LGDJ, 1992).

¹⁵ J-P Chevènement, 1914–2014. *L’Europe sortie de l’histoire?* (Paris, Fayard, 2013) 295ff. And on this defect, F Lordon, *La Malfaçon. Monnaie européenne et souveraineté démocratique* (Paris, Les Liens qui libèrent, 2014).

The euro could indeed cease to be the means of payment in France, without even having to change the provisions of the Commercial Code, which states that ‘The accounting documents shall be expressed in Euros and drafted in the French language’ (Article L 123-22).¹⁶ Ever since the Bretton Woods agreement was abandoned in 1971, money has been treated as a commodity like any other, but this can only be sustained if its function as a measure of value is concealed. On any market worthy of the name, the weights and measures which are the common reference enabling exchange to take place cannot themselves be treated as things to be exchanged. The refusal to consider this foundational function of money inevitably ruins any market economy.¹⁷ Be that as it may, accounting exploits money’s function as a standard of value, to measure not only the value of existing goods of all sorts, but also credit-worthiness, or, more generally, future values. In other words, the word ‘accounting’ is deceptive: it precisely does not count (in the sense of enumerating things of the same nature); rather it evaluates; and it evaluates not only what is, but also what may be, using money as a way of taming the future.

This first form of government by numbers was not introduced by states, but by businesses. Although accounting techniques already existed in antiquity, especially in Ancient Rome,¹⁸ it was in the medieval era that modern accountancy emerged, with the keeping of personal accounts and later the invention of the *partita doppia*, the double-entry system, by the merchants of large Italian towns.¹⁹ This system solved the problems raised by the expansion of credit. Books in which the inflow and outflow of goods and money were entered as they arose were not suitable for credit arrangements with suppliers or clients. If I have granted a credit of 1,000 florins to a client, I can never be absolutely certain that I will recover the sum, so I cannot enter it as an available asset. By the same token, if I have a debt of 1,000 florins with a supplier, it must figure on the books, even if these 1,000 florins are still in my account. To give a faithful representation of these operations, merchants therefore opened specific accounts: ‘client’ and ‘supplier’ accounts for the operations of credit; and ‘sales’ and ‘purchases’ for the corresponding transfers of goods. They then opened more specific

¹⁶ French Commercial Code, Art L 123-22.

¹⁷ cf L Fantacci, *La moneta. Storia di un’ istituzione mancata* (Venice, Marsilio, 2005) 276; S Jubé, *Droit social et normalisation comptable* (Paris, LGDJ, 2011) 63ff.

¹⁸ For the case of Rome, see G Minaud, *La Comptabilité à Rome. Essai d’histoire économique sur la pensée comptable commerciale et privée dans le monde antique romain* (Lausanne, Presses polytechniques et universitaires romandes, 2005).

¹⁹ On this history, see J-H Vlaemminck, *Histoires et doctrines de la comptabilité* (Bruxelles, Treurenberg, 1956); (Brussels, Treurenberg Press, 1956; rpt. Vesoul, Pragnos Press, 1979); Y Lemarchand, *Du dépérissement à l’amortissement. Enquête sur l’histoire d’un concept et de sa traduction comptable* (Rennes, Ouest Éditions 1993) 719; S Jubé, *Droit social et normalisation comptable* (Paris, LGDJ, 2011) 673.

accounts corresponding to the elements of their wealth which could be identified as a source of expenditure or income. All these books were kept in the same accounting currency, which could be different from the currency used for payment. When a sale occurred on credit, the same sum was entered in the 'sales' and in the 'clients' account. When this debt was settled, the sum was entered in the 'clients' and the 'cash' accounts. Thus any economic operation gave rise to at least two accounting entries. This is why historians regard keeping separate accounts for credit operations as the origin of double-entry book-keeping.

In the words of the great German historian and sociologist Werner Sombart—to whom we owe the word 'capitalism'—'capitalism and double-entry book-keeping are absolutely inseparable; their relation to one another is as form to content'.²⁰ The invention of the double-entry system went hand in hand with other legal techniques which were also highly successful—bills of exchange, discounts, endorsements and trusts. When analysed closely, all of these credit transactions reveal the dogmatic basis on which the market economy rests: they are all implicitly backed up by a third, who acts as a guarantor. The normative force invested in numbers through these key innovations was closely linked to the introduction of algebra in Europe.²¹ The arithmetical and geometric figures of equality used by Aristotle to illustrate his theory of justice only allowed known magnitudes to be compared. With algebraic equations, *equality became a question*, and algebra could help arrive at the numerical value of a certain number of unknowns.²² Double-entry book-keeping exploited these new techniques. It brought within the sphere of calculation elements which had previously been excluded: not only the money one has, but all the resources mobilised for one's trade; not only the value of one's present goods, but also an estimation of future values. Additionally, double-entry book-keeping gave the legal principle of equality a new systematising power, since charts of numbers were organised according to a rigorous principle of equal rights and obligations.

²⁰ W Sombart, *Der moderne Kapitalismus. Historisch-systematische Darstellung des gesamteuropäischen Wirtschaftslebens von seinen Anfängen bis zur Gegenwart* [final edition, 1928] (Berlin, Duncker & Humblot, 1986); passage translated into French by M Nikitin in *Cahiers de l'histoire de la comptabilité*, 2, 19ff., quoted by B Colasse, *Les Fondements de la comptabilité* (Paris, La Découverte, 2007) 10. See also W Sombart, *Der Bourgeois. Zur Geistesgeschichte des modernen Wirtschaftsmenschen* [1913], English tr as *The Quintessence of Capitalism: A Study of the History and Psychology of the Modern Business Man*, tr and ed M Epstein (New York City, EP Dutton, 1915).

²¹ The first systematic exposition of double-entry book-keeping was in the work of a mathematician and monk, Luca Pacioli, entitled *Summa de arithmetica, geometria, proportioni et proportionalita* (Venice, 1494). But it makes up only one chapter of this work, which remained famous for introducing algebra into the West, from Arab scholars. Pacioli also elaborated the notion of 'divine proportion' (see above, ch 4, p 72), which he took as the title of a later work illustrated by Leonardo da Vinci (*De Divina Proportione* [1509], French tr G Duschesne and M Giraud (Librairie du Compagnonnage, 1980)).

²² I owe this insight to Pierre-Yves Narvor, philosopher-scholar and mathematician.

This new form can be discussed alongside the contemporary invention of the laws of perspective, which conferred a comparable objectivity on depictions of reality.²³ Tables of figures (or, later, statistical tables) can be regarded as a sort of portrait, an objective *figuration* of reality. The French language already points to this meaning, through its designation of the chart of accounts as a *tableau chiffré* (literally, a *figured table* or *figured painting*). Michel Foucault famously gives a foundational role to painting in his ‘archaeology of the human sciences’.²⁴ However, painting is only one way of projecting an image onto a flat surface. It should be relativised by two others: the map and the mirror.²⁵ ‘The merchant’s mirror,’ a metaphor often used to describe accounting, and found in the title of Richard Dafforne’s 1636 treatise on book-keeping, published in London, *The Merchant’s Mirrour, or Directions for the Perfect Ordering and Keeping of his Accounts*,²⁶ can be regarded as a precursor of our legal concept of ‘faithful image’ or fair view. What gives double-entry book-keeping its originality and power is that fundamentally heterogeneous things, people and operations are presented as a coherent and homogeneous whole, by the use of a unit of account which ‘views’ them all from the same perspective, showing the relative importance of each one’s place in the financial life of the company. The laws of perspective result in exactly the same ordering effect, since the size of each object in a painting will be exactly proportional to its distance from the spectator’s viewpoint, irrespective of any qualitative criteria.

Of course, this objectivity is as fabricated in the case of book-keeping as it is in painting, where the composition will vary according to the spectator being addressed, and the desired effect. Today’s dominant accounting regulations, which are Anglo-American, have always privileged the viewpoint of investors; the financial reports accordingly seek to gain their trust, and to enable them to form an opinion on the accounts. In mainland Europe, by contrast, the accounting tradition has always addressed the state, particularly the tax authorities: it is for them that a company’s accounts should appear transparent. And the books would look different again if the privileged viewpoint were that of the people whose work keeps the company going. At present, employees are regarded as a liability and an expense.²⁷ This is one of the reasons for share-price-induced redundancies, which

²³ cf S Jubé, ‘De quelle entreprise les normes comptables internationales permettent-elles de rendre compte?’ in A Supiot (ed), *L’Entreprise dans un monde sans frontières* (Paris, Dalloz, 2015) 147–63.

²⁴ M Foucault, *The Order of Things. An Archeology of the Human Sciences*, (London, Tavistock Publications, 1970).

²⁵ VI Stoichita, *L’Instauration du tableau* (Genève, Droz, 1999) 207ff.

²⁶ Quoted by Y Lemarchand, ‘Le Miroir du marchand. Norme et construction de l’image comptable’, in A Supiot (ed), *Tisser le lien social* (ch 2 fn 47) 213.

²⁷ cf on this point Jubé, *Droit social et normalisation comptable* (n 19).

automatically show up as ‘value creation’, whereas in reality they drain the lifeblood of a company, sometimes bleeding it to death like an over-greedy vampire. So, there is nothing mechanical about the recording of numerical data, not even according to the same accounting standards. The information is filtered through a range of possible presentations, highlighting or playing down this or that aspect, in a process of window dressing or, at the other extreme, of ‘creative accounting’ close to cooking the books. However, none of this will be visible in the final financial statements and, if well executed, they will have the persuasive self-evidence of a truth. Unlike scientific truths, which are always a modifiable approximation of the state of the world, legal truths fix a certain representation of the world and continue to produce their normative effects as long as people continue to believe in them. Their veracity does not depend on fluctuating empirical data but on the trust they are able to elicit, in this case, trust in the accounting image presented by a company regarding its economic situation. If that trust falters, either for good reasons (too wide a gap between the accounting image and reality) or for bad ones (a rumour, stock-market panic), then the company’s credit will plummet, as occurred in the Enron scandal.

Double-entry book-keeping has a further crucial characteristic, which is its application of an unbending principle of balance to the represented system of rights and obligations. The term ‘balance’ comes via the Italian *bilancio* from the Latin *bilanx*, used to designate a pair of scales in which two (*bis*) pans (*lancis*) are in equilibrium. Everything on the *balance sheet* must, precisely, be balanced. The merchant can see at once the state of his company and the entries he can act on to ensure it does not go under. In other words, the books present the company as a *homeostatic whole* whose internal equilibrium must be respected. The company director must react to the numerical information given by the accounts, in order to avoid spiralling imbalances becoming so critical that the company collapses in entropy. Profit and loss, from this perspective, are simply indicators which need to be interpreted in the light of other figures. This is why the pressure from the financial markets to get fixated on ‘the bottom line’—the company’s net balance—can lead to suicidal strategies, if to increase profits one loses the skills (which themselves are excluded from the company’s accounts) which ensured the company’s market position in the first place. This is the slippery slope on which ‘fabless’ companies navigate, in their belief that they will be able to keep on amassing golden eggs while outsourcing the goose which lays them.

II. MANAGING

In the Roman Republic, the population census which was carried out every five years ended on a ritual of purification, the *lustrum*, to mark the

city's rebirth. The two specialist legal experts, or censors, who were entrusted with this task through a non-renewable mandate counted the citizens and the goods they possessed, appointed senators, and supervised public morality. 'Census' and 'censorship' in modern English retain a reference to this dual function, just as 'lustre' denotes a period of time (five years) as well as a literal and metaphorical radiance (the Latin *lūstrāre* means to purify ceremonially, to expiate or redeem). Thomas Berns has shown in a recent book how a long line of early modern jurists sought to have the Roman institution of the *censor* restored, among them Jean Bodin, Lipsius, and Montchrestien, and, on the Protestant side, Althusius.²⁸ Censors, like judges, were legal officers, but unlike judges, they did not apply the law. Instead, their task resembled what could be called—without fear of anachronism—*public management*, a knowledge-based activity.

The Roman censor's primary function was to provide the sovereign with *knowledge* of human and material resources, and thus to contribute to the country's political economy, dissolving the limit Aristotle had drawn between the *oikos* and the *polis*, and treating state administration on the one hand, and the management of a company or a family on the other in the same terms. The most important knowledge provided by the censors was that of the distribution of wealth within the population, this being, ever since the Middle Ages, construed as a 'mirror of the Prince' in the same way as accounting was a 'mirror of the merchant'. It allowed the monarch to gauge his own importance and that of his kingdom. The metaphor of the mirror was also used to refer to the first codifications of laws; for example, the famous *Sachsenspiegel*, the mirror of the Saxons, a code of laws in Middle Low German. Whereas the mirror of the laws composed the image of an ideal order for the sovereign and his subjects to contemplate, the mirror held up by the censors was supposed to present the kingdom as it really was. This 'mirror of the prince' became the 'mirror of the nation' a few centuries later, and continues today in the form of ONS in the UK or Eurostat at the European level.

Equipped with this knowledge, the sovereign could act on two fronts. First, he could *correct* over-large disparities in wealth. Political and legal thought at the time was particularly sensitive to the fact that such inequalities were a source of unrest and sedition, and thus a threat to law and order. Francis Bacon spared no one on this point, comparing money to muck that must not be allowed to accumulate if one wants it to fertilise the land and

²⁸ T Berns, *Gouverner sans gouverner. Une archéologie politique de la statistique* (Paris, PUF, 2009) 163. This book expands an analysis already present in Berns's *Souveraineté, droit et gouvernementalité. Lectures du politique moderne à partir de Bodin* (Brussels, Léo Scheer, 2005) 183ff. On this history, see Jean-Claude Perrot's earlier *Une histoire intellectuelle de l'économie politique* (Paris, EHESS, 1992) 143ff.

not pollute the atmosphere.²⁹ Secondly, the sovereign's knowledge was to allow the deserving poor to be *distinguished* from those whom Montchrétien called 'importunate beggars'³⁰ and, more generally enable 'banishment of the vagabonds, the idle, the thieves, the tricksters and the ruffians',³¹ in Bodin's words. To banish is also to make public—one publishes marriage banns—a publicity which in this case is both a punishment and a way of making society transparent to itself. In Bodin's time, only individuals were targeted, but today whole nations are demoted by rating agencies and made to toe the line by the IMF or the European troika. And information technology helps realise the vision of a society laid bare for its leaders to observe, in a way Bodin and the Chinese Legalists could not have hoped for in their wildest dreams. But might this transparency, Bodin nonetheless asked, lead to tyranny? Certainly not, he replied, and for at least two reasons: the honest citizen has nothing to hide;³² and besides, this transparency does not constrain people from the outside, as would a sentence handed down by a judge, but from within, by encouraging everyone to behave well. Unlike Justice, who is armed with a sword but who is also blindfold so as not to see particularities, the budding discipline of statistics has no power to coerce, but it wants to see absolutely everything.³³

So once again we come upon the figure of the government of souls, dear to both the Pope and the *Tennô* of imperial Japan. The population censuses in the Bible likewise have a religious dimension, and are to be performed only under God's instructions, and within the limits He poses.³⁴ God alone keeps the register of souls, and King David even regrets that he complied with God's order³⁵—but maybe it was Satan's³⁶—to conduct a census of the populations of Israel and Juda. The institution of the *censor*, in encouraging spontaneous compliance with the rules of a society which had been made self-transparent, contains in embryonic form all the ingredients of participatory management. The only elements lacking were the 'objective' images which today statistics and indicators, after two centuries' development, can provide of everyone's activities.

Since the census's primary function was to assess the wealth of the kingdom, it is hardly surprising that the legislative field in which statistics developed most spectacularly was taxation. As the historian Jean-Claude Perrot

²⁹ F Bacon 'Of Seditions and Troubles' in *The Essays or Counsels, Civil and Moral* [3rd ed, 1625].

³⁰ A de Montchrétien, *Traité d'économie politique* [1615] (Genève, Droz, 1999) 237.

³¹ J Bodin, *Six Books Of The Commonwealth*, tr MJ Tooley (Oxford, Blackwell, 1955), VI, 1 (quoted by T Berns, *Souveraineté, droit et gouvernementalité* (n 28) 194).

³² Bodin, *ibid.*

³³ cf Berns, *Gouverner sans gouverner* (n 28) 134–35.

³⁴ *Numbers*, I, 49.

³⁵ *The Book of Samuel*, II, 24:10.

³⁶ *Chronicles*, Book One, 21:1–17.

has remarked, 'the overlap of the census and taxation was for many years the best and the worst motivations for book-keeping'.³⁷ The example he takes is from the early eighteenth century, and Vauban's research into the possibility of introducing a royal levy. To assess the potential yield of this policy, Vauban used two different methods. He isolated a 'proportional mean' of several measurements of the same object (for example, the surface area of the kingdom), and he calculated a 'mean value' arrived at by aggregating heterogeneous data into 'a sort of whole'.³⁸ For example, he calculated average agricultural yields using data from different parishes or years. Whereas quantities had previously been estimated purely pragmatically (with the idea of 'grosso modo', 'taking the good years and the bad', 'all things told'), taxation gave rise to new techniques of quantification, and new entities such as 'sorts of wholes,' which then became operative categories in law.

The normative force of these new categories increased considerably when the state acquired powerful tools for carrying out censuses, and for calculating and comparing quantified data on the country's population. The two types of mean identified by Vauban—an objective average, calculated from many imperfect observations of the same object, and a subjective average, derived from the aggregation of heterogeneous objects—could then be combined. Adolphe Quételet who, despite his profession as an astronomer, is regarded as one of the founding fathers of statistics and sociology, used these methods. When the exhaustive data he had gathered on the number of births, deaths, marriages, crimes, etc, was plotted on a graph, there appeared regularities which, for example for statistics of fertility, had the form of a bell (the 'Gaussian function'): the pinnacle of the bell corresponded to the age of greatest fertility. One hundred years earlier, Johann Peter Süßmilch, a Prussian pastor and almoner in the army of Frederick II, had seen in this type of regularity the expression of a 'divine order', which he described as follows:

The most wise Creator and Governor of the world brings forth from the nothingness the hosts of humans by creating those He has commanded to live. The Lord has us all pass in the same way before his eyes, until such a time as each of us, having attained the goal decreed, deserts the world's stage. Our emergence, our passage before the Lord of Hosts, and our departure all occur in admirable order. Our appearance in the land of the living occurs progressively, without precipitation and according to certain numbers, which are always in a precise relation to the army of the living and the numbers of the departing. Just before we enter the land of the living, some of us are struck off the tally, these are the stillborn. But even this operation occurs in accordance with fixed proportions. Two facts are

³⁷ Perrot, *Une histoire intellectuelle de l'économie politique* (n 28) 147.

³⁸ *ibid*, 28–29.

particularly worthy of our attention concerning our emergence from the void: 20 girls are always born for 21 boys, and the newly born are always a little more numerous than those who return to dust. This is how the human army continues to increase slightly, but always in a set proportion.³⁹

Like all nineteenth-century scientists, Quételet abandoned the idea of a divine order, and used the numerical regularities discovered to construct the image of the ‘average man’ whose role in statistics is the same as that of ‘the normally prudent and diligent man’, or the ‘reasonable person’ in issues of civil liability, that is, a standard of normality by which the deviations of individual cases may be measured. Quételet called the regular effects revealed by numbers ‘binomial law’, but Pearson later renamed it ‘normal law’ [*loi normale*].⁴⁰ This shift signalled the emergence of a *normality* induced from the observation of facts, which displaced the *legality* of the legal system, and hence replaced the subject of law with an object of care, through the institution of what Foucault has called ‘biopolitics’.⁴¹

The ‘objective laws’ brought to light by quantification inevitably had an impact on law. They were based on the supposition of constant causes which could explain the observed regularities. The inductive method used did not measure the effects of an identifiable cause, but inferred from the unchanging nature of certain measurements that constant causes existed. In biology, this idea of explaining phenomena through quantification was extraordinarily successful because it held out the promise of discovering laws which would be as rigorous and unquestionable as the laws of physics. Since legal systems attach normative effects to the laws of science,⁴² they could certainly not ignore these ‘normal laws’, all the more so as Quételet and his successors did not restrict their quantifications to physical features alone, but also calculated what was called ‘moral behaviour’, and today would be called socio-cultural phenomena such as marriage, suicide or homicide. It becomes clear that no simple limit can be drawn between physical and socio-economic features. Studying the statistics of mortality, for example, shows differentials linked to wealth or working conditions, such that one must impute social causes to physical effects. Research of this kind, as carried out, for example, by the doctor Louis René Villermé in the first half of the nineteenth century, encouraged the

³⁹ JP Süßmilch, *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts aus der Geburt, dem Tode und der Fortpflanzung desselben*, 2 Teile [1st ed 1741, 2nd ed 1761–1762], vol II, ch I, §14, 468. On these origins, see also H Le Bras, *Naissance de la mortalité. L'origine politique de la statistique et de la démographie* (Paris, Gallimard-Le Seuil, 2000).

⁴⁰ In 1897. cf TM Porter, *The Rise of Statistical Thinking* (Princeton, Princeton University Press, 1986).

⁴¹ cf M Foucault, ‘Society must be defended’, *Lectures at the Collège de France, 1975–1976*, tr D Macey (New York City, Picador, 2003).

⁴² This point is developed in A Supiot, ‘L'autorité de la science. Vérité scientifique et vérité légale’ in P Rosanvallon (ed), *Science et Démocratie. Colloque de rentrée du Collège de France* (Paris, Odile Jacob, 2014) 81–109.

adoption of the first social laws, which were introduced to tackle the relative over-representation of death and disease among the working class.⁴³ The statistical measurement of the specific physical risks run by certain categories of the population was thus pivotal in the birth of social legislation, which was the first area to respond to the social differences revealed by quantification.

The use of the term 'social' here, to qualify a new branch of law, implied a new legal representation of society. 'Society', as conceived in the French 1789 Declaration, was an ideal homogeneous body composed of free and equal persons (even if this ideal was already compromised by the exclusion of women from universal suffrage and, later, when voting was linked to a tax threshold, the exclusion of the poor). The only political arithmetic to have legal validity was therefore elections—one person, one vote: in Tocqueville's words, 'the notion of government has been simplified. Numbers alone make laws and the law. Politics has been reduced to a question of arithmetic'.⁴⁴ The 'society' sketched by social law is quite different. It is not a homogeneous political body, but a 'sort of whole', to borrow Vauban's words, composed of heterogeneous and also dysfunctional elements, as revealed by statistical studies and the new discipline of sociology. This 'whole' cannot survive without legal measures to support the most vulnerable, above all working-class women and children. This is why the jurist Louis Josserand gave the name of *class law* to what was otherwise known as 'workers' law' or 'industrial legislation',⁴⁵ implying that the physical and spiritual hardships of this new class were not regarded as facts of nature, but as the consequences of the industrial revolution. Social legislation was thus built on the conviction that material inequalities such as illness, accidents, or life expectancy, but also inequalities in ways of life, had socio-economic causes.

At the same time, but inversely, socio-biology and racial biology attributed physical causes to social phenomena. This was the direction taken by Francis Galton (1822–1911), a cousin and admirer of Darwin, and one of the inventors of biometrics and eugenics, who sought to relate the distribution of physical, intellectual and spiritual qualities revealed by statistics to natural selection. He advocated eugenicist legislation, to improve the human species by encouraging the reproduction of the fittest and the most capable, and the progressive elimination (through sterilisation) of those whom the 'normal law' categorised as deviants.⁴⁶ Nazi Germany was certainly not the only country to pass laws designed to eliminate the 'unfit'; this occurred

⁴³ L-R Villermé, *Tableau de l'état physique et moral des ouvriers employés dans les manufactures de coton, de laine et de soie* (Paris, Renouard, 1840); rpt, *Éditions d'histoire sociale* (1979), 2 vols, 458 and 451.

⁴⁴ de Tocqueville, *The Old Regime and the Revolution*, Vol II (n 1).

⁴⁵ L Josserand, 'Sur la reconstitution d'un droit de classe' (Dalloz, Recueil hebdomadaire, 1937) 1–4.

⁴⁶ cf A Pichot, *La Société pure. De Darwin à Hitler* (Paris, Flammarion, 2000); and, by the same author, *Aux origines des théories raciales. De la Bible à Darwin* (Paris, Flammarion, 2008).

in the United States and in almost all the Protestant countries of Northern Europe, with the remarkable exception of the United Kingdom. Many progressive thinkers viewed the successful opposition to these laws mounted in the Catholic countries of Southern Europe as a sign of a reactionary attitude going against the movement of history. In some Western countries this eugenicist and racial legislation remained in place long after the end of the Second World War. In the US, racial laws were abolished only in 1964, and the eugenicist legislation in Sweden remained in force until 1976. An estimated 63,000 mentally ill and 'socially maladjusted' people (90% of whom were women) were sterilised against their will in application of these eugenicist laws in Sweden as from 1934.⁴⁷

Both these ways of articulating physical and socio-economic data, as revealed by statistics, supposed that society was a whole, a social body, whose laws of functioning can be elucidated by quantification, and whose malfunctions can be corrected through legal measures. The social sciences, beyond their diversity and their divisions, all defined themselves in relation to this new object called 'Society' with a capital S, a totality which could be contemplated from the outside using the same methods of quantification as the natural sciences. The social sciences also sought to found a legal order on the 'normal laws' which Society had been shown scientifically to obey. Legal qualification and statistical qualification were thus interwoven, since the law was grounded in 'truths' revealed by the quantification of economic and social facts. 'Qualification', in both cases, means relating facts to categories of thought, but there are important differences between this operation in law and in statistics.

All judicial decisions are based on prior operations of *legal qualification*. The judge who is called upon to decide, for example, whether the suicide of an employee in his home can be qualified as a work accident has to examine—and possibly broaden—the notion of 'industrial accident'. This is what the French Cour de cassation did when it ruled that 'an accident occurring at a moment when the employee is no longer in subordination to the employer constitutes a work accident if the employee proves that it occurred due to the work'.⁴⁸ The fact that the employer did not take the necessary steps to ensure that the working relationship responsible for the suicide did not deteriorate was qualified in the same decision as 'gross negligence', with the result that the widow and orphans gained rights to 'full redress'. The judge decides on the qualifications—here, 'work accident', 'gross negligence'—only after hearing an adversarial debate between the two parties [*audi alteram partem*]. This debate can be re-opened on appeal or in the Supreme Court. Only at the end of this process will a legal truth be fixed, as

⁴⁷ cf A Drouard, 'À propos de l'eugénisme scandinave. Bilan des recherches et travaux récents' (1998) *Population*, 53, 3, 633–42.

⁴⁸ Civ 2, 22 February 2007, No 05-13771, Bull civ (Bulletin des arrêts de la Cour de cassation: Chambres civiles) II, No 54.

case law. And even then, this truth can be challenged if a judge goes against precedent or if Parliament intervenes. In other words, legal qualification operates in the reflexive medium of language, and thus remains indefinitely open to reinterpretation.

Statistical qualification is less easy to grasp because it works behind the scenes and does not follow procedural rules in the way legal qualification does. Despite this, qualification is a necessary stage in the production of a statistical image of social facts because *one cannot quantify what has not been qualified*. Statisticians talk of ‘conventions of equivalence’ to refer to the aggregation of heterogeneous elements into a single whole.⁴⁹ This procedure is necessary because every enumeration must begin by defining *what* is being counted. To count apples, I must begin by distinguishing them from pears and plums. And if they are for immediate consumption, I shall have to separate the ripe from the unripe and the rotten apples. Since, not unlike us humans, apples do not change overnight from immaturity to maturity, and on to the disorders of old age, I shall have to decide like a judge how to qualify each of my apples in order to single out the edible ones. If I am an apple-seller, I will be tempted to qualify as edible an apple which a more demanding client would qualify as rotten. In other words, the qualification of the objects of a calculation implies a standard of judgment which is not itself an object of calculation, but which makes the calculation possible.

In some cases, statistics simply adopts pre-existing legal qualifications, as when it counts work accidents or the national population. In other cases, however, it uses its own categories, which may then carry over into law. This is precisely what happened with the category ‘unemployed’, which was a category invented by labour statisticians in the late nineteenth century.⁵⁰ However, the constant is always the construction of equivalences, so that heterogeneous elements may nonetheless be counted. Although these conventions of equivalence may be as hotly debated as any issue in the court room or before parliament, statistical qualification still differs in two essential respects from the work of a judge. Since statistics are supposedly the preserve of technical experts, the decisions are not the object of revisable open debate, and there is no standard procedure by which qualifications may be contested. Secondly, once the element has been qualified, it is used not to judge but to count, to fix the facts of the case in figures not letters. In other words, the pronouncements of statistics lie outside the reflexive medium of language, and this gives them a very particular dogmatic power.

This symbolic power of numbers was reinforced by the use of what are called Arabic numerals, transmitted by the Arab Enlightenment, although actually of Indian origin. Unlike Roman or Greek numerals, which retained

⁴⁹ A Derosières, ‘Entre réalisme métrologique et conventions d’équivalence: les ambiguïtés de la sociologie quantitative’ (2001/2) *Genèses* 43, 112–127.

⁵⁰ cf R Salais, N Baverez and B Reynaud-Cressent, *L’Invention du chômage*, 1st edn (Paris, PUF, 1986); 2nd edn (PUF, coll ‘Quadrige’, 1999) 288.

semantic traces of a particular alphabet, Hindu-Arabic numerals had the advantage of being potentially universal (as well as abolishing the distance between writing and calculation). They can be compared to sinogrammes, which are understood by Chinese people even if they speak different languages: they simply have to trace the strokes of the character on a slip of paper or on the palm of their hand. But the person they address still has to be able to read sinogrammes, whereas the hegemony of Hindu-Arabic numerals has universalised the normative force of numbers and realised the Babelian dream of a language shared by all humanity.⁵¹

III. JUDGING

Another dilemma central to law, which modern methods of quantifying social facts sought to address from the outset, was how to choose rationally when in a situation of uncertainty. Legal procedure deals with this, and if one were to teach only one area of law in all law faculties it should unquestionably be procedure. The aim of every trial is to prevent a conflict from degenerating into fisticuffs. Legal procedure converts conflict into litigation, that is, into a regulated exchange of arguments under the supervision of a third party who will hand down a judgement binding on all parties. The role of the judge is to weigh up the arguments in the scales of justice, establish the truth or falsehood of the facts produced, and take a decision which shall have the force of law.

The role of the judge is similar to that of a gambler, who also takes decisions in situations of uncertainty. Rabelais merged the two in his colourful Judge Bridlegoose, who explains to Pantagruel how he decides on cases by throwing the dice, 'as the custom of the judicatory requires, ... and by the rule thereof to direct and regulate our actions and procedures'.⁵² Throwing the dice is entrusting oneself to God's judgement, as Saint Augustine observed regarding drawing lots.⁵³ But ever since Canon law forbade bringing God into settling cases in this way, the search for rational proof took over.⁵⁴ Similarly, the experienced gambler does not simply rely on chance, but instead tries to calculate the chances of winning or losing before placing his bets. Pascal's famous wager was directed precisely at this calculating gambler. If he has not received faith through divine grace, then only he can decide

⁵¹ European merchants banned the use of Hindu-Arabic numerals in bookkeeping until the end of the fifteenth century, when its use became standard, long after it had started to be used in mathematics (cf Vlaeminck, *Histoires et doctrines de la comptabilité* (n 19) 54).

⁵² Rabelais, *Le Tiers Livre*, Édition de Pierre Michel. Préface de Lucien Febvre, (Paris, Gallimard, 1973) Ch 39.

⁵³ Saint Augustine, *De Doctrina Christiana*, L I, Ch XXVIII, 29, quoted by E Coumet, 'La théorie du hasard est-elle née par hasard?' (1970) *Annales ESC*, 3, 578.

⁵⁴ cf J-P Lévy, *La Hiérarchie des preuves dans le Droit savant du Moyen Âge depuis la renaissance du droit romain jusqu'à la fin du XVI^e siècle* (Paris, Sirey, 1939) 174; H Lévy-Bruhl, *La Preuve judiciaire. Étude de sociologie juridique* (Paris, Marcel Rivière et Cie, 1964).

whether or not he should believe in the existence of God. Since he has already 'embarked' on life's journey, he cannot escape this question, but his decision will be taken in a situation of uncertainty. Pascal shows that he can decide rationally to believe or not, using the same calculations as at the gaming table. The mathematical rigour of Pascal's demonstration and its sheer daring (basing faith on a calculation) is a precious resource for our understanding of the religious dimension of governance by numbers to this very day. Pascal begins by showing that certainty and uncertainty are not separated by an unbridgeable gulf, but are linked by the 'proportion of the chances'⁵⁵ of gain and loss. In the case of the existence of God, the chance is set at a one in two chance. All that remains after this step is to apply the amount of the stakes to this probability: a libertine but finite life on the one hand, and on the other, eternal salvation. The maths holds no secrets, and must lead to *rational belief*, a truth of which 'all men are capable'. One could argue that Pascal does not calculate everything rationally because he decides arbitrarily that there is a 1:2 chance of winning or losing. However, any other proportion would have given much the same result, given that the trump card of infinity has been introduced into the equation. At all events, this is a good example of the impossibility of an entirely self-enclosed calculation divorced from any reference to a value judgement, a qualitative moment underpinning the demonstration. Calculations of probability are at once descriptive and normative.

The problem Pascal was trying to solve in this exploration of probability was in fact a question of law: how should losses and gains be allotted in the case of breach of an aleatory contract?⁵⁶ As Alain Desrosières has shown, this question cannot be answered without appealing to an arbiter who stands outside the game and is able to construct 'spaces of equivalence between incompatible, heterogeneous future events which have not yet taken place'.⁵⁷ Although calculations of probability can replace the qualitative operations which a judge carries out in order to arrive at a position 'beyond reasonable doubt' (the judge's '*intime conviction*'), and although these calculations can thus replace legal procedure, the figure of the impartial third party does not disappear for all that. In making incommensurable facts commensurable, the third carries out exactly the same type of operations as those undertaken by jurists when they subsume different factual situations under the same legal qualification.

Like the judge, this third must first decide on the truth or falsehood of the facts alleged. In the courtroom, this question is ultimately a matter for 'the prudence of the judge', in the words of Domat, the most brilliant jurist of his time (and friend of Pascal).⁵⁸ Prudence, one of the four cardinal Christian

⁵⁵ B Pascal, *Les Pensées in Oeuvres Complètes* (Paris, Gallimard, 1954), pp 1214–1215.

⁵⁶ cf E Courmet, 'La théorie du hasard est-elle née par hasard?' in *Annales. Économies, Sociétés, Civilisations*, no. 3, 1970, pp 574–98.

⁵⁷ Desrosières, *La Politique des grands nombres*, (n 2) 65.

⁵⁸ J Domat, *Les Loix civiles dans leur ordre naturel* [1689–94] (Paris, M de Héricourt éditeur, 1777) 285.

virtues—the others being justice, fortitude and temperance—is the faculty of discernment thanks to which actions may be guided by an exact representation of the truth. The famous sculptures of the tomb of Francis II of Brittany portray Prudence as a twin-facing figure, representing from the front a young woman holding in her right hand a compass, the symbol of the measure appropriate to every action, and in her left hand, a mirror.⁵⁹ Due to this mirror, she does not simply face the future, but also looks into herself, for self-knowledge, and behind her to the past. No prudent action is indeed possible without self-knowledge and the benefits of experience, as this sculpture also shows, on its reverse side, through the depiction of a pensive old man facing away from us and towards the past.

Figure 5.1: The Allegory of Prudence, one of the four cardinal virtues which stand at the corners of the tomb of Francis II, Duke of Brittany, and his wife Marguerite de Foix, sculpted by Michel Colombe, Nantes Cathedral © Florian / WikiCommons



⁵⁹ On this tomb, cf Fulcanelli, 'Les gardes du corps de François II de Bretagne', in *Les Demeures philosophales et le symbolisme hermétique dans ses rapports avec l'art sacré et l'ésotérisme du grand œuvre*, 3rd edn (Paris, Jean-Jacques Pauvert, 1965) Vol 2, 181–238.

The good judge (whose jurisprudence is authoritative) is thus one who takes into account past experience, through self-examination, who is able to assess the reliability of the evidence presented concerning the alleged facts, and who can anticipate the effects of his decision. A key facilitator of these essentially qualitative evaluations is what in French procedure is called the *principe du contradictoire*, which means that the judge decides only on the basis of evidence which all the parties to the trial have been able to discuss. This is the rule laid down in Article 427 of the French Code of Criminal Procedure: ‘The judge may only base his decision on evidence which was submitted in the course of the hearing and adversarially discussed before him’. The value attributed to a piece of evidence presented to the judge will depend on several factors: the conditions surrounding it (a testimony under oath carries greater weight than a simple declaration before a police officer), on the character of the person testifying (the words of an honest citizen are more trustworthy than those of a ruffian) and on the credibility of the facts attested (seeing the Virgin Mary appear is less credible than seeing a shepherdess).

The founding fathers of calculations of probability—Leibniz, Bernoulli, and Condorcet—attempted to quantify these types of factors, in order to give a numerical value to the possible truth of a reported fact. In her *Classical Probability in the Enlightenment*, Lorraine Daston cites many examples of these calculations, as applied in the field of law.⁶⁰ Condorcet, in one of his *Mémoires à l’Académie royale des sciences*, arrived at the following formula to calculate the probability of an extraordinary event reported by a witness:⁶¹

Let us suppose that u and e represent the probability of the truth of an extraordinary event and of the falsity of the same event, and that at the same time u^1 and e^1 express that the probability of a testimony will or will not conform to the truth, and that a witness has testified to the truth of this event [...], the probability that the extraordinary event declared true really did occur will be:

$$\frac{uu^1}{uu^1 + ee^1}$$

and that it is false:

$$\frac{ee^1}{uu^1 + ee^1}$$

Some years later, Laplace arrived at a significantly more complicated formula in his calculations of the probability (P_i) of the truthfulness of a

⁶⁰ Daston, *Classical Probability in the Enlightenment* (n 2) 306–69.

⁶¹ M-J-A de Condorcet, *Mémoire sur le calcul des probabilités* [1786], in *Arithmétique politique: textes rares ou inédits* (1767–1789), critical edition with commentaries by Bernard Bru and Pierre Crépel (Paris, INED- PUF, 1985) 432.

testimony which claims that a number i was drawn from an urn containing n numbers.⁶² There are four possibilities, he maintains: the witness does not lie and is right ($P1 = pr/n$); the witness does not lie but is wrong ($P2 = p[1 - n]/r$); the witness lies and is not wrong ($P3 = [1 - p][r]/n$); and the witness lies and is wrong ($P4 = [1 - p][1 - r]/n$: L). This gives the following mathematical formula:

$$Pi = \frac{\frac{pr}{n} + \frac{(1-p)(1-r)}{n(n-1)}}{\frac{pr}{n} + \frac{p(1-r)}{n} + \frac{(1-p)r}{n} + \frac{(1-p)(1-r)}{n}}$$

or:

$$Pi = pr + \frac{(1-p)(1-r)}{n-1}$$

Formulas of this sort already give substance to the dream of replacing the judge, who decides impartially on the truth of an alleged fact, with a calculating machine.⁶³ They prefigure the role of computers in regulating the financial markets through governance by numbers. Calculations of probability also embody a change in the hierarchy of values by privileging considerations of utility over knowledge in the face of uncertainty. Pascal's wager already demonstrates this inversion, insofar as his libertine has no interest in fathoming the mysteries of existence, all he wants is to maximise his winnings. Through calculation, he can evade both the abyss of a world devoid of sense, and the absoluteness of a world over-saturated with sense. Thus purged of any metaphysical qualms, he can live his life in the dimension of the gambling table, which knows neither heights nor depths. This shift in values separates Greek investigations—centred on the contemplation of the world—from our own, which have to prove their usefulness. Usefulness is indeed what gave statistics its momentum: society is constructed as an object of knowledge only in order to make it easier to manage. René Thom has argued that at the turn of the eighteenth and nineteenth centuries, the mathematics of control supplanted the mathematics of intelligibility, due to the professionalisation of the activity of the scholar or scientist: 'Armed with the certainties of science, the enlightened man gradually transformed into what today we would call a technocrat'.⁶⁴

⁶² P-S de Laplace, *Théorie analytique des probabilités* [1812], 3rd edn (Paris, Coursier, 1820) 457, quoted by Daston, *Classical Probability in the Enlightenment* (n 2) 335ff.

⁶³ Laplace even applied calculations of probability to judges' decisions in court, in *Essai philosophique sur les probabilités*, 5th edn [1825], preface by René Thom (Paris, Christian Bourgois, 1986) 136–42.

⁶⁴ Thom, Preface to Laplace, *Essai philosophique sur les probabilités* (n 2) 6–7.

IV. LEGISLATING

The first calculations of probability bear this tendency out, in that they did not confine themselves to establishing certain facts, but additionally sought to formulate the rules governing these facts. Calculations of probability thus overstepped the limits of stating what *is*, and concerned themselves with what *should be*. They did not simply describe, they prescribed.

The legitimacy of probability calculations as a basis for legal decisions was first debated in the context of a public health issue: the question of whether inoculation against smallpox should be made obligatory, as a preventive measure.⁶⁵ It was clear that this would reduce the incidence of the illness as a whole, but the inoculation had also caused the death of a number of people vaccinated. On the basis of the patchy statistics existing at the time, the risk was evaluated at 1/300. When Daniel Bernoulli presented a paper to the Academy of Sciences on the subject in 1760, he recommended applying a formula similar to the one used for calculating one's chances of winning at the lottery. Since the results gave an increased life expectancy of about three years for those inoculated, he implicitly recommended inoculation for everyone. The case was hotly debated. Bernoulli's argument for inoculation was echoed by most of the enlightened minds of the time, especially Voltaire, and the issue was framed as a conflict between the forces of progress and of reaction, where progress meant adapting the government of men to the facts of science.⁶⁶ Among the *philosophes*, only d'Alembert came out against, arguing that one could not apply to a problem where human lives were at stake a calculation based on incomplete data.⁶⁷

Since then, the questions raised by this famous controversy have not gone away. Public health policy is still obliged to take into account the two facets of illness, as a quantifiable social fact and as a singular event in a person's private life. In the nineteenth century, hygienicist doctors advocating a 'numerical method' which standardised care on the basis of medical statistics fought it out with doctors who set store by clinical experience and individualised discussion with the patient. Claude Bernard, who was critical of the numerical method, accused it of treating conditions 'on average,' instead of using in-depth knowledge of the particular determinations of the illness.⁶⁸ The fact that the primary factors of illness appeared to be physical

⁶⁵ On this debate, see Laplace (n 63 above) 145ff; J-P Benzécri, *L'Analyse des données* (Paris, Dunod, 1973); Daston, *Classical Probability in the Enlightenment* (n 2) 83ff; Le Bras, *Naissance de la mortalité* (n 3).

⁶⁶ A Rowbotham, 'The Philosophes and the propaganda for inoculation of smallpox in eighteenth-century France' (1935) *University of California Publications in Modern Philology*, 18, 265–90; AA Rusnock, *Quantifying Health and Population in Eighteenth-Century England and France* (Cambridge, Cambridge University Press, 2002) 249 esp 43–91.

⁶⁷ cf Daston, *Classical Probability in the Enlightenment* (n 2) 84ff.

⁶⁸ cf Desrosières, *La Politique des grands nombres* (n 2) 104ff.

doubtless helped justify the use of calculations of probability to decide on preventive or other treatments, since it seemed legitimate to accept statistical regularities which derived from the unchanging and universal laws of the physical world. This is why the first applications of probability calculations to legal issues all concerned physical phenomena, particularly mortality, which the development of statistics could represent in the form of quantified tables. The ‘Galilean sciences’, which are also based on measuring regularities observed in nature, are not so different. Techniques such as life insurance and life annuities, which were still assimilated to games of chance in the seventeenth century—and particularly blameworthy ones at that, because they played with an individual’s life—tended to be considered, by the nineteenth century, as a sign of forethought, which the authorities would do well to foster in the venerable minds of the *pater familias*.

The legitimization of probability calculations started with a Gambling Act in the UK, passed in 1774, which made the interests of the person insured into the criterion by which to distinguish between insurance (legitimate) and a bet (legally void).⁶⁹ John Law, and the crash of his system insuring lottery losses, was fresh in people’s minds. And in order to decide whether the insurance contract was ‘in the interests of the person insured’, the question posed was: does it imply the long time of foresight, or the short time of speculation? This same question could helpfully be applied today, if only there existed some genuine determination to regulate the financial markets. For everything points to the fact that insurance on the financial markets has become speculative in the way that led to its being banned until the eighteenth century. The lifting of this ban—a change which enabled the construction of the modern Social State—was not unconditional. The generalisation of social statistics seemed to transform uncertain events into calculable risks, but these calculations were still screened by a principle of prudence. This principle cannot itself be an object of calculation because it applies to the essential function of insurance and not just the extent of particular financial reserves. In other words, the principle of prudence should oblige one to set solvency ratios⁷⁰ and limit the activities of insurance to exclude speculative operations.

The importance of insurance in the construction of the social state is unquestionable, but its precise role merits closer analysis. François Ewald, in his book on the birth of the welfare state, examines the debates which led to the inclusion of insurable risk within legal liability.⁷¹ This marked a legal turning-point, the beginning, he argues, of a society which had become

⁶⁹ cf Daston, *Classical Probability in the Enlightenment* (n 2) 175ff.

⁷⁰ This was the main lesson drawn by European law from the financial crash of 2008. See the ‘Solvency II’ Directive 2009/138/EC of 25 November 2009, on access to the business of Insurance and Reinsurance, and their practice.

⁷¹ Ewald, *L’État providence*, (ch 4 n 31) 143ff.

totally objectifiable and transparent to itself, regulated by norms rather than governed by law. He calls it a ‘society of insurance techniques’ [*une société assurantielle*]. This reading leads him to deny any essential difference between social insurance and private insurance. There is no good reason, he argues, to oppose them ‘because both use the same techniques of risk, and both proceed by pooling and sharing out the burden of these risks’. Thus one could say that within the vast field of ‘social’ security, that is, of security which is mutualised through insurance, what we usually call ‘Social Security’ is but one part.⁷² The concept of a society of insurance techniques thus leads to the conclusion that social insurance and private insurance are functionally equivalent. Both types ‘pool’ risks and use the same actuarial techniques, such that private insurance would be perfectly capable of covering those risks today covered by social security. From there, it is a small step to maintaining that the choice between the two should depend ultimately on their relative cost, set by the market. This step was taken recently by the Court of Justice of the European Union, when it stated, in a decision of 15 July 2010, that ‘preservation of [those] elements of solidarity is not inherently irreconcilable with the application of a procurement procedure’ since ‘the pooling of risks, upon which any insurance activity is based [...] can be ensured by a body or [a] undertaking’.⁷³ The case involved the requirement that the social partners turn to the insurance market for the management of a pension fund established by a collective agreement. A draft European directive of 2012 on public procurement similarly included this requirement, regarding ‘obligatory social security’. The political uproar this caused obliged the Commission to withdraw the provision.⁷⁴

The notion of a society of insurance techniques cannot, however, do justice to the scope and complexity of the legal changes brought about by the quantification of social facts. As regards the scope: insurance is only one aspect of the shift from faith in persons, operative at the very heart of institutions, to faith in numbers.⁷⁵ It is a shift clearly visible today in insurance contracts, for which statistical risk assessments have progressively supplanted prudent examination of the situation of each candidate.⁷⁶ But already in the nineteenth century this movement was emerging in fields as diverse as medical practice and public administration. Quantifying social facts lends them an appearance of objectivity, and makes them commensurable on the scale of the planet. Belief in numbers can thus foster the hope

⁷² *ibid.*, 390.

⁷³ Court of Justice of the European Union (Grand Chamber), 15 July 2010, *Commission v/ Federal Republic of Germany*, Case C-271/08, *Droit social* 2010, 1233, observations Francis Kessler.

⁷⁴ *cf* Written Question No 02501 by Mme Marie-Noëlle Lienemann (Sénat, *Journal officiel*, 18 October 2012, 2262).

⁷⁵ *cf* Porter, *Trust in Numbers* (n 2).

⁷⁶ *cf* Daston, *Classical Probability in the Enlightenment* (n 2) 182ff.

that another type of rule of law may exist, founded not on dogma but on observed regularities valid for all humankind.

Advances in quantification thus went hand in hand with the idea of a uniform and universal law, such as Condorcet had advocated, in his sharp criticism of Montesquieu's legal relativism. His model for this law was that of weights and measures, a model 'which can only displease men of law who fear to see the number of trials diminish'. He justifies his ideas as follows:

Since truth, reason, justice, the rights of men, and the interests of property, liberty and safety are the same everywhere, there is no good reason why all the provinces of a State, or even all States, should not have the same criminal laws, the same civil laws, the same laws on trade, etc. A good law should be good for all men, just as a true proposition is true for all. Where in different countries the laws would appear to need to be different, or have objects which should not be ruled by laws, like most of the rules of trade, or are based on prejudices and customs which should be eradicated; one of the best ways of destroying these is to cease to support them through laws.⁷⁷

Condorcet goes on to say that Montesquieu is wrong to evoke the legal function of Tartar or Chinese ceremonies because just as mathematicians accustomed to calculations of probability are capable of explaining the rules of a particular game, so it should be possible to calculate the rules applicable to *all* humanity.⁷⁸ The vision of law sketched here prefigures the situation under globalisation: the deregulation of trade, and the eradication of regional and national legal cultures in the name of a uniform law. The only element missing is the natural selection of the fittest 'legislative products' through competition between national legal systems.

Applying probability calculations to social facts has, however, always met with opposition. The early eighteenth-century mathematician Pierre de Montmort identified the two reasons why one should beware of these calculations. The first was that human action does not obey the unchanging laws of nature (and one is fooling oneself if one thinks self-interest can be equated with this type of law). The second was the human mind's inability to grasp all the factors determining any given action.⁷⁹ In the following century, Comte added scathing criticism of 'the pretension of some geometers to render social investigations positive by subjecting them to a fanciful mathematical theory of chances',⁸⁰ in this explicitly targeting Condorcet

⁷⁷ Condorcet, 'Observations sur le vingt-neuvième livre de l'Esprit des lois' in ALC Destutt de Tracy, *Commentaire sur l'Esprit des lois de Montesquieu* (Liège, Desoert, 1817) 458.

⁷⁸ *ibid.*, 461–62.

⁷⁹ PR de Montmort, *Essai d'analyse sur les jeux de hazard*, 2nd edn (Paris, Jacques Quillau, 1713) quoted by Daston, (n 2) 317.

⁸⁰ A Comte, 'Relation of Sociology to the other departments of positive philosophy' in *The Positive Philosophy*, tr H Martineau, intro F Harrison (London, George Bell and Son, 1896), Vol 2, Ch IV, 223.

and Laplace. He considered that the high degree of abstraction of mathematics disqualified it from being used at all rigorously for the close study of nature.

Can one possibly imagine a more radically irrational conception than that which takes for its philosophical basis, or its principal method of conclusive explanation, for all the social sciences, a supposed mathematical theory, in which, as is normal for purely mathematical speculations, signs being taken for ideas, we attempt to subject to calculation the necessarily sophistical notion of numerical probability, which amounts to offering our own ignorance as the natural measure of the degree of probability of our various opinions?⁸¹

More recently, this criticism was echoed by Karl Polanyi who attacked the ‘immature dogmatism [which] stood guard at the gates of moral statistics, through which the reality of society had announced its entrance in the guise of mathematical precision’.⁸² Quantification is legitimate in the social sciences only if it is limited to what can be precisely counted, and does not construct simulations which extrapolate general laws from incomplete measurements of sets of heterogeneous facts. Frédéric Le Play, an engineer by training, and his successors, observed this method scrupulously in their minutely detailed surveys of the living conditions of the peasantry and working-class populations in different European countries.⁸³ Le Play had been struck by the lack of scientific rigour in the existing statistical tables which, he said, ‘take into account neither the specific nature of the individuals, nor the particular character of their living environments; the official data thus neglects the principal facts which science must consider in order to reach conclusions which concern individual existences or different social categories’.⁸⁴

This ethno-accounting continues to be practised today by some researchers, despite the overwhelming dominance of standard econometrics. Instead of replacing the real with prefabricated statistical categories, this type of research attempts to understand in all their complexity the systems of values operative in a human group.⁸⁵ For instance, instead of projecting an a priori notion of value onto poor populations in the context of quantified anti-poverty programmes, these researchers regard the attribution of value as a social process which must be understood before one can really improve these people’s lot.

⁸¹ *ibid*, 224 [*tr mod*].

⁸² K Polanyi, ‘The Machine and the Discovery of Society’ [1957] lecture: <http://kpolanyi.scoolaid.net>, 4.

⁸³ *cf* the excellent biography of Le Play by F Arnault, *Frédéric Le Play. De la métallurgie à la science sociale* (Nancy, Presses universitaires de Nancy, 1993).

⁸⁴ F Le Play, *Les Ouvriers européens* (Paris, Imprimerie impériale, 1855) 301.

⁸⁵ See, for example, A Cottureau and MM Mazok, *Une famille andalouse. Ethnocomptabilité d’une économie invisible* (Paris, Bouchène, 2012).

Keep adding. On kill lists, drone warfare and the politics of databases

Jutta Weber

Institut für Medienwissenschaften, Universität Paderborn, Germany

Environment and Planning D: Society and Space

2016, Vol. 34(1) 107–125

© The Author(s) 2015

Reprints and permissions:

sagepub.co.uk/journalsPermissions.nav

DOI: 10.1177/0263775815623537

epd.sagepub.com



Abstract

Alongside drones and Special Forces, the ‘disposition matrix’ – a kill/capture list and database – is a key device in the US government’s global ‘war on terror’, in which targeting individuals has become increasingly institutionalized. The majority of studies to date have focused on the human world of the military, insurgents and policy makers with a limited access to reliable knowledge. Using insights from technoscience and software studies, I seek here to develop a material-based perspective focusing on the neglected non-human world of software artefacts, which codify, standardize and sort our world. I will first present available knowledge about the ‘disposition matrix’ and the ‘targeting methodology’. Second, I will elaborate on the materiality of databases and data mining algorithms, showing how their technorationality is built on recombination, which fosters the production of possible future targets for a data-driven killing apparatus, in which human and non-human decision-making processes are intimately intertwined. In the third part of my article, I will discuss how computational actors make the messy targeting process more opaque and less traceable – not at least because of their underlying technorationality with its open-ended search heuristics – which advances a possibilistic, preemptive culture of technosecurity.

Keywords

Database, data mining, kill list, post-Newtonian rationality, algorithm, drone warfare

The magic of modern technoscience is a lot of hard work, smoke-filled rooms, and boring lists of numbers and settings. Tyranny or democracy, its import on our lives cannot be denied. (Bowker and Star, 2000: 50)

Corresponding author:

Jutta Weber, Institut für Medienwissenschaften, Universität Paderborn, Warburgerstr. 100, D-33098 Paderborn, Germany.
Email: jutta.weber@upb.de

The 'disposition matrix': Kill lists, databases and the production of targets

Since 9/11, the number of US kill and watch lists is constantly growing, and they are playing an ever more crucial role in the politics of targeted killing. This article explores the material agency and epistemological dimensions of the 'disposition matrix', the key database of diverse kill lists in the US 'war on terror'. Its aim is to understand how sociotechnical artefacts such as databases and algorithms are intertwined with human decision-making processes in the production of targets. Analysing the cultural logic of data-driven warfare, I want to make visible the non-human sociopolitical actors, which emerge from a post-Newtonian technorationality of recombination and (cor)relation which resources the unpredictable and advances a preemptive culture of technosecurity.

The 'disposition matrix', the US government's main kill list, was devised in 2010 by CIA director John Brennan (formerly Barack Obama's counterterrorism adviser) and merges the diverse kill lists maintained by the Pentagon, the Central Intelligence Agency (CIA) and the Joint Special Operations Command (JSOC). Some critics speculate that the 'disposition matrix' was introduced to regulate and thereby streamline the kill/capture process between the diverse organizations and to bypass the Joint Chiefs of Staff (Miller, 2012). But, it will become obvious that the 'harmonization' of these different kill lists is also a result of the dynamics of data analytics.

Most information about the 'disposition matrix' – as well as about other 'terrorist' kill or watch lists – is secret or classified. There are very few documents available, produced by government-friendly as well as by critical researchers, investigative journalists or NGOs, that provide a limited amount of information about the discourses and practices of the 'disposition matrix'. Its existence was publicly disclosed in 2012 by a series of Washington Post articles based on pronouncements made by senior members of the Obama administration (Miller, 2012; de Young, 2012; Whitlock, 2012).¹

Databases such as the 'disposition matrix' as well as other watch or kill lists are devices for profiling terrorists or suspects based on human intelligence (HUMINT) and, especially, on signals intelligence (SIGINT).² New data infrastructures and analytics (Kitchin, 2014) are playing a crucial and increasing role in the politics of intelligence production and targeted killing in contemporary US warfare (Belcher, 2014; González, 2015). Geographers Ian Shaw and Majed Akhter circumscribe the function of the 'disposition matrix' in the following way:

Electronic Targeting Folders' store information on terror suspects from around the planet. These documents exist in a database referred to as 'disposition matrix', which forms the bureaucratic knife-edge of the Barack Obama administration's program of targeted killings. The 'disposition matrix' contains the names of 'dangerous individuals' listed against the resources marshalled to kill or capture them, either by drones or Special Forces. The institutional tool harmonizes the kill lists that exist across the US Central Intelligence Agency (CIA) and the Department of Defense, *thereby centralizing the management of life and death in the White House*. (Shaw and Akhter, 2014: 211; my emphasis)

The targets of the 'disposition matrix' are killed in drone attacks or night raids. As far as is generally known, most targeted killings by drones have been undertaken by the Pentagon in Afghanistan, Iraq and Libya. Outside conventional war theatres, drones are used by the CIA and JSOC in countries such as Pakistan, Yemen, Somalia and Syria. Thousands of night raids have been conducted primarily by JSOC in Iraq and Afghanistan (Gregory, 2013; Woods, 2015).

Perhaps the most detailed description of how the ‘disposition matrix’ is compiled has been given by law professor Gregory S. McNeal (2014) in his case study ‘Targeted Killing and Accountability’. It is a highly informative but equally problematic study insofar as it embraces the often quite unspecific definition of ‘terrorist’ and other, related terms used by the US government. It is not only based on military policy documents, governmental answers to Freedom of Information Act (FOIA) requests, court documents, press reports and academic work – but also on participant observation of the official training of and ‘confidential interviews with members of the military, special operations, and intelligence community involved in the targeted killing process’ (McNeal, 2014: 681).

Targeting ‘methodology’: How to define and select a ‘terrorist’

According to McNeal, the nomination of a target for the ‘disposition matrix’ includes four steps: identification, vetting, validation and nomination – the latter often with presidential approval. On so-called ‘Terror Tuesday’, US President Obama confers with his security experts about which individuals are those against whom strikes are to be personally authorized:

Every week or so, more than 100 members of the government’s sprawling national security apparatus gather, by secure video teleconference, to pore over terrorist suspects’ biographies and recommend to the president who should be the next to die. This secret ‘nominations’ process is an invention of the Obama administration, a grim debating society.... (Becker and Shane, 2012)

Recently, the investigative journalism platform ‘The Intercept’ reported, on the basis of leaked material, that intelligence analysts produce a short description of the suspect and the threat s/he poses in the form of a ‘baseball card’, which – together with operational information – is then “‘staffed up to higher echelons” for action. On average, it took 58 days for the president to sign off on a target’ (Scahill, 2015).

This process of approval is not entirely new: it was invented by US President Lyndon B. Johnson, who personally selected targets during parts of the Vietnam War (Humphreys, 1984; Gregory, 2012) – though these targets were not primarily human beings, as with Obama’s list, but objects.

Nowadays, however, the ‘disposition matrix’ is a crucial component of computational counterinsurgency and, as such, is part of the ‘distanced, computer-centric approach of RMA [Revolution in Military Affairs; JW]’ (Belcher, 2014: 51). It is a flexible database based on structured and unstructured data and on small as well as big data that can be searched systematically using advanced data mining algorithms. It is a unique and key device in the ‘global war on terror’. Its technorationality draws upon a logic of tinkering that data mines the unknown, exploring all manner of (often highly unlikely) possibilities. Huge amounts of data are searched and clustered to *produce* patterns of correlations between data and thus to ‘discover knowledge in databases’ (Hildebrandt and Gutwirth, 2008, Kitchin, 2014). The discovery approach does not rest on the idea of correlations based on causal relationships but assumes that a (possible) past correlation will appear again at some point in the future.

With smart applications, however, the target is to collect and aggregate as much data as possible, in order to mine them for relevant patterns that allow the profiler to anticipate future behaviours. The hiding of data in fact diminishes the ‘intelligence’ of the applications. (Gutwirth and Hildebrandt, 2010: 7)

The bigger the data collection, the more possibilities there are to produce ‘knowledge’ (interesting combinations/patterns) through recombination. Thus, it is not only policy but also the inner logic of data analytics that drives the centralization of various watch and kill lists.

Definitions

In the last few decades, military and intelligence services in the United States have collected information on suspected insurgents – so-called terrorists – in diverse databases for the purpose of including them on watch and kill lists and for the purpose of filtering out specific features and behavioural patterns linked to ‘terrorism’ by means of data mining. This is clearly a delicate and highly selective task, not least given the fact that there is no clear international or legally binding definition of terrorism and that the definitions used by US government institutions vary quite widely (Schmid, 2011).

Given the secrecy surrounding the procedure, the relevant question is: Who counts as a terrorist, and why? And, consequently, what kind of data are to be collected? How does somebody come to be listed in databases such as the Terrorist Identities Datamart Environment (TIDE) – the biggest list of known and suspected terrorists, which gathers sensitive military and civil intelligence including classified information managed by the National Counterterrorism Center (NCTC) – or the Terrorist Screening Database (TSD), managed by the FBI, in which between 680,000 (Scahill and Devereaux, 2014b) and 875,000 people (de Goede, 2013) are registered? The TSD database is

a watchlist of ‘known or suspected terrorists’ that is shared with local law enforcement agencies, private contractors, and foreign governments—*more than 40 percent of the persons on the watchlist are described by the government as having ‘no recognized terrorist group affiliation’.* (Scahill and Devereaux, 2014b; my emphasis)

Since 2010, the ‘disposition matrix’ has been compiled using these and other databases. It is unclear exactly how the information in these databases has been collected and what specific targeting methodologies and algorithms are used.³

McNeal (2014) states that for the Obama government, a sufficient condition for being listed on any kill list is to be a member of an ‘organized armed group’. But what counts as an organized armed group? The definition could easily fit a US American family, in which all adults possess a firearm. Or again, it might describe a group of tribal elders in Waziristan who traditionally carry weapons as a sign of their status. Sometimes, even non-members of such ‘groups’ are added to the list if they are regarded as being important for the group – again, there are no strict criteria for cases when non-members might be added.

In July 2014, a ‘Watchlisting Guidance’ document (NCTC, 2014) – issued in March 2013 by the NCTC – was leaked to ‘The Intercept’. It contains guidelines for placing individuals on the TSDC or TIDE database and thereby reveals just how vague the selection criteria are – this at least partially explains the high number of selectees on the watch and kill lists. The document describes as ‘terrorist’ activity not only actions such as hostage taking, assassination or bombing but also ‘destruction of government property and damaging computers used by financial institutions... They also define as *terrorism any act that is ‘dangerous’ to property and intended to influence government policy through intimidation*’ (Scahill and Devereaux, 2014a; my emphasis). This vagueness in defining ‘terrorist suspects’ and ‘terrorists’ facilitates the inclusion of highly diverse data in the terrorist databases. Increasingly, they contain data on non-violent political activists and individuals who challenge the dominant political order in general. In this context, military

researchers have recently begun to mine social media intelligence (SOCMINT), from Twitter to Facebook, in the hope of ‘connecting the dots’. The effects of this, however, are highly problematic. In the fear of failing to spot potential suspects, the search criteria are constructed very broadly; accordingly, more and more data are included in watch and kill lists, while detection algorithms are defined very broadly to pick up on any possible correlations and patterns. The number of false positives is increased rapidly:

To reduce both those numbers (of false negatives and positives), you need *a well-defined profile*. And that’s a problem when it comes to terrorism. In hindsight, it was really easy to connect the 9/11 dots and point to the warning signs, but it’s much harder before the fact. Certainly, there are common warning signs that many terrorist plots share, but each is unique, as well. The better you can define what you’re looking for, the better your results will be. Data mining for terrorist plots is going to be sloppy, and it’s going to be hard to find anything useful. (Schneider, 2006; my emphasis)

Meta-data, social network analysis (SNA) and Skynet

Intelligence uses a variety of data mining tools and approaches such as social network, link, video⁴ and content or sentiment analysis to select and track targets on the basis of HUMINT and SIGINT (Joint Warfighting Center, 2011; Ressler, 2006; Sageman, 2004; ICWatch, 2015). In countries such as Pakistan, Yemen and Syria, which have few US armed forces on the ground, most of the intelligence gathered is based on SIGINT. SIGINT from video feeds, mobile phones, geo-locational information as well as data from email, social media and other internet services are used for data analysis – often based on quantitative link analysis methodology. This means that the more often somebody contacts a suspect, the more suspicious the person becomes – even though s/he might be a cousin or a friend who is not part of any so-called terrorist network. It works on the basis of a two (or three) -hop query through data collections often provided by security agencies such as the CIA or the National Security Agency (NSA) to find connections to other suspected ‘terrorists’ or members of ‘terrorist’ organizations.⁵

Meanwhile, SNA had

provided a framework for construction of models of networks by measuring the number of direct interactions between individuals, or ‘nodes’. With a quantitative tool called ‘link analysis’ and accompanying software, intelligence analysts could see the raw data from drone surveillance and links among telephones transformed into a ‘map’ of the insurgent ‘network’ in each locality. (Porter, 2011)

Organized armed ‘terrorist’ groups are frequently interpreted as social networks (Sageman, 2004; Ressler, 2006). The importance of a member of an assumed terrorist organization is weighed according to the outcome of the SNA in a kind of cost–benefit analysis: Steve Ressler from the Department of Homeland Security stresses that such an analysis focuses ‘on the value of the network structure rather than the characteristics of the individual’ (Ressler, 2006: 2), because these ‘terrorist’ organizations are interpreted as non-hierarchically organized networks with often only loosely connected individuals. Therefore, not only Taliban and al-Qaida leaders are regarded as a possible targets but also indeed, in principle, anybody who is in loose contact with members of the network. This description of a ‘terrorist’ network corresponds quite well to SNA approaches, which map and visualize huge amounts of metadata and fuse them into quasi-naturalized sociograms.⁶ The ‘Commander’s Handbook for Attack of the Network’ (2012) by the

former US Joint Warfighting Center describes the methodology and actions needed to exploit ‘terrorist network vulnerabilities’ quite bluntly: ‘SNA helps to identify which nodes in the network can be killed, captured or influenced to achieve desired effects’ (2011, IV-3). While it takes (‘terrorist’) networks (as identified by SNA) for granted, at the same time, it issues a serious warning concerning the shortcomings of the data mining approach:

...there is a significant caveat when using SNA – the link analysis is unique to the analyst developing the picture of the network. Additionally in developing a link analysis it is critical to ensure that there is an understanding of how or why a link was made between two nodes. (Joint Warfighting Center, 2011, IV-3; my emphasis)

SNA focuses on mapping relationships between people, places and things to develop a so-called ‘pattern of life’ analysis, which carves out the ‘process-based relationship between key nodes’ (Shaw, 2013). It is not only senior leaders of a ‘terrorist’ group who are regarded as valid objects for targeted assassination but also anybody who is identified (by an algorithm or an analyst) as being vital to the group – according to their strategic position in the network. This is why it is important to understand ‘how or why a link was made’: otherwise, this logic would rapidly lead to a multiplicity of targets. And yet exactly how these links are established and what the specific criteria are is often not obvious to military end-users, many of whom are not trained as software developers.⁷ The ‘how’ or ‘why’ of the link becomes even less clear in the case of data mining software such as Analyst’s Notebook, which includes ‘intuitive’ human-machine interfaces that make the work of inbuilt categories and representations invisible (Bowker and Star, 2000; Dourish, 2001; Suchman, 1994). One example of inbuilt criteria is SNA’s assumption that insurgent groups *are* networks, in which the centrality of an actor is determined by the quantity of his or her contacts with other suspects. Stohl and Stohl have pointed out that SNA cannot effectively distinguish the ability to network by means of communication and connectivity from ‘the ability to mobilize, control and coordinate members for specific planned acts’ (2007: 110). The relevant categories for the ‘pattern of life’ analysis rest on problematic assumptions, such as that travelling certain routes frequently, visiting suspicious locations or contacting suspects is undoubtedly the signature of a ‘terrorist’. Jeremy Scahill and Glenn Greenwald point to the fact that not only the identification of targets, but also the identification of their physical locations and the attacks themselves are based on meta-data analysis:

... the NSA, ... often identifies targets based on controversial metadata analysis and cell-phone tracking technologies. Rather than confirming a target’s identity with operatives or informants on the ground, the CIA or the US military then orders a strike based on the activity and location of the mobile phone a person is believed to be using. (Scahill and Greenwald, 2014)⁸

Retired US general and former NSA and CIA director Michael Hayden bluntly admitted that ‘We kill people based on metadata’ (Cole, 2013).

One effect of the logic of this targeting methodology can be studied paradigmatically in the document ‘Skynet. Courier Detection via Machine Learning’ (NSA, 2012) leaked by Edward Snowden. According to the NSA document, the renowned Al Jazeera journalist Ahmad Muaffaq Zaidan was placed on a watch list because of his travel patterns, phone call logs and the sources he was using. He is cited

as an example to demonstrate the powers of SKYNET, a program that analyses location and communication data (or ‘metadata’) from bulk call records in order to detect suspicious patterns. [...] According to the presentation, the NSA uses its version of SKYNET to identify

people that it believes move like couriers used by Al Qaeda's senior leadership. The program assessed Zaidan as a likely match. (Currier et al., 2015)

Ahmad Muaffaq Zaidan was obviously listed because of his professional work as a journalist working on the al-Qaida and Taliban movement thereby meeting insurgents including Osama Bin Laden. Any analyst who has a profound knowledge of the language, policy and socio-cultural context of Pakistan would have realized that the contacts of the journalist result from his professional work and do not necessarily indicate any insurgent activity. When the targeting process is automated – particularly at a time when competent analysts are few and far between⁹ – it makes the targeting increasingly non-reproducible while nevertheless producing ever more suspects and including them on watch and kill lists.

In general, the 'disposition matrix' can be understood as a constantly evolving database, which includes not only biographies but also conclusions drawn from data analysis, primarily on the basis of metadata. Overall, the 'pattern of life' analysis resembles law enforcement strategies of collecting data on criminal behaviour. And though the 'disposition matrix' partly builds on narratives of 'terrorist' biographies (e.g. de Goede, 2013; Kessler and Wouter, 2013), it is also a searching device in which big datasets are placed in relation to one another and recombined – establishing profiles of the supposedly most dangerous suspects.

Obviously, people are killed not because they are identified as high-ranking members of a specific 'terrorist' network, but because they show specific behaviours or link patterns, which are regarded by analysts or software designers as suspect or which 'emerge' from the data analysis. The analysis seeks to detect 'persistent anomalies in normal rhythms of activity, which are read as signs ("signatures") of imminent threat. . . The principal limitation – and *the grave danger – lies in mistaking form for substance*' (Gregory, 2013; my emphasis). The quantitative methodology cannot make qualitative distinctions between relationships of different 'nodes', which are easily subsumed into terror networks. Accordingly, relatives, friends and co-workers who have multiple connections to suspects or targets are added to the list.

The historian and journalist Gareth Porter also points out that many people living in the Southern or Eastern Pashtun area have a few mobile numbers of Taliban commanders in their mobile as a 'survival mechanism' – and the same might be true for people living in Waziristan. And although the targets included in the 'disposition matrix' are identified persons, the indicators which made them high-value targets are often derived from a targeting method which rests on predefined categories, does not establish causal relationships and describes only formally patterns of relations on the basis of meta-data. On the basis of methodologies such as SNA, geospatial or sentiment analysis, analysts produce target lists and the knowledge about 'how and why a link was made' will necessarily get lost during this multi-layered process of merging and filtering huge amounts of metadata.

None of these problems can be resolved by having more accurate definitions of terrorism or by honing the criteria used to add someone to the list or by perfecting algorithms – because the process of mistaking form for substance is occurring in a very literal way and is an integral part of the procedure: there seems to be no narrative based on cause and effect trajectories to explain why somebody is considered a 'terrorist' who poses an imminent threat. There is no transparent or consistent line of argument, which would justify the criteria and render them coherent. There is no (open) claim to produce truth or at least some meaning in this process. The pattern of life approach draws on a technoscientific logic of recombination, (cor)relation and possibilities – and this logic rests on very weak

probabilities and is highly constructed. At the same time, this approach spurs on the desire (or the perceived need) to collect more and more data: the larger the amount of data stored in the database and the higher the numbers of possible combinations this yields (of nodes of networks, for example), the more high-value targets can be 'identified'. And it is not only 'hundreds of people [who] make incremental contributions to a well-oiled killing machine' (McNeal, 2014: 685) but also the inner logic of databases and big data analysis.

Based on this perspective, I will draw on insights from technoscience and software studies to render this inner logic more visible and to develop a more detailed, material-based understanding of these practices. This approach has its own limitations, because the specific programs used in the targeting process are secret and therefore not available for closer analysis. Nevertheless, I would argue that understanding the impact of the general principles of contemporary databases and data mining algorithms can decisively improve our understanding of the targeting process as the epistemological underpinning of the apparatus becomes visible.

The epistemology and materiality of databases

Information systems are material objects, but so too is information as it is manifest within them. Its specific materialities shape the forms of processing that it allows. Any account of what information is, or what it does within social, cultural, or institutional settings must, then, be grounded in an examination of these material considerations. (Dourish, 2014: 1)

Technoscience and especially software studies have pointed out that software permeates every realm of contemporary life: '(M)ore and more of the spaces of everyday life come loaded up with software, lines of code, that are installing a new kind of automatically reproduced background and whose nature is only now starting to become clear' (Thrift and French, 2002: 309). This is especially true of contemporary warfare and military organizations. Accordingly, my aim here is to make the inner logic of the database as well as data mining and machine learning techniques visible by examining their epistemological and material basis – that on which analysts draw in order to search for and predict potential targets.

First, I will discuss the shift from the hierarchical to the relational as well as post-relational database, from the storage to the search device used to examine structured (small) data to the distributed system that can search semi- or unstructured (big) data in parallel.¹⁰ I will then have a closer look at machine learning techniques – especially genetic algorithms.

Rethinking the 'disposition matrix' from this perspective, I want to show how mining techniques in combination with post-relational NoSQL databases build on automated processes of systematized tinkering and recombination and thus fuel the production and collection of data, suspects and targets.

What is a list and what is a database?

Lists are made to add, combine and, eventually, order items *without* relying on a pre-given order (Stäheli, 2012: 234–236). Any list is a tool of abstraction and often an answer to a problem. Furthermore, 'the criteria of selection are not fixed at the outset but evolve during the list's use' (Stäheli, 2012: 237). They are not inherent to the list. Its rules of inclusion or exclusion can be changed according to the circumstances.¹² Representational forms (such as a list or a database) and knowledge are intrinsically intertwined (Goody, 1977) and the

potential of abstraction in lists relies on discontinuity and decontextualization – in contrast to narratives which have a pre-given structure, for example.

Stäheli (2012) interprets the list as a kind of (simple) database. Databases are structured collections of data. They are theoretically indefinite. Lev Manovich pointed out that they have no beginning, end or development. They are not telling stories and they have no internal grammar. ‘Instead, [...databases] are collections of individual items, where every item has the same significance as any other’ (Manovich, 2001).

Databases are structured differently – in hierarchical, network-like or post-relational ways. It is important to differentiate between the traditional form of the list (or database) and a more recent cultural expression of the list, namely, the post-relational database.

Early databases were organized in a hierarchical way with a tree-like structure. For these traditional databases, the user needs to know how the database is structured and what data it contains. In this model, every data item contains a physical storage address, and the way information is retrieved depends on how the data are organized. These databases are less dynamic than relational ones, because they can only answer the kinds of questions the programmers were aware of when they designed them.

In the early 1970s, Codd (1970) and others developed relational database models and made it possible to separate storage and retrieval (Dourish, 2014; Kitchin, 2014). In such a database, data are not organized in a hierarchical, tree-like pattern that branches out from a root but rather in a table, so that each segment of data can be placed in multiple relationships to other items. Databases thus went from being a means of organization to becoming a means of querying. Relational databases are highly flexible, dynamic and open-ended systems. This became possible because of the shift from hierarchical to relational database management systems and the rapidly increased power of central processing units (CPUs). The relational database is indispensable for the real-time management of complex, dynamic and open systems:

Relational databases enabled more efficient and sophisticated organization and querying of structured data (using SQL – structured query languages). Alongside relational databases, the development of spreadsheets allowed large volumes of numeric data to be structured and stored and for formulae to be applied to the data to produce new derived data. (Kitchin, 2014: 32)

This became the dominant database management system, turning the database from a storage and retrieval device into a search device (Amoore, 2013; Hildebrandt and Gutwirth, 2008).

The post-relational NoSQL (not only SQL) database emerged in the early years of the 21st century. It is capable of storing and querying enormous amounts of structured as well as semi- or unstructured data, as required for highly centralized web services such as Google, Facebook or Amazon – or the databases of the intelligence services (Kitchin, 2014: 86).

Post-relational databases are distributed on many servers, which are flexible and easily extendable big data systems ‘holding the traits of extensionality (can add new fields easily) and scalability (can expand rapidly) regardless of volume... The use of NoSQL databases means that changeable data can be managed at high velocity, adapting to new fields’ (Kitchin, 2014: 78). And while the traditional list is a perfect medium to (re-)combine and relate all kinds of data, NoSQL database design as well as smart knowledge discovery techniques make ‘access to very large, exhaustive, dynamic, fine-grained, indexical, varied, relational, flexible and scalable data’ (Kitchin, 2014: 79) possible. New database design, increased computational power and distributed infrastructures managed by techniques such as MapReduce (Kitchin, 2014: 86f) enable new forms of (big) data analysis.

Nowadays, it is not only new database structures that define the way data are related and combined but also data mining algorithms: 'Together, data structures and algorithms are two halves of the ontology of the world according to a computer' (Manovich, 2001: 198). As mentioned above, knowledge discovery techniques such as data or text mining, sentiment and SNA are used massively in the hope of extracting relevant patterns from the piles of military and civil intelligence.

A new technoscientific rationality

The shift in cultural expression from narrative to (post-relational) databases and the emergence of new, flexible algorithms can be seen as part of a profound reconfiguration of epistemology and ontology within a new epoch called 'technoscience' (Latour, 1986). Technoscience culture itself can be characterized by the observation that everyday life is thoroughly pervaded by discourses and practices of technosciences such as computer science, genetics or Artificial Intelligence. All these discourses and practices are in the process of reconfiguring culturally contested concepts such as 'nature', 'the body' and 'subjectivity'. The fusion of science and technology in technoscience has become an entrepreneurial and pragmatic project, in which technology assumes a lead role in the development of innovative solutions for most of the core problems of our societies. As I have argued elsewhere (Weber, 2003, 2011), the new technoscientific rationality is much more flexible and is characterized by a strong interest in the unpredictable, in processes of emergence, and in the unknown. This epistemological shift is also embedded in globalized media culture, in which

[m]any new media objects do not tell stories. Instead, they are collections of individual items, [...] on which the user can perform various operations: view, navigate, search. *The user experience of such computerized collections is therefore quite distinct from reading a narrative.* (Manovich, 2001; my emphasis)

This new epistemological logic is rooted historically in systems theory and cybernetics, which provide the common ground for today's dominant technoscientific discourses and practices (Weber, 2003, 2011). Technosciences such as robotics, genetics and computer science are built on new epistemologies and ontologies, and on the new conceptual frameworks, identities and modes of governance which emerged in the second half of the 20th century (cf. Haraway, 1985/1991; Latour, 1986). The key features of technoscientific rationality include formalized and systematized tinkering as well as the use of trial and error, bottom-up search heuristics and post-processing for the solution of complex problems.

Adaptation, imitation and imagination are key to a rationality aimed at resourcing the unpredictable and to attempts to find ways of exploiting surplus processes by technical means (Haraway, 1985/1991; Nordmann, 2006; Weber, 2003). In contrast to modern scientific rationality, it is not interested in the analysis of intrinsic properties of entities (organisms, machines) but focuses instead on their behaviour, on their (inter)relations and on possible recombination of modules, fragments of code and building blocks of systems. Technoscience increasingly substitutes representation and understanding with investigation and intervention (Weber, 2003). This new post-Newtonian rationality has also imprinted itself deeply on processes of listing, data collection and search heuristics in the so-called 'global war on terror'. As Louise Amoore has recently pointed out, techniques such as 'risk profiling, algorithmic modelling, information integration, and data analytics [have] become the authoritative knowledges of our time' (Amoore, 2013: 9).

'How to solve problems you do not fully understand'

Kill lists as well as lists in general are flexible and dynamic because they are not based on clear selection criteria. Anything can be added to a list when the rules governing what qualifies as an item to be listed can be changed constantly. Kill lists such as the 'disposition matrix' are founded upon search procedures and devices designed to sift through tremendous amounts of data – from drone feeds to social media – and to scan this data universe in the hope of connecting 'the' dots. In this way, the hope is to find hidden threats or 'terrorists', while data are adjusted automatically, problem spaces of algorithms are searched for patterns, and chat room conversations are scanned for keywords. It is not a specific entity that is being searched for but patterns, irregularities and possibilities.

New forms of data mining algorithms that are ruled by a similar logic, such as genetic algorithms, emerged in the 1980s. While algorithms had previously been designed 'top-down' to solve a specific problem in a straightforwardly rational-cognitive way, genetic algorithms work in a 'bottom-up' way, usually by describing a problem and converging the solution towards said problem. Within this logic, the most effective way to find a solution is to give a sound description of the 'problem space', to define robust parameters and to then use processes of trial and error (referred to elsewhere in this article as systematic 'tinkering') to search this space. In both cases, it is not a clearly defined problem that is the object of the (re)search but rather a broadly defined target or problem along with a few boundary conditions within which the goal is to be achieved (to find the terrorist or to solve another problem). This approach departs significantly from the core norms of traditional science – such as the objective description of universal laws, the representation of nature, consistency, and the subject-object divide. This technorationality is based on systematized tinkering and on exploring the boundary conditions of emergent behaviour; it makes use of search heuristics, algorithms that simulate 'evolution' via tinkering, and techniques of post-processing. I seek to illustrate this more clearly in the following: In 1992, John Holland published an article entitled *'Genetic Algorithms. Computer Programs - that "evolve" in ways that resemble natural selection can solve complex problems even their creators do not fully understand'* (Holland, 1992). It seems that Holland was promising something one cannot reasonably promise: to develop a problem-solving strategy for problems which are not (yet?) understood. However, what sounds absurd initially might also be seen as the leitmotif of technoscientific rationality.

Holland developed so-called optimized, self-learning computer programs that were designed to solve certain tasks – such as finding the most effective algorithm for sorting different numbers according to their size. It works as follows: first, a fitness factor for the task is defined. Then, a computer randomly produces diverse algorithms, which are rated and selected according to the fitness factor that indicates their 'success'. A pre-defined percentage of the computer programmes that match the task best according to the fitness factor are reproduced, while all the other programmes are deleted. The successful algorithms are crossed over by swapping those parts of the programme's digital code that are located at the same position in the code. Then, the process is started over again. In effect, the procedure can be described as a smart, optimized and systematized process of trial and error, because it is conducted in iterative loops until an appropriate solution is found for the problem at hand. *And although millions of useless programmes are produced, new solutions arise with the help of genetic algorithms* (which are an underclass of evolutionary algorithms) on the basis of processing power and time. This bottom-up method can compete with and often produces better results than traditional programmes designed by software engineers in a top-down, rational-cognitive way.

These trans-classic ways of computing and, especially, of data-mining information are key to a technoscience culture in which the world is reconfigured as flexible, open-ended and unpredictable, while at the same time becoming a place of combination, recombination and re-design (Haraway, 1985/1991). Alongside other applications, genetic algorithms are central to contemporary methods of data mining. The database (or specified parts of the database) is defined as the search space, and genetic algorithms are used to search vast amounts of data for patterns, relations, associations and ‘anomalies’. In this way, data can be classified (by applying known categories to new data) and clustered (by searching for as yet unknown groups or structures in the data), and patterns can be extracted. These can be used to predict, to test hypotheses and to optimize search strategies (for finding optimal association rules, for example). Randomly producing relations and recombinations is a key part of mining the ‘disposition matrix’ and fuels the desire for more data while producing more ‘hits’ (that is, suspects). The idea of systematically scanning a (pre-defined) space for a possible solution, of endlessly recombining data in the hope to ‘identify’ a possible threat or a possible suspect, looks familiar when we think of today’s pre-emptive technosecurity measures. The huge amount of ever expanding data gathered by the NSA can be seen as part of this technorationality, which fuels the ‘need’ for ever more data.

In the next section, I will discuss the affinities between the new technorationality, with its open-ended search heuristics, and a postmodern preemptive technosecurity, which seeks to anticipate and avert all potential threats. I will point out how today’s practices of imagination are rooted in Cold War security culture and will also highlight their key differences to contemporary technosecurity culture.

Preemptive culture of technosecurity

Features of the new technorationality can be found prominently in a culture of preemptive technosecurity, which focuses on anticipating ‘unknown unknowns’ (Daase and Kessler, 2007) – unknown risks posed by unknown actors – rather than concentrating on the empirical, causal assessment of objective and concrete threats posed by identifiable ‘risk’ actors (Aradau et al., 2008). Sophisticated surveillance applications such as data mining, computer simulations (Bogard, 2012), scenario-planning techniques and worst-case imagination (de Goede, 2008) are primarily directed towards uncertainty and unpredictable risks (Salter, 2008; Bröckling et al., 2011). This technorationality at work in the targeting process becomes obvious from the way targeted killings are justified by CIA director John Brennan:

[W]e conduct targeted strikes because they are necessary to mitigate an actual ongoing threat. . . And what do we mean when we say significant threat? . . . A significant threat might be posed by an individual who is an operational leader of al-Qaida or one of its associated forces. Or perhaps the individual is himself an operative, in the midst of actually training for or planning to carry out attacks against US persons and interests. *Or perhaps the individual possesses unique operational skills that are being leveraged in a planned attack.* (Brennan, 2012; my emphasis)

Again, the criteria for a high-value target are more than vague: not only does being a senior al-Qaida leader make you eligible to be listed in the ‘disposition matrix’ but also planning an attack or even having certain skills that might be needed in a planned attack. This leaves ample room for interpretation: when do we know for sure that somebody is planning an attack? It seems that even possessing certain skills makes you a (possible) suspect and might justify your preemptive assassination. Evidently, ‘(t)he logic of preemption prioritizes the power of imagination over the power of fact – suspicions over evidence’ (Salter, 2008: 243).

Potential threats come to be defined so broadly that in principle anybody can pose one in the near future,¹³ while the analysis rests on indicators and observations of behaviour. This way of defining possible targets is contrary to the modern scientific understanding of cause and effect, but it fits very well to the tinkering logic of today's technorationality. Today, incremental and automated processes of recombining and interrelating data (provided largely via SIGINT) are the epistemological foundation for risk management – a procedure that is organized on the basis of predefined categories and is dominated by imagination in the sense of projecting (im)probable scenarios, connections and circumstances. Semi-automated technologies of predictive analysis and preemptive action, real-time tracking and targeting are regarded as appropriate ways to handle the challenge of unpredictable risks – an approach reminiscent of the desire to find a 'technological fix' and thus to achieve technological 'preparedness' or indeed superiority (cf. Der Derian, 2009; de Goede, 2008).

Yet the use of imagination in security practices is not entirely new. Worst-case scenarios and computer simulations that used techniques of imagination were already deployed during the Cold War when the unprecedented threat of nuclear war in the 1940s created an entirely new situation marked by insecurity. The latter could be addressed neither on the basis of previous experience nor by experimentation. In the 1960s famous 'defence intellectuals', such as US think tank RAND expert Hermann Kahn (1960) devised all manner of (in)conceivable scenarios resulting from a nuclear strike or counter strike that went *beyond the question of probability* (Ghamari-Tabrizi, 2005; Kaplan, 1983); such scenarios included the deaths of hundreds of millions of people, survival strategies for highly improbable scenarios and biopolitical measures for a post-nuclear (!) age. However, whereas in the Cold War security discourse, strategists were dealing with a *concrete* situation with *concrete* actors, today's security discourses are increasingly about possibilistic threats and their presumed actors.

Uncertainty has long been incorporated into calculations by way of statistics: '... algorithmic logics have already begun to define the management of uncertain futures of many kinds – from flood risk in the insurance industry to catastrophe risk in the financial markets' (Amoore, 2009: 52). What we are experiencing today, however, is 'a *change in emphasis from the statistical calculation of probability to the algorithmic arraying of possibilities* [...]' (Amoore, 2013: 23; my emphasis). It seems that these algorithms are increasingly dominating the discourses and practices of civil and military security agencies, substituting traditional probability with the 'imagination of possibilities' (Amoore, 2013: 24). Today – for fear of failing to spot potential singularities – data segments are recombined to put a defined problem space into a grid as completely as possible, even if 99% of the solutions, though technically possible, are unfeasible or highly unlikely. What used to be tested in worst-case scenarios is now perfected in a kind of systematized and formalized tinkering on the basis of data mining and huge, flexible, post-relational databases hoarding big data.

In the following, I want to highlight the impacts and consequences of this technorationality combined with the new culture of technosecurity and examine the role of the 'disposition matrix' in this context.

Resourcing the unpredictable: Technoscientific rationality and the 'disposition matrix'

Post-relational databases and genetic algorithms can be regarded as the paradigmatic media of a post-Newtonian rationality and the preferred medium of an intelligence community

keen to map a world perceived as incoherent, unpredictable and full of risks (Aradau and van Munster, 2007). Surplus processes of ‘emergent’ behaviour are exploited by collecting a huge amount of data on the basis of HUMINT and especially SIGINT, including SOCMINT. These databases are searched, mostly on a quantitative or associative basis, by flexible algorithms looking for links, connections, similarities or patterns. The logic followed here is not one of cause-and-effect but rather one of preemption and possibility. In the face of unknown unknowns, it is no longer accountability and traditional scientific rigour that are used to counter threats but rather the technical exploitation of chance and imagination by means of systematized tinkering and formalized processes of trial and error. Consequently, according to the data-driven logic of comprehensive (re-)combination, anybody and everybody can become a target: while massive amounts of surveillance data are gathered

without any judicial review let alone search warrants...a surveillance state and a secretive, unaccountable judicial body...analyzes who you are and then decrees what should be done with you, how you should be ‘disposed’ of, beyond the reach of any minimal accountability or transparency. (Greenwald, 2012)

An important part of this logic is driven by technoscientific practices, which decline to engage in any kind of objective representation of the world – even though politicians, police, military and secret services personnel vehemently claim the scientific validity of the technologies used in their public rhetoric of legitimation. A core part of the construction of the ‘disposition matrix’ consists of extremely vague categorizations of what counts as terrorism and what is a ‘central’ node in a ‘terrorist network’. The ‘disposition matrix’ depends on maintaining secrecy about what makes somebody ‘eligible’ to be included in it or to become the target of a drone strike or a raid. It relies on metadata and on data mining tools such as SNA (which is opaque even to the analysts themselves), often follows a purely quantitative logic and/or ignores the social, political and cultural context, in which the data are gathered. This logic is not grounded in objective, reproducible methods and there is not even a coherent narrative about why a person is more dangerous than another person, or why they ‘need’ to be assassinated. While a numerical list gives priority to some people over others (qualifying him or her as *the* most dangerous terrorist, for example), a database collects all the information that is available. The way patterns are constructed changes with every new piece of information collected. Within this technorational framework (the purpose of which is to preempt highly unlikely possibilities), it is impossible to explain why somebody is supposedly *the* most dangerous terrorist or the most important one for the network. The process seems to follow a logic of eliminating every possible danger. Within this logic, the database is the perfect tool for preemptive security measures, because it has no need of the logic of cause and effect. It widens the search space and provides endless new patterns of possibilistic networks.

It is not only that ‘extraordinary and exclusionary political measures are activated through the invocation of an existential threat’ (Opitz, 2011: 94), the new technoscientific rationality built on resourcing the unpredictable by means of systematized search practices also provides a new basis for a security culture – a culture driven by the (necessarily vain) wish to preempt any possibilistic risk. Given this new technorationality, illiberal security discourses and practices such as secret blacklisting and targeted assassinations appear increasingly rational. And to make the increasingly powerful non-human agency of algorithms and database systems invisible, the symbolic power of the sovereign is emphasized: on ‘Terror Tuesdays’ it (appears that it) is only the sovereign who decides about life and death.

Acknowledgements

I would like to thank Louise Amoore, Claudia Aradau, Marieke de Goede, Derek Gregory, Anna Leander, Urs Stäheli, Lucy Suchman and many more who provided helpful advice on earlier versions of this article when it was presented at the COST workshop ‘*The Politics of List: Law, Security, Technology*’ at the Kent Law School, University of Kent in Canterbury in November 2013 and the symposium *Security by Remote Control* at the Centre for Science Studies at Lancaster University in May 2014. Many thanks for helpful critical insights also to the four anonymous reviewers and the guest editors who helped very much to clarify these thoughts. I am also indebted to Katrin M. Kämpf for research assistance. All remaining errors remain my own.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was made possible in part by a sabbatical in the spring and summer term 2015 granted by the University of Paderborn.

Notes

1. See also Greenwald (2012), Gettinger (2015) and Woods (2015).
2. Signals intelligence (SIGINT) is defined as ‘[i]ntelligence derived from communications, electronic, and foreign instrumentation signals’ (Department of Defense, 2007: 224). The term communications signals (COMINT) signifies voice information or messages sent between people who have been intercepted from foreign sources, while electronic intelligence (ELINT) is ‘(t)echnical and geolocational intelligence derived from foreign noncommunications electromagnetic radiations’ (Department of Defense, 2007: 77). Foreign instrumentation signals (FISINT) includes data from foreign sources of telemetry or video data links transmitted by satellites, UAVs, missiles, etc.
3. However, the newly released database Intelligence Community Watch (ICWatch, 2015) developed by the group ‘Transparency Toolkit’ and now hosted by Wikileaks shows that many US analysts now concentrate on producing targets and work with data mining software such as IBM’s Analyst’s Notebook or Palantir.
4. For example, around 7 terabytes of drone imagery data are disseminated every day by the Air Force’s Distributed Common Ground System (DCGS) (Gettinger, 2015).
5. Greg Miller has pointed out that the CIA has made identifying targets for targeted killing by drones ‘a designated career track’ (Miller and Tate, 2011).
6. This approach is based on work by Valdis Krebs, who was the first to use SNA to map a terrorist network – in this case, the network of the 9/11 attackers; see Krebs (2002).
7. See, for example, the self-description of an ‘intelligence analyst’ at ICWatch who has the following software-related ‘skills’: ‘i2 Analyst Notebook, Microsoft Office, Internet,... PowerPoint, Analyst Notebook,... Microsoft Excel, Time Management, Facebook,..., Microsoft Word, Social Networking, Research’, <https://icwatch.wikileaks.org/nsadocs/andrea-javor55587789OhioHIDTACriminalIntelligenceAnalystIntern2013-05-01>.
8. '[Th]is account is bolstered by top-secret NSA documents previously provided by whistleblower Edward Snowden. It is also supported by a former drone sensor operator with the US Air Force, Brandon Bryant, who has become an outspoken critic of the lethal operations in which he was directly involved in Iraq, Afghanistan and Yemen. In one tactic, the NSA “geolocates” the SIM card or handset of a suspected terrorist’s mobile phone, enabling the CIA and US military to

- conduct night raids and drone strikes to kill or capture the individual in possession of the device' (Scahill and Greenwald, 2014b).
9. This becomes apparent, for example, in the wish expressed by the US military to build 'Reachback Research Centers' for Human Terrain Teams, from where social scientists, analysts and others are supposed to provide cultural context; see González and Price (2015, no pagination).
 10. Structured data rest on a predefined data model, while semi-structured data are loosely, irregularly structured and cannot be processed in relational databases. '(U)nstructured data do not have a defined data model or common identifiable structure' (Kitchin, 2014: 6).
 11. See the sections on technorationality.
 12. Although they are also linked to the algorithms used.
 13. Which is not to say that some people are more likely to be targeted according to categories such as race, class or gender.

References

- Amoore L (2009) Algorithmic war: everyday geographies of the war on terror. *Antipode: A Radical Journal of Geography* 41: 49–69.
- Amoore L (2013) *The Politics of Possibility. Risk and Security Beyond Probability*. Durham, London: Duke University Press.
- Aradau C, Lobo-Guerrero L and van Munster R (2008) Security, technologies of risk, and the political: Guest editors' introduction. *Security Dialogue* 39(2–3): 147–154.
- Aradau C and van Munster R (2007) Governing terrorism through risk: Taking precautions, (un)knowing the future. *European Journal of International Relations* 13(1): 89–115.
- Becker J and Shane S (2012) Secret 'kill list' proves a test of Obama's principles and will. *New York Times*, 29 May.
- Belcher O (2014) *The afterlives of counterinsurgency: Postcolonialism, military social science, and Afghanistan 2006-2012*. PhD Thesis. Available at: https://circle.ubc.ca/bitstream/handle/2429/45520/ubc_2014_spring_belcher_oliver.pdf?sequence=5 (accessed 10 December 2015).
- Bogard W (2012) Simulation and post-panopticism. In: Ball K, Haggerty K and Lyon D (eds) *Routledge Handbook of Surveillance Studies*. New York: Routledge, pp. 30–37.
- Bowker GC and Star SL (2000) *Sorting Things Out: Classification and its Consequences*. Cambridge, MA: MIT Press.
- Brennan JO (2012) Transcript of remarks by John O. Brennan, Assistant to the President for Homeland Security and Counterterrorism. The Ethics and Efficacy of the President's Counterterrorism Strategy. Available at: <http://www.wilsoncenter.org/event/the-ethics-and-ethics-us-counterterrorism-strategy> (accessed 10 December 2012).
- Bröckling U, Krasmann S and Lemke T (2011) *Governmentality: Current Issues and Future Challenges*. New York: Routledge.
- Codd E (1970) A relational model of data for large shared data banks. *Communications of the ACM* 13(6): 377–387.
- Cole D (2013) We kill people based on metadata. *The New York Review of Books*, 15 August, Available at: <http://www.nybooks.com/articles/archives/2013/aug/15/nsa-they-know-much-more-you-think/?insrc=rel> (accessed 10 December 2012).
- Currier C, Greenwald G and Fishman A (2015) US government designated prominent Al Jazeera journalist as member of Al Qaeda. *The Intercept*, 8 May. Available at: <https://firstlook.org/theintercept/2015/05/08/u-s-government-designated-prominent-al-jazeera-journalist-al-qaeda-member-put-watch-list/> (accessed 10 December 2012).
- Daase C and Kessler O (2007) Knowns and unknowns in the 'war on terror': Uncertainty and the political construction of danger. *Security Dialogue* 38(4): 411–434.
- de Goede M (2008) Beyond risk: Premediation and the post-9/11 security imagination. *Security Dialogue* 39(2–3): 155–176.

- de Goede M (2013) The politics of security listing. Classification, criteria, consequence, critique. In: *COST-workshop, the politics of lists: Law, security, technology*, Canterbury, UK, 31st October–1st November, Kent Law School.
- Department of Defense (2007) *Dictionary of military and associated terms*. Available at: http://www.dtic.mil/doctrine/new_pubs/jp1_02.pdf (accessed 10 December 2012).
- Der Derian J (2009) *Virtuous War: Mapping the Military-Industrial-Media-Entertainment Network*, 2nd ed. New York: Routledge.
- de Young K (2012) A CIA veteran transforms US counterterrorism policy. *Washington Post* 24 October. Available at: http://articles.washingtonpost.com/2012-10-24/world/35499428_1_drone-strikes-brennan-obama-administration (accessed 10 December 2012).
- Dourish P (2001) *The Foundations of Embodied Interaction*. Cambridge: MIT Press.
- Dourish P (2014) NoSQL: The shifting materialities of database technology. *Computational Culture* 4. Available at: <http://computationalculture.net/article/no-sql-the-shifting-materialities-of-database-technology> (accessed 10 December 2012).
- Gettinger D (2015) The disposition matrix. *Center for the Study of Drones Blog*, 25 April. Available at: <http://dronecenter.bard.edu/the-disposition-matrix/> (accessed 10 December 2012).
- Ghamari-Tabrizi S (2005) *The worlds of Herman Kahn: The intuitive science of thermonuclear war*. Cambridge, Massachusetts: Harvard University Press.
- González RJ (2015) Seeing into hearts and minds. Part 2. ‘Big data’, algorithms and computational counterinsurgency. *Anthropology Today* 31(4) August, 13–18.
- González RJ and Price D (2015) Remaking the human terrain: The US military’s continuing quest to commandeer culture. Available at: <http://www.counterpunch.org/2015/07/31/remaking-the-human-terrain-the-us-militarys-continuing-quest-to-commandeer-culture/> (accessed 31 July 2015).
- Goody J (1977) *The Domestication of the Savage Mind*. Cambridge: Cambridge University Press.
- Greenwald G (2012) Obama moves to make the War on Terror permanent. *The Guardian*, 24 October. Available at: <http://www.theguardian.com/commentisfree/2012/oct/24/obama-terrorism-kill-list> (accessed 10 December 2015).
- Gregory D (2013) Theory of the drone 3: Killing grounds. *Geographical Imaginations Blog*, 29 July. Available at: <http://geographicaliminations.com/2013/07/29/theory-of-the-drone-3-killing-grounds/> (accessed 10 December 2015).
- Gregory D (2012) I don’t like Tuesdays. *Geographical Imaginations Blog*, 26 October. Available at: <http://geographicaliminations.com/2012/10/26/i-dont-like-tuesdays/> (accessed 10 December 2015).
- Gutwirth S and Hildebrandt M (2010) Some caveats on profiling. In: Gutwirth S, Pouillet Y and de Hert P (eds) *Data Protection in a Profiled World*. Dordrecht: Springer.
- Haraway D (1985/1991) Manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s. *Socialist Review* Vol 80: 65–108 (Reprinted in Haraway D (1991) *Simians, Cyborgs, and Women: the Reinvention of Nature*. London/New York: Routledge, pp.149–181).
- Hildebrandt M and Gutwirth S (2008) *Profiling the European Citizen. Cross Disciplinary Perspectives*. Dordrecht: Springer.
- Holland JH (1992) Genetic Algorithms Computer programs that ‘evolve’ in ways that resemble natural selection can solve complex problems even their creators do not fully understand. *Scientific American* 267: 66–72.
- Humphreys D (1984) On the Tuesday Lunch at the Johnson White House: a preliminary assessment. *Diplomatic History* 8: 81–101.
- ICWatch (2015) Intelligence community watch 5 May. Available at: <https://icwatch.wikileaks.org/> (accessed 10 December 2015).
- Joint Warfighting Center (2011) *Joint Doctrine Support Division. Commander’s Handbook for Attack the Network, Version 1.0*. Suffolk/Virginia, 20 May. Available at: http://www.dtic.mil/doctrine/doctrine/jwfc/atn_hbk.pdf (accessed 10 December 2015).
- Kahn H (1960) *On Thermonuclear War*. Princeton: Princeton University Press.

- Kaplan F (1983) *The Wizards of Armageddon*. New York: Simon and Schuster.
- Kessler O and Wouter W (2013) A grim debating society. In: *COST-Workshop, the politics of lists: law, security, technology*, Canterbury, UK, 31st October–1st November, Kent Law School.
- Kitchin R (2014) *The Data Revolution. Big Data, Open Data, Data Infrastructures & Their Consequences*. Los Angeles: Sage.
- Krebs V (2002) Uncloaking terrorist networks. *First Monday* 7(4). Available at: <http://firstmonday.org/ojs/index.php/fm/article/view/941/863/> (accessed 10 December 2015).
- Latour B (1986) *Science in Action*. Milton Keynes: Open University Press.
- Manovich L (2001) *The Language of New Media*. Cambridge: MIT Press.
- McNeal G (2014) Kill-lists and accountability. *Georgetown Law Journal* 102: 681–794.
- Miller G (2012) Plan for hunting terrorists signals US intends to keep adding names to kill lists. *The Washington Post*, 23 October. Available at: http://www.washingtonpost.com/world/national-security/plan-for-hunting-terrorists-signals-us-intends-to-keep-adding-names-to-kill-lists/2012/10/23/4789b2ae-18b3-11e2-a55c-39408fbc6a4b_story.html (accessed 10 December 2015).
- Miller G and Tate J (2011) CIA shifts focus to killing targets. *The Washington Post*, 1 September. Available at: http://www.washingtonpost.com/world/national-security/cia-shifts-focus-to-killing-targets/2011/08/30/gIQA7MZGvJ_story.html (accessed 10 December 2015).
- National Counterterrorism Center (NCTC) (2013) Watchlisting guidance march. Available at: <https://snowdenarchive.cjfe.org/greenstone/collect/snowden1/index/assoc/HASH01d1/4a00c36e.dir/doc.pdf> (accessed 10 December 2015).
- National Security Agency (2012) Skynet. Courier detection via machine learning. 6 June. Available at: <https://snowdenarchive.cjfe.org/greenstone/collect/snowden1/index/assoc/HASHc939.dir/doc.pdf> (accessed 10 December 2015).
- Nordmann A (2006) Collapse of distance: Epistemic strategies of science and technoscience. *Danish Yearbook of Philosophy* 41: 7–34.
- Opitz S (2011) Government unlimited: The security dispositif of illiberal governmentality in governmentality. In: Bröckling U, Krasmann S and Lemke T (eds) *Current Issues and Future Challenges*. New York, London: Routledge, pp. 93–114.
- Porter G (2011) How McChrystal and Petraeus built an indiscriminate ‘killing machine’. *Truthout Monday*, 26 September. Available at: <http://www.truth-out.org/news/item/3588-how-mcchrystal-and-petraeus-built-an-indiscriminate-killing-machine> (accessed 10 December 2015).
- Ressler S (2006) Social network analysis as an approach to combat terrorism: Past, present, and future research. *Homeland Security Affairs* 2(2): 1–10.
- Sageman M (2004) *Understanding Terrorist Networks*. Philadelphia: University of Pennsylvania Press.
- Salter M (2008) Risk and imagination in the war on terror. In: Amore L and de Goede M (eds) *Risk and the War on Terror*. New York/London: Routledge, pp. 233–246.
- Scahill J and Devereaux R (2014a) The Secret Government Rulebook for labeling you a terrorist. *The Intercept*, 23 July. Available at: <https://firstlook.org/theintercept/article/2014/07/23/blacklisted/> (accessed 10 December 2015).
- Scahill J and Devereaux R (2014b) Barack Obama’s Secret Terrorist-tracking system, by the numbers. *The Intercept*, 5 August. Available at: <https://firstlook.org/theintercept/2014/08/05/watch-commander/> (accessed 10 December 2015).
- Scahill J and Greenwald G (2014) The NSA’s secret role in the US assassination program. *The Intercept*, 10 February. Available at: <https://firstlook.org/theintercept/article/2014/02/10/the-nasas-secret-role/> (accessed 10 December 2015).
- Scahill J (2015) The Assassination complex. Secret military documents expose the inner workings of Obama’s drone wars. *The Intercept*, 15 October. Available at: <https://theintercept.com/drone-papers/the-assassination-complex/> (accessed 10 December 2015).
- Schmid A (2011) The Definition of terrorism. In: Schmid A (ed.) *The Routledge Handbook of Terrorism Research*. Abingdon, VA: Routledge, pp. 39–99.
- Schneier B (2006) Data mining for terrorists. *Schneier Blog*, 3 March. Available at: https://www.schneier.com/blog/archives/2006/03/data_mining_for.html (accessed 10 December 2015).

- Shaw I (2013) Bureaucratic assassination—How do US targeted killings work? *Understanding Empire Blog*, 3 October. Available at: <http://understandingempire.wordpress.com/2013/10/03/bureaucratic-assassination-how-do-u-s-targeted-killings-work> (accessed 10 December 2015).
- Shaw I and Akhter M (2014) The dronification of state violence. *Critical Asian Studies* 46(2): 211–234.
- Stäheli U (2012) Listing the global: Dis/Connectivity beyond representation? *Distinktion: Scandinavian Journal of Social Theory* 13(3): 233–246.
- Stohl C and Stohl M (2007) Networks of terror: Theoretical assumptions and pragmatic consequences. *Communication Theory* 17: 93–124.
- Suchman L (1994) Do categories have politics? The language/action perspective reconsidered. *Computer Supported Cooperative Work (CSCW)* 2: 177–190.
- Thrift N and French S (2002) The automatic production of space. *Transactions of the Institute of British Geographers NS* 27: 309–335.
- Weber J (2003) *Umkämpfte Bedeutungen: Naturkonzepte im Zeitalter der Technoscience*. Frankfurt, New York: Campus.
- Weber J (2011) Blackboxing organisms, exploiting the unpredictable: Control paradigms in human-machine translation. In: Carrier M and Nordmann A (eds) *Science in the Context of Application*. Dordrecht/Heidelberg/London/New York: Springer, pp. 409–429.
- Whitlock C (2012) Remote US base at core of secret operations. *The Washington Post*, 25 October. Available at: http://www.washingtonpost.com/world/national-security/remote-us-base-at-core-of-secret-operations/2012/10/25/a26a9392-197a-11e2-bd10-5ff056538b7c_story.html (accessed 10 December 2015).
- Woods C (2015) Covert drone strikes and the fiction of zero civilian casualties. In: Aaronson M, Aslam W, Dyson T, et al. (eds) *Precision Strike Warfare and International Intervention: Strategic, Ethico-Legal, and Decisional Implications*. New York, London: Routledge, pp. 95–113.

Jutta Weber is a STS Scholar, Philosopher of Technology and Professor for Media Studies at the University of Paderborn. Her research focuses on epistemological, ontological and sociopolitical dimensions of computational technoscience culture(s) asking how and for whom the non/human actors work.

7 The Infinite Forecast

The concentration of computing resources at a few institutions probably affected no field more than it affected climatology. In the 1960s and the 1970s, this data-driven, regionally oriented, descriptive field would be transformed into a theory-driven, globally oriented discipline increasingly focused on forecasting the future. The change would be wrought not by traditional climatologists, but by scientists based in theoretical meteorology and computer programming, working at a handful of institutions endowed with what were then enormous computing resources. Unlike traditional climatologists, who searched for regularities in data from the past, this new generation of scientists sought to simulate the climate, building models from the same techniques used in numerical weather prediction. From there, they moved gradually toward simulating the entire Earth system, replicating the world in a machine.

If you can simulate the climate, you can do experiments. God-like, you can move the continents, make the sun flare up or dim, add or subtract greenhouse gases, or fill the stratosphere with dust. You can cook the Earth, or freeze it, and nobody will even complain. Then you can watch and see what happens.

For a scientist, experiments are all-important. You use them to find out what really matters in a complicated system. In a laboratory experiment, you create a simplified situation, blocking out most of the real world's complexity while retaining a few variables you can manipulate. Then you compare the outcome with an unmodified "control" that leaves those variables at their ordinary values.

In the geophysical sciences, though, the controlled-experiment strategy generally doesn't work. The system you are dealing with is just too large and too complex. You can isolate some things, such as the radiative properties of gases, in a laboratory, but to understand how those things affect the climate you need to know how they interact with everything else.

There is no “control Earth” that you can hold constant while twisting the dials on a different, experimental Earth, changing carbon dioxide or aerosols or solar input to find out how they interact, or which one affects the climate most, or how much difference a change in one variable might make.

Sometimes you get a “natural experiment,” such as a major volcanic eruption that measurably cools the whole planet for a year or two. Similarly, the oceanographer Roger Revelle famously called human carbon dioxide emissions a “large scale geophysical experiment.”^{1,2} Yet these aren’t really experiments, precisely because there is no control Earth. You don’t know with certainty what *would have happened* without the eruption, or the CO₂ increase. You can assume that without the change things would have remained much the same, which seems like a pretty good assumption until you realize that climate varies naturally over a rather wide range. So unless the effect is very large and sudden—for example, a massive volcanic eruption or a gigantic meteor impact—you can’t know for sure that you are seeing a signal and not just more noise.

Simulation modeling opened up a way out of this quandary. Only through simulation can you systematically and repeatedly test variations in the “forcings” (the variables that control the climate system). Even more important, only through modeling can you create a control—a simulated Earth with pre-industrial levels of greenhouse gases, or without the chlorofluorocarbons that erode the ozone layer, or without aerosols from fossil fuel and agricultural waste combustion—against which to analyze what is happening on the real Earth. As we saw in chapter 6, John von Neumann and others understood the significance of this power “to replace certain experimental procedures” almost immediately, although the full extent of it would take some time to dawn on anyone.³

A convergence of technical capabilities and theoretical understanding made climate simulation possible. By the late 1930s, theoretical meteorology had set its sights firmly on the planetary scale as the most fundamental level of explanation. Rossby and others had established a theory of large-scale circulation based on very long waves, confirming and detailing the three-cell circulatory structure described by Ferrel almost a century earlier. (See figure 2.6.) Rossby’s 1941 summary of “the scientific basis of modern meteorology” already focused on the planetary circulation as the ultimate cause of weather patterns.⁴ World War II military aviators, flying frequently at high altitudes, accumulated substantial experience of the polar jet stream at 50–60° latitude, near the northern boundary of the mid-latitude

Ferrel cell.⁵ Rossby's long waves explained the jet stream's meanders, which in turn helped explain the movements of weather systems closer to the ground.

Therefore, models of *global* atmospheric motion occupied the pinnacle of Charney's hierarchy of models. Today such models are known as GCMs, an acronym standing interchangeably for "general circulation model" and "global circulation model."⁶ GCMs represented the last step in von Neumann's meteorological research program, which would culminate in what he called the "infinite forecast."⁷ By this phrase, von Neumann did not intend deterministic prediction of weather over long or "infinite" periods. Instead, he had in mind the statistically "ordinary circulation pattern" that would emerge when "atmospheric conditions . . . have become, due to the lapse of very long time intervals, causally and statistically independent of whatever initial conditions may have existed." This phrase sounds remarkably like the mathematical concept of chaos, by which minute variations in initial conditions rapidly generate extreme divergences in outcomes: a butterfly flaps its wings over Brazil and causes a tornado in Texas. In fact, the theoretical meteorologist Edward Lorenz first discovered what we now call chaos theory while working with atmospheric models in the early 1960s.⁸ But in the mid 1950s, these results, and the idea of chaos itself, remained unknown. In 1955, von Neumann's "infinite forecast" expressed the widespread belief that global atmospheric flows might display predictable symmetry, stability, and/or periodicity. Research aimed at finding such predictable features remained active throughout the 1950s.⁹

But how could modelers verify an "infinite forecast"? In other words, what did meteorologists actually know *from data* about the general circulation in the mid 1950s? An image of the state of the art may be found in the work of MIT's General Circulation Project, which began in 1948 and continued for some 20 years under the leadership of Victor Starr, supported principally by the Air Force and the Atomic Energy Commission. (UCLA conducted similar, independent work under the same auspices.) The General Circulation Project collected every available data source that might reveal more details of the circulation's structure. Articles describing these data almost invariably opened with extensive caveats regarding the small quantity and poor quality of upper-air measurements then available. Nonetheless, a crude data-based picture began to emerge. One study, by Starr and Robert White (of the Travelers Insurance Corporation), included all available upper-air observations for 1950 from 75 stations along five

latitude bands, each with 10–19 stations. This “involved altogether a total of 176,000 individual wind readings, 57,000 humidity readings, and 77,000 temperature readings.”¹⁰ In the mid 1950s, such a quantity of observations seemed gigantic. Yet these data remained insufficient for all but the crudest possible picture of global flows. After ten years of intensive effort, Starr would write: “. . . whether we like it or not, meteorologists have been struggling with problems of the most primitive kind concerning the motions of the atmosphere. . . . The questions at issue have not been such as relate to some fine points concerning a general scheme that is accepted as sound. Rather [they concern] whether some crucial portion of the system operates forward or in reverse.”

Starr was talking about the basic mechanism of the large-scale circulatory cells. (See figure 2.7.) Did those cells produce a positive energy release, converting potential energy into kinetic energy (as in Ferrel’s scheme), or a negative one, converting kinetic energy into potential energy (as General Circulation Project studies of the mid 1950s seemed to show)? Starr wrote that even this fundamental question could not yet be answered because general circulation theory remained inadequate.

The limiting factor always has been, and will continue to be, the completeness and accuracy of the de facto pictures of the general circulation. . . . What counts are not mere tabulations of data; it is their intelligent organization according to physical laws so as to lead to physical depiction of relevant processes and schemes of motion. . . . Due no doubt to the complexity of the system considered, correct processes have thus far found their incorporation into theoretical models, almost without exception, only *after* their empirical discovery.¹¹

Further details of this issue need not concern us here. What is of interest to us is Starr’s conviction that the absence of sufficient data, especially in the vertical dimension, still rendered theories of the general circulation fundamentally speculative, even on very basic issues. Starr’s *cri de coeur* for “intelligent organization” of data leading to “physical depiction of relevant processes and schemes of motion” would be answered through general circulation modeling.

The first experiments with GCMs came only months after the operational launch of numerical weather prediction. In these models, the limits of predictability, numerical methods, and computer power would be tested together. As Nebeker has shown, GCMs would reunify meteorology’s three main strands—forecasting, dynamical-theoretical meteorology, and empirical-statistical climatology—within a single research program.¹² They would transform climatology from a statistical science oriented toward the

particularity of regional climates into a theoretical science more focused on the global scale. Ultimately, they would also guide vast changes in the global data infrastructure, and they would transform the sources and the very meaning of the word ‘data’.

In this chapter, I discuss the basic principles of climate simulation, focusing on general circulation models. I then tell the story of the first generation of GCMs and the modeling groups that created them, ending with a genealogy that links them to subsequent groups and models. Finally, I discuss early studies of carbon dioxide doubling (a paradigmatic experiment that later became a benchmark for climate-change studies) and the role of data friction in delaying the empirical evaluation of climate simulations.

How Climate Models Work

Charney’s model hierarchy sketched a path from simple to complex: from two-dimensional, regional forecast models to three-dimensional hemispheric and global circulation models. As climate modeling matured, another model hierarchy emerged, this one aimed not at forecasting but at characterizing how the atmosphere and the oceans process solar energy. This section departs from the historical approach for purposes of exposition, briefly describing how climate models work before returning to the history of GCMs.

Earth is bathed in a constant flood of solar energy. The laws of physics dictate that over time the planet must remain, on average, in thermal equilibrium. In other words, it must ultimately re-radiate all the energy it receives from the sun back into space. The atmosphere’s blanket of gases—primarily nitrogen, oxygen, and water vapor—absorbs much of the incoming radiation as heat. The oceans absorb solar energy directly; they also transfer heat to and from the atmosphere. With their great mass, the oceans retain much more energy than the air, functioning as a gigantic heat sink and moderating changes of temperature in the atmosphere. If Earth had no atmosphere or oceans, its average surface temperature would be about -19°C . Instead, the heat retained in the atmosphere and oceans maintains it at the current global average of about 15°C .

At the equator, Earth receives more heat than it can re-radiate to space; at the poles, it re-radiates more heat than it receives. Thus the climate system, as a thermodynamic engine, serves to transport heat from the equator toward the poles. The most fundamental climatological questions regard exactly how much heat is retained (the global average temperature),

where the energy resides (in the oceans, atmosphere, land surfaces, etc.), how it is distributed, and how it circulates around the globe in the course of moving poleward.

Fundamentally, then, Earth's temperature is a matter of what climatologists call "energy balance." Modeling the climate therefore begins with the "energy budget": the relationship between incoming solar radiation and outgoing Earth radiation. Energy balance models (EBMs) use measured or calculated values for such factors as solar radiation, albedo (reflectance), and atmospheric absorption and radiation to compute a single global radiative temperature. The simplest, "zero-dimensional" EBMs treat Earth as if it were a point mass. These models involve just a few equations and can be solved by hand, with no need for computers. Energy balance can also be calculated one-dimensionally, by latitude bands or "zones," to study how the relationship changes between the equator and the poles, or two-dimensionally, including both zonal and longitudinal or "meridional" energy flows. Svante Arrhenius's calculations of carbon dioxide's effect on Earth's temperature constituted one of the earliest one-dimensional (zonal) EBMs.¹³

A second type of climate model, the radiative-convective (RC) model, focuses on vertical transfers of energy in the atmosphere through radiative and convective processes. Such models typically simulate the atmosphere's temperature profile in either one dimension (vertical) or two (vertical and zonal). When Callendar revived the carbon dioxide theory of climate change in 1938, he used a one-dimensional radiative model that divided the atmosphere into twelve vertical layers.¹⁴

A third type is the two-dimensional statistical-dynamical model, employed primarily to study the circulatory cells. In these models the dimensions are vertical and meridional. Schneider and Dickinson, who first described the hierarchy of climate models, identified sub-classes of EBMs and RC models, as well as several kinds of dynamical models less computationally demanding than GCMs.¹⁵

In contrast with the way NWP models developed, work on computerized climate models did not follow a straightforward path up the hierarchy from simple to complex. Instead, climate modeling *began* with GCMs, the most complex models of all. In the course of this work, new radiative-convective models were developed—sometimes by the same people, such as Syukuro Manabe, who also pioneered general circulation modeling at the Geophysical Fluid Dynamics Laboratory (see below).¹⁶ Major work on new EBMs—the simplest models—followed later, in the late 1960s.¹⁷ Work on RC models and EBMs helped GCM builders conjure up code for vertical

transfers of heat, and also provided “reality checks” on GCM results.¹⁸ Climate scientists continue to use these simpler models for many purposes, but this book will not discuss them further.¹⁹

General circulation models (GCMs) are three-dimensional simulations, integrated over time. The earliest such models used simplified equations, but virtually all modern GCMs are based on the atmospheric primitive equations developed by Vilhelm Bjerknes, Lewis Fry Richardson, and others, which were in turn based on the Navier-Stokes fluid dynamics equations. GCMs simulate not only the planetary heat exchange described by EBMs and RC models, but also the planetary circulation or movement of the atmosphere: patterns of flow, such as the jet streams and Hadley cells, resulting from the interaction of planetary rotation, insolation, gravitation, heat exchange, humidity, orography (surface features such as mountain ranges), sea surface temperature and friction, and many other factors. The oceans also circulate, with dynamics of their own. Transfers of energy between the oceans and the atmosphere play an enormous role in both weather and climate. For this reason, today’s atmospheric GCMs (AGCMs) are typically linked to ocean GCMs in “coupled atmosphere-ocean models” (AOGCMs).

All GCMs consist of two major elements. The “dynamical core” simulates large-scale movement using the primitive equations of fluid motion. The underlying mathematics of dynamical cores are relatively well understood. However, like any equations, they may be expressed in different forms for different purposes. Further, solving the equations on a computer requires representing them numerically, and there are numerous ways to do this, each with characteristic computational benefits and drawbacks. For example, the rectangular latitude-longitude grid is only one way to represent the Earth’s surface, and it is not the best one for modeling a sphere, because the convergence of longitude lines near the poles inconveniently shortens the model time step. To avoid this, modelers have experimented with many kinds of grids, including triangular, hexagonal, icosahedral, and Gaussian ones.

The second element, the “model physics,” includes all the other major processes that occur in the atmosphere. Many of these processes involve transfers of heat. Others involve transfers of moisture—for example, from lakes, rivers, and oceans to the atmosphere and vice versa. In the real atmosphere these processes generally occur at scales much smaller than the model grids—all the way down to the molecular level, at which heat is absorbed and re-radiated by gases; modelers call these “sub-grid scale” processes. Model physics also includes friction between land or ocean

surfaces and the air, transfers of heat between the ocean and the atmosphere, cloud formation, and many other processes. Modelers represent sub-grid-scale physics indirectly by means of parameters (mathematical functions and constants that capture the large-scale effects of smaller-scale processes without modeling them directly). Parameterizing physical processes accurately is the most difficult aspect of climate modeling and is a source of considerable scientific and political controversy.

As climate modeling evolved and spread, modelers worked to improve their simulations along three major fronts at once. First, they developed better numerical schemes for integrating model equations, reducing the amount of error incurred by approximating the solutions. Second, to resolve smaller-scale phenomena, they decreased the distance between model gridpoints. Finally, they added more physical processes to the models. Major additions to climate model physics included radiative transfer, cloud formation, ocean circulation, albedo, sulfate emissions, and particulate aerosols. In the 1980s, modelers sought to expand climate studies by adding other elements of the overall climate system, such as sea ice, vegetation, snow, and agriculture, to create “Earth system models” (ESMs). By the mid 1990s, some models included the entire carbon cycle, including uptake by plants, absorption by the oceans, and release through fossil fuel combustion and the decay of plant matter. Figure 7.1 illustrates additions to climate model physics from the mid 1970s to about 2005, based on the climate models used in the four assessment reports of the Intergovernmental Panel on Climate Change. (These include virtually all of the world’s GCMs.) In chapter 13, we will explore model physics and the controversies surrounding parameterization in much more detail.

At this writing, in 2009, typical climate AGCM grid resolutions at the surface are 1–5° latitude by 4–8° longitude, translating roughly as rectangles with sides between 100 and 500 km in length. Layers of varying depth represent the vertical dimension to a height of around 20 km, with more layers at lower altitudes, where the atmosphere is denser; modern GCMs typically have 30–50 layers. Early GCMs used a Cartesian grid structure (figure 7.2), computing vertical and horizontal mass and energy transfers between grid boxes at each time step (typically 10–15 minutes). Later GCMs used spectral transform techniques to carry out some computations in “wave space” (see below). Whereas converting early models into computer programs required only a few thousand lines of FORTRAN, today’s most sophisticated models contain more than a million lines of program code.

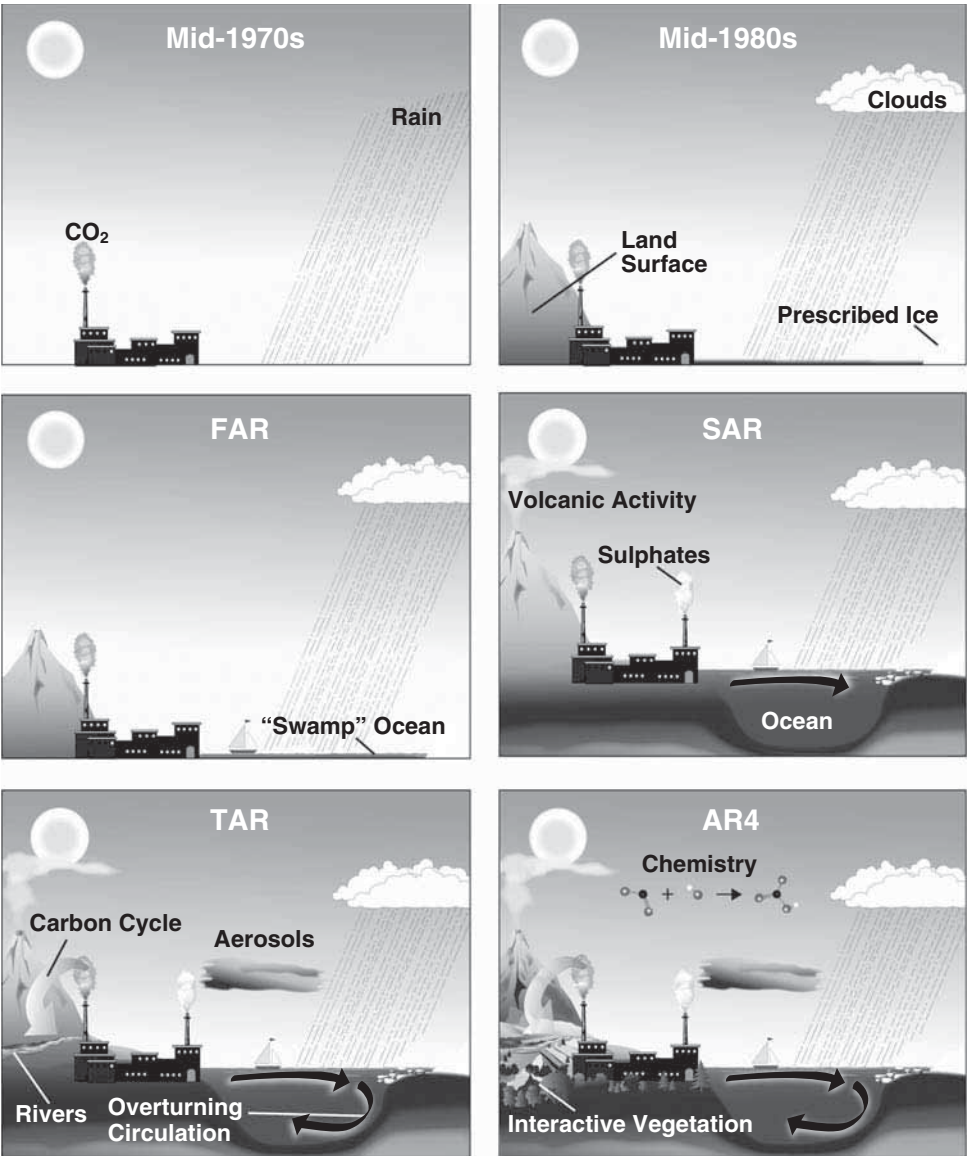


Figure 7.1
Processes incorporated in generations of GCMs beginning in the mid 1970s. Acronyms refer to the four assessment reports (AR) of the Intergovernmental Panel on Climate Change, released in 1990 (FAR), 1995 (SAR), 2001 (TAR), and 2007 (AR4). Source: *Climate Change 2007: The Physical Science Basis* (Cambridge University Press, 2007). Image courtesy of IPCC.

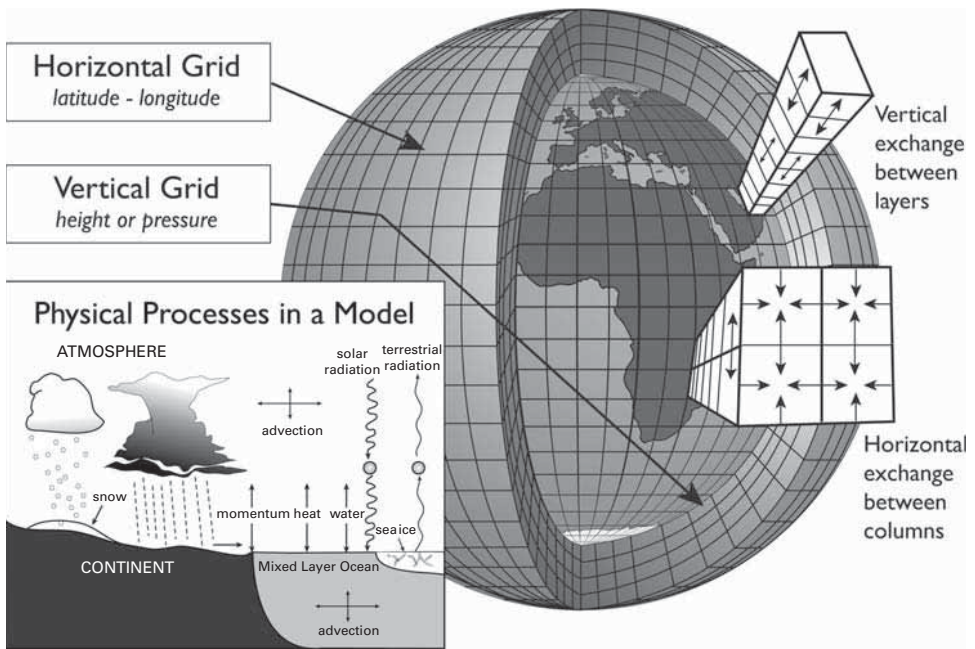


Figure 7.2

A schematic representation of the Cartesian grids used in finite-difference GCMs. Graphic by Courtney Ritz and Trevor Burnham.

GCMs can be used both to forecast the weather and to simulate the climate. With a forecast GCM, you want to know exactly what will happen tomorrow, or next week, so you initialize the model with observations. (This means that you set the values for each variable in every grid box using the best available data.) Then you run the model for a week or so at the highest possible resolution. Because of the chaotic nature of weather, however, forecast GCMs lose almost all their predictive skill after two to three weeks. Climate GCMs are used quite differently. You want to see the model's climate—its average behavior over long periods, not the specific weather it generates on any particular day. So you need to run the model for years, decades, or even longer. That can add up to a lot of very expensive supercomputer time. To reduce the amount of computer time each run required, early climate modelers often initialized GCMs with climatological averages—observational data. Today, however, models typically are *not* initialized with data. Instead, they are simply allowed to “spin up” from a resting state, with the various forces driving the climate—solar

radiation, gravity, evaporation, the Coriolis effect, and so on—generating the model's circulation. The spin-up phase, which takes years to decades of simulated time, ends when the model comes into a relatively steady state known as "equilibrium." At equilibrium the model has developed its own "climate," with Hadley, Ferrel, and polar cells, circulatory patterns such as jet streams, seasonal changes, a vertical temperature profile, and other characteristic features.

Only when the model comes to equilibrium does the actual climate simulation begin. After that, you run the model for many simulated years (20, 100, perhaps even 1000) and measure its averages, just as you would average real weather data to characterize the real climate. For example, at each gridpoint you might take the maximum and minimum temperature for each day in a simulated January, add them and divide by 2, then add the averages for 50 simulated Januaries and divide by 50 to get the model's average temperature in January (and so on). To evaluate the simulation, you would compare its averages with real climatological data. If your model is a good one, it should more or less reproduce, for example, the seasons and the global distribution of temperature and rainfall.

No climate model, past or present, can precisely reproduce every detail of the real climate. Furthermore, since models represent so many processes and variables, it is commonplace for a GCM to reproduce one variable (e.g. temperature) quite well even as it does poorly on another variable (e.g. winds or rainfall). Because the models are complex, diagnosing the reasons for these performance differences can be extremely difficult. The goal is to get as close as is possible to a realistic climate, using a minimum of ad hoc adjustments, in order to understand why the system behaves as it does. Ultimately you want to know how changes in "forcings"—the variables that alter system behavior, such as solar output, greenhouse gases, and particulate aerosols—affect the global climate. We will return to these matters below, but for the moment we will once again follow the historical thread, beginning with the earliest effort to carry out an "infinite forecast."

The next five sections of this chapter describe pioneering efforts in climate modeling. Readers versed in meteorology and/or computer modeling should have no trouble following the discussion, but others' eyes may glaze over. If you are among the latter, I invite you to skip ahead to the section titled "The General Circulation of Circulation Models."

The Prototype: Norman Phillips's Model

The first person to attempt a computerized general circulation model was Norman Phillips. During World War II, as an Army Air Force officer, Phillips had studied meteorology. He went on to graduate training at Chicago under George Platzman (a member of the ENIAC experiment team) and Carl-Gustav Rossby. Phillips joined the IAS Meteorology Project in 1951 and worked with Rossby's group in Stockholm during 1953 and 1954. While in Stockholm, he participated in the world's first operational numerical forecasts. Thus Phillips found himself at the very center of early NWP research. By 1954 he had already worked with his generation's foremost dynamic meteorologists, and they had encouraged him in his ambition. By mid 1955, Phillips had completed a two-layer, hemispheric, quasi-geostrophic computer model.²⁰

As we saw in chapter 6, results from the initial ENIAC tests of numerical weather prediction had elated the experimenters, who hadn't expected their highly simplified model to work so well. Having worked closely with the group, Phillips shared their euphoria. The historian John Lewis notes that Phillips also paid close attention to another line of research on circulation: "dishpan" model experiments.²¹ These analog models consisted of a rotating tank filled with viscous fluid. When heated at the rim and cooled in the center, the tank produced flow patterns resembling those observed in the atmosphere. Watching these flows, Phillips felt "almost forced to the conclusion that at least the gross features of the general circulation of the atmosphere can be predicted without having to specify the heating and cooling in great detail."²²

Phillips's published study began with a discussion of the chief features of the general circulation then known from observation. These included the following:

- the vertical temperature profile of the atmosphere and the existence of the stratosphere
- the decrease of temperature between the equator and the poles, with the largest effect occurring in middle latitudes
- average wind direction and speed at different latitudes and altitudes, including such features as the trade winds and jet streams
- cyclones (low pressure systems), anticyclones (high pressure systems), and the associated fronts, major features of the circulation above the tropical latitudes
- the absence of an "organized" meridional (equator-to-pole) circulation outside the trade wind regions.²³

Much of this knowledge had been acquired in the previous 15 years, as upper-air data networks emerged.

For theorists, the above-mentioned features and their interactions demanded explanation. For example, cyclones and anticyclones are large-scale eddies, much like those that form near rocks in a river as water flows over and around them. Globally, the circulation transports solar heat from the equator to the poles. If there is no organized meridional (longitudinal) circulation, such eddies must be involved in this heat transport process—but how? And how did they interact with the average zonal (latitudinal) winds?²⁴

Phillips applied nascent NWP techniques, testing whether the geostrophic approximation could reproduce these features of the general circulation. He described his approach as a “numerical experiment” whose “ideal form would . . . be to start with an atmosphere at rest . . . and simply make a numerical forecast for a long time.” He hoped that “ultimately some sort of quasi-steady state would be reached, in which the input of energy would be balanced by frictional losses, and the typical flow patterns would have some resemblance to those in the actual atmosphere.”

Phillips carried out his first “numerical experiment” on the IAS computer at Princeton, a machine with just 1 kilobyte of main memory and 2 kilobytes of magnetic drum storage. To navigate between these memory constraints and his mathematical model, he chose a 17×16 finite-difference grid, with gridpoints spaced 625 km apart in the y coordinate (latitude) and 375 km apart along the x coordinate (longitude). This rendered a model surface that was 10,000 km by 6000 km. The y axis represented roughly the actual distance from equator to pole, while the x axis approximated the size of a single large eddy and was thus much smaller than Earth’s circumference at the equator (about 40,000 km). To simulate the circulatory flow, eddies moving off the eastern edge of the model re-entered it on the west, making the model’s topology effectively cylindrical. Two pressure levels represented the vertical dimension. The model used a one-day time step during a “spin-up” of 130 simulated days. After that, the time step was reduced to around 2 hours and the model was run for 31 simulated days.²⁵

Phillips used numerous simplifying techniques to make his model tractable. For example, the model contained no moisture or clouds. It failed to replicate many characteristics of the observed circulation, but it did reproduce some fundamental features, including the easterly-westerly-easterly zonal distribution of surface winds, a jet stream, and a net transport of heat from equator to pole. It is now generally regarded as the first working numerical general circulation model.

Almost in passing, Phillips made note of what would become a crucial issue for all future GCMs. "The experiment," he wrote, "*contains empirical elements* in that the representation of certain physical effects is based on meteorological experience with the actual atmosphere, *rather than being predicted from fundamental laws of physics*." For example, rather than attempt to simulate evaporation and condensation directly, Phillips simply fixed his model's stability factor at 80 percent of its measured value in the atmosphere. Phillips hoped that "a more complete theory of the atmospheric motions [would] eventually explain these quantities also." This tension between "empirical elements" and prediction from physical theory has persisted throughout the subsequent history of atmospheric modeling. Even as modelers eliminated some empirical elements in favor of theory-based calculation, they introduced others as models became more complex.

Phillips's model provoked enormous excitement. In the short term, it sparked action by John von Neumann, who immediately called a conference at Princeton on "Application of Numerical Integration Techniques to the Problem of the General Circulation" and composed a research proposal on "Dynamics of the General Circulation." As John Lewis points out, by framing the project as a contribution to forecasting von Neumann positioned it strategically to gain further funding from the Weather Bureau, the Air Force, and the Navy.²⁶ In the long term, Phillips's model inspired an entire generation of dynamical meteorologists and climate scientists, not only in the United States but also in the United Kingdom and Japan. In 1956, his paper received the first Napier Shaw Prize of the UK's Royal Meteorological Society. Akio Arakawa, later a leader in general circulation modeling, has noted more than once that his "excitement about the new developments" in studies of the general circulation "reached its climax when Phillips's paper appeared in 1956." In order to "share this excitement with other Japanese meteorologists" Arakawa, then working at the Japan Meteorological Agency, published a monograph in Japanese describing Phillips's work and its relevance to circulation theories.²⁷

With Phillips's experiment as proof of concept, a new generation of theoretical meteorologists began to envision models based directly on the primitive equations. Phillips marked out the path: start with simplifying assumptions, such as barotropy and quasi-geostrophy, then eliminate them, one by one, until nothing remained but the primary physics. Putting this program into practice would require not only a lot more computer power, but also further refinement of numerical methods for solving differential equations. Perfecting primitive-equation GCMs became

something of a “holy grail” for both forecasting and climatology. In the following sections, I describe the first four efforts to meet this challenge. All four were based in the United States, but Japanese émigré scientists played major roles in three of them.

The Geophysical Fluid Dynamics Laboratory

Responding positively to von Neumann’s proposal, the US Weather Bureau created a General Circulation Research Section under the direction of Joseph Smagorinsky in 1955. Smagorinsky saw his charge as completing the final step of the von Neumann–Charney computer modeling program: a three-dimensional, global, primitive-equation general circulation model of the atmosphere.²⁸ The General Circulation Research Section initially found laboratory space in Suitland, Maryland, near the Weather Bureau’s JNWP unit. Subsequently this lab endured several changes of name and location, moving first to Washington, D.C. as the General Circulation Research Laboratory. Renamed the Geophysical Fluid Dynamics Laboratory in 1963, the lab decamped to Princeton University in 1968, where it remains. (For consistency, I will refer to all these incarnations by the lab’s current acronym, GFDL.)

In 1955–56, as lab operations commenced, Smagorinsky collaborated with von Neumann, Charney, and Phillips to develop a two-level baroclinic model based on a subset of the primitive equations. Like Phillips’s, this model reduced complexity by using “walls” to mark off a section of the planetary sphere. This time the walls were latitudinal instead of longitudinal, so that the model could simulate zonal circulation across about 65° of latitude, roughly two thirds of one hemisphere.²⁹

Like virtually all GCMs, GFDL’s early models were developed by collaborative teams consisting chiefly of dynamical meteorologists and computer programmers, many of whom, including Leith Holloway and Richard Wetherald of GFDL, had begun their careers as meteorologists. Often wrongly seen as purely mechanical work, in the late 1950s and early 1960s scientific computer programming was an arcane and difficult art. Scientists expressed GCMs as sets of variables, parameters, and systems of equations, many of them nonlinear. Solving those equations with a computer program required choosing from among multiple possible ways to translate the differential equations into finite-difference equations. These then had to be translated into computer code, which required another series of choices, almost all of which would influence both the efficiency and the accuracy of computer processing.

Writing code for GCMs required great skill and ingenuity not only with programming itself, but also with the complex mathematics of the theoretical models and with numerical and computational methods. Therefore, GCM laboratory teams often consulted, and sometimes included, mathematicians specializing in such techniques as numerical analysis and non-linear computational stability. (For example, GFDL employed Douglas Lilly.) At first these partners in model development received recognition only as assistants, but within a few years GFDL and some other laboratories acknowledged the scientific importance of their technical contributions by listing the main programmers as co-authors.

In 1959, Smagorinsky invited Syukuro Manabe of the Tokyo NWP Group to join the General Circulation Research Laboratory. Impressed by Manabe's early publications, Smagorinsky assigned Manabe to GCM development. Smagorinsky provided Manabe with a programming staff, allowing him to focus on the mathematics of the models without writing code.³⁰ Initially, they worked on re-coding Smagorinsky's two-level baroclinic model for the experimental IBM STRETCH supercomputer, then still under development. When the STRETCH finally arrived in 1962, GFDL shared the machine with the Weather Bureau's numerical weather prediction unit. In an interview with me, programmer Richard Wetherald described this arrangement as "disastrous" for GFDL, which had second priority on the breakdown-prone machine. By 1965, Smagorinsky, Manabe, Holloway, Wetherald, and other collaborators had completed a nine-level, hemispheric GCM using the full set of primitive equations.³¹ They began by re-coding relevant parts of the old two-level model in FORTRAN to avoid the difficult STRAP assembly language used by the IBM STRETCH.

From the beginning, GFDL took a long-range view of the circulation modeling effort. Lab members expected a slow path to realistic simulations, and they remained acutely aware of the pitfall of getting the right results for the wrong reasons. Their research strategy used GCMs to diagnose what remained poorly understood or poorly modeled, and simpler models to refine both theoretical approaches and modeling techniques, in an iterative process:

We first constructed with considerable care, and in fact programmed, the most general of a hierarchy of models in order to uncover in some detail the body of physics needed, to determine where the obvious weaknesses were, and to give us some idea of the computational limitations we could expect. The perspective thus gained was invaluable. We then laid out a program of simplified models which can be constructed as a sub-set of the most general one. The main requirements were (1) that each model represent a physically realizable state, (2) that they could be

constructed computationally . . . , and (3) that they collectively would provide a step-by-step study of the behavior of new processes and their influence on the interactive system. Hence, many of the intermediate models in themselves may lack detailed similitude to the atmosphere but provide the insight necessary for careful and systematic scientific inquiry.³²

This strict attention to correcting physical theory and numerical methods before seeking verisimilitude became a hallmark of the GFDL modeling approach.³³ The full primitive-equation GCM (“the most general” model) served as a conceptual framework, driving work on simpler models which led to refinements of the GCM.

Exchanges of energy between the oceans and the atmosphere are fundamental to general circulation physics. Sea water, far denser than the atmosphere, retains much more heat. Ocean currents such as the Gulf Stream absorb, release, and circulate this heat around the planet, strongly affecting global atmospheric temperatures and flows. Smagorinsky foresaw, very early, the need to couple ocean circulation models to atmospheric GCMs. In 1961 he brought the ocean modeler Kirk Bryan to the GFDL to begin this work.³⁴ At first, GFDL used a highly simplified one-layer ocean model, widely known as the “Manabe swamp ocean.” Ultimately, however, better climate simulations would require coupling atmospheric GCMs to ocean GCMs. In 1969, Manabe and Bryan published the first results from a coupled atmosphere-ocean general circulation model (AOGCM).³⁵ However, this model used a highly idealized continent-ocean configuration that did not much resemble the real Earth. The first results from an AOGCM with more realistic continent-ocean configurations did not appear until 1975.³⁶

By the mid 1960s, Smagorinsky had taken a leading role in planning the gigantic Global Atmospheric Research Program (GARP), a project which would continue into the 1980s. GARP occupied an increasing share of Smagorinsky’s time, and Manabe emerged as the *de facto* leader of GFDL’s GCM effort. Manabe’s work style was always highly collaborative. Manabe’s group was among the first to perform carbon dioxide doubling experiments with GCMs,³⁷ to couple atmospheric GCMs with ocean models,³⁸ and to perform very long runs of GCMs under carbon dioxide doubling.³⁹ Box 7.1 sketches the major GFDL model series through the mid 1990s.

The UCLA Department of Meteorology

Jacob Bjerknes founded the UCLA Department of Meteorology in 1940. He soon established a General Circulation Project as a central focus of the department’s research. Yale Mintz, a Bjerknes graduate student who

Box 7.1**The GFDL GCM Series**

The following list, derived from interviews with various GFDL staff members in the late 1990s, describes the major GFDL models in the informal terms used at the laboratory.

MARKFORT

MARKFORT was GFDL's first "production" model. The prototype for the MARKFORT series was the original nine-level Smagorinsky-Manabe hemispheric model described in the text.^a Used well into the 1960s, a two-level version of the model was initially run on the IBM STRETCH.

Zodiac

The Zodiac finite-difference model series was the second major GFDL GCM and its first fully global one. Used throughout the 1970s, its most important innovation was a spherical coordinate system developed by Yoshio Kurihara.^b

Sector

Not a separate GCM but a subset of the GFDL global model series. To conserve computer time (especially for coupled atmosphere-ocean modeling), integrations were performed on a longitudinal "sector" of the globe (e.g. 60° or 120°) with a symmetry assumption for conversion to global results. The early Sector models employed highly idealized land-ocean distributions.^c

Skyhigh

Work on Skyhigh, a GCM with high vertical resolution covering the troposphere, the stratosphere, and the mesosphere, began in 1975.^d

GFDL Spectral Model

In the mid 1970s, GFDL imported a copy of the spectral GCM code developed by William Bourke at the Australian Numerical Meteorological Research Centre.^e Bourke and Barrie Hunt had originally worked out the spectral modeling techniques while visiting GFDL in the early 1970s.

Box 7.1

(continued)

Supersource

In the late 1970s, Leith Holloway began to re-code the GFDL spectral model to add modularity and user-specifiable options. The resulting model, Supersource, remained in use at GFDL through the 1990s. Supersource physics descend from Manabe et al.'s Zodiac grid model series. Users can specify code components and options. Supersource has often been used as the atmospheric component in coupled atmosphere-ocean GCM studies.^f

- a. J. Smagorinsky et al., "Numerical Results from a Nine-Level General Circulation Model of the Atmosphere," *Monthly Weather Review* 93, 1965: 727–68.
- b. Yoshio Kurihara, "Numerical Integration of the Primitive Equations on a Spherical Grid," *Monthly Weather Review* 93, no. 7, 1965: 399–415.
- c. See e.g. S. Manabe and K. Bryan, "Climate Calculations with a Combined Ocean-Atmosphere Model," *Journal of the Atmospheric Sciences* 26, no. 4, 1969: 786–89.
- d. J. D. Mahlman et al., "Simulated Response of the Atmospheric Circulation to a Large Ozone Reduction," in *Proceedings of the WMO Symposium on the Geophysical Aspects and Consequences of Changes in the Composition of the Stratosphere*, Toronto, 1978.
- e. W. Bourke, "A Multi-Level Spectral Model. I. Formulation and Hemispheric Integrations," *Monthly Weather Review* 102 (1974): 687–701; T. Gordon and B. Stern, "Spectral Modeling at GFDL," in *Report of the International Symposium on Spectral Methods in Numerical Weather Prediction*, 1974; C. T. Gordon, "Verification of the GFDL Spectral Model," in *Weather Forecasting and Weather Forecasts*, ed. D. L. Williamson et al., Advanced Study Program, National Center for Atmospheric Research, 1976, volume 2.
- f. S. Manabe and R. J. Stouffer, "Two Stable Equilibria of a Coupled Ocean-Atmosphere Model," *Journal of Climate* 1, 1988: 841–65; S. Manabe et al., "Response of a Coupled Ocean-Atmosphere Model to Increasing Atmospheric Carbon Dioxide," *Ambio* 23, no. 1, 1994: 44–49.

received his PhD in 1949, stayed at UCLA as Bjerknes's associate project director. Among other things, the General Circulation Project carried out extensive data analysis for a climatological atlas. An obituary later recalled Mintz's "heroic efforts . . . in the earlier phase of this project during which he orchestrated an army of student helpers and amateur programmers to feed a prodigious amount of data through paper tape to SWAC, the earliest computer on campus."⁴⁰

In the late 1950s, Mintz began to design numerical GCMs.⁴¹ As Smagorinsky had done, Mintz recruited a Tokyo University meteorologist, Akio Arakawa, to help him build general circulation models. Arakawa, known for his wizardry with numerical methods, was particularly interested in building robust schemes for parameterizing cumulus convection, a major but poorly understood process of vertical heat transport in the atmosphere. Beginning in 1961, Mintz and Arakawa constructed a series of increasingly sophisticated GCMs. Arakawa persuaded Mintz to pay more attention to designing model dynamics that could sustain long-term integration.⁴² The first UCLA GCM, completed in 1963, was a two-level global primitive-equation model with 7° latitude by 9° longitude horizontal resolution. It included realistic land-sea distributions and surface topography. Mintz never learned to program computers; Arakawa did all the model coding. With this project completed, Arakawa returned to Japan, but Mintz persuaded him to return to UCLA permanently in 1965.

Of all the world's general circulation modeling groups, the UCLA laboratory probably had the greatest influence on others, especially in the 1960s and the 1970s. This influence resulted not only from continuing innovation, particularly in cumulus parameterization, but also from the UCLA group's exceptional openness to collaboration and sharing. Whereas GFDL was a pure-research institution, UCLA operated in the mode of an academic graduate program, with a mission that included training and knowledge diffusion. Also more typical of the academic tradition, until the 1980s the UCLA group focused primarily on model development, leaving "production" uses of the models (e.g. experimental studies) to other institutions.

Because the UCLA group emphasized advancing the state of the art rather than perfecting the models in detail, its models developed somewhat more rapidly than those of more experiment-focused GCM groups. In addition, the more open nature of the institution encouraged migration of the model to other laboratories. UCLA Department of Meteorology graduates carried the model with them to numerous other institutions, and visitors from around the world spent time at the group's laboratories. This

pattern is vividly apparent in the history of the UCLA model series, described by Arakawa in a festschrift celebrating his work.⁴³ Box 7.2, based on Arakawa's account, my interviews with him, and model documentation, summarizes the models' characteristics and their migration to other laboratories.

The Livermore Atmospheric Model (LAM)

In 1960, Cecil E. "Chuck" Leith began work on a GCM at the Lawrence Livermore National Laboratory in Livermore, California. Trained as a physicist, Leith became interested in atmospheric dynamics through his discussions with Joseph Knox, a meteorologist at Livermore. As Leith recalled it in a 1997 interview, Knox was there because of the lab's interest in nuclear

Box 7.2

The UCLA GCM Series

(N.B.: The numbering in this box follows Arakawa, "A Personal History.")

UCLA I The initial model, completed in 1963.

UCLA II When Arakawa returned from Japan in 1965, he and Mintz abandoned the UCLA prototype and began work on the first "production" GCM (UCLA II). It increased model resolution to 4° latitude by 5° longitude (although it still had only two vertical levels), and it introduced a new horizontal grid structure. In the latter half of the 1960s, IBM's Large Scale Scientific Computation Department in San Jose provided important computational assistance and wrote a manual describing the model.^a Around 1970, Lawrence Gates, a UCLA graduate, carried the model with him to the RAND Corporation, where he deployed it in studies sponsored by the Advanced Research Projects Agency of the US Department of Defense. The RAND version of the model eventually migrated to Oregon State University.^b A three-level version of UCLA II, developed around 1968, soon traveled to three NASA laboratories. In 1972, the Goddard Institute for Space Studies (GISS) adopted the model. Later in the 1970s, it migrated to the Goddard Laboratory for Atmospheric Sciences and the Goddard Laboratory for Atmospheres.

UCLA III Extended vertical resolution to six or twelve levels and incorporated the Arakawa/Lamb "C" finite-difference horizontal grid, used in all subsequent UCLA models. Two versions of this model, with slightly different sets of prognostic variables, were built in the mid 1970s. One version was exported to the US Naval Environment Prediction Research Facility and the Fleet Numerical Oceanographic Center, both in Monterey, California, where it evolved into an operational forecasting system called NOGAPS.^c

Box 7.2

(continued)

It also traveled to the Meteorological Research Institute in Tsukuba, Japan, where it continues to be used in a wide variety of forecasting and climate studies.

UCLA IV Begun in the late 1970s, UCLA IV employed a new vertical coordinate system which used the top of the planetary boundary layer as a coordinate surface and extended vertical resolution to 15 layers. This model was adopted by the Navy research centers mentioned above, as well as by the Goddard Laboratory for Atmospheres. Versions also made their way to Lawrence Livermore National Laboratory and the Central Weather Bureau of the Republic of China. In 1988, David Randall, a former student of Arakawa's, introduced the model at Colorado State University.

UCLA V An improved version of UCLA III with up to 29 vertical levels. Begun around 1990, UCLA V included new schemes for radiation, cloud prediction, cumulus convection, and other parameters.

- a. W. E. Langlois and H. C. W. Kwok, "Description of the Mintz-Arakawa Numerical General Circulation Model," in *Numerical Simulation of Weather and Climate* (IBM-UCLA technical report, 1969); "Numerical Simulation of Weather and Climate Part II: Computational Aspects," n.d.
- b. D. Randall, "Colorado State University General Circulation Model: Introduction," kiwi.atmos.colostate.edu.
- c. T. F. Hogan and T. E. Rosmond, "The Description of the Navy Operational Global Atmospheric Prediction System's Spectral Forecast Model," *Monthly Weather Review* 119, no. 8, 1991: 1786–815.

fallout. When Leith expressed interest in numerical simulations of the atmosphere, Knox invited him to go to MIT to visit Charney and Norman Phillips. They made the trip together in the spring of 1960.⁴⁴

With Charney's encouragement and the blessing of the Livermore Laboratory's director, Edward Teller, who had long been interested in weather modification, Leith spent the summer of 1960 at the Swedish Institute of Meteorology, studying the literature on global circulation and learning about numerical simulation methods. By the end of the summer he had coded a five-level GCM for Livermore's newest computer, the Livermore Automatic Research Calculator (LARC), due to be delivered in the fall of 1960. Leith wrote the code in Stockholm, basing it on the manual for the new machine. His initial model, like Smagorinsky's first effort, covered only the northern hemisphere, with a "slippery wall" at

60°N. It had five vertical levels, a $5^\circ \times 5^\circ$ horizontal grid, and a five-minute time step. At John von Neumann's suggestion, Leith introduced an artificially high viscosity to damp the effects of small-scale atmospheric waves. (This caused serious problems and helped to stimulate Leith's career-long interest in turbulence.) By the end of 1960, Leith's five-level simulation was running on the LARC. The model came to be known as the LAM (for Leith Atmospheric Model or Livermore Atmospheric Model).

The fate of Leith's work contrasts starkly with that of the GFDL and UCLA modeling efforts, illustrating significant institutional contrasts of Cold War-era American science. Livermore and GFDL were both government laboratories, but whereas GFDL served a pure research function in a civilian environment, most of Livermore's work was on secret military projects related to the design of atomic weapons. Although unclassified work such as the LAM *could* have been published in the open literature, Livermore's culture of secrecy did not reward such publication. Leith's other work (like most Livermore research) appeared only in classified reports circulated internally. As a result, Leith's first nonclassified publication did not appear until 1965, a long delay in a fast-evolving field.⁴⁵ Around that time, Leith abandoned work on the model. As a result, the LAM's mathematics and computer code did not have much direct effect on GCM development.

However, by 1963 Leith had already presented his model in numerous talks. These talks made a deep impression on their audiences because Leith often screened an animated film of LAM results. In that era, with the field of computer graphics in its earliest infancy, most output took the form of printouts. Leith collaborated with a Hollywood company called Pacific Title to turn these printouts into a film, using color tints to highlight particular features.

The film showed a hemispheric projection, with the North Pole in the center of the frame. Sixty days' worth of simulation results appeared. One second's worth of film equaled one simulated model day. In the first few minutes, atmospheric features appeared one by one; in the final segment, all the features appeared superimposed. Diurnal tides—the 12-hourly rise and fall of the atmosphere under the influence of solar heating and gravity—were among the features that showed up quite clearly. "I remember I drove places to give talks about what I was doing," Leith recalled, "and people would be watching the film with interest. I remember once somebody came up to me afterwards and said, 'I'm from Israel, and I noticed the remarkably realistic way in which you've got these things tracking across Israel.' And of course I don't know what's going on in Israel, I had

never paid any attention to it, but he had spotted the fact that . . . it was doing the right sort of things as far as he was concerned.”⁴⁶ In interviews with me, several pioneering climate modelers who had seen Leith’s talks in the 1960s mentioned the elation they experienced on watching his movie. For the first time they could actually witness the dynamic activity of their models, rather than having to imagine it.

Leith became increasingly interested in statistical modeling of turbulence, one of the many points of commonality between atmospheric science and nuclear weapons design. Although Leith ceased work on his own GCM, he became involved with the nascent GCM group at the National Center for Atmospheric Research. In the summers of 1965 and 1966, as the NCAR team awaited delivery of a new CDC 3600 computer, Leith offered use of Livermore’s computer to Warren Washington of NCAR, who described Leith to me as “a kind of father figure” for his own modeling work. Leith began to visit NCAR frequently, contributing especially in the area of mathematical methods.⁴⁷ In 1968, Leith left Livermore permanently to join NCAR, where he played instrumental roles in several climate modeling projects, both as an administrator and as a turbulence specialist.

The National Center for Atmospheric Research

The US National Center for Atmospheric Research, established in 1960, initiated its own GCM effort in 1964 under Akira Kasahara and Warren Washington. Kasahara—like Syukuro Manabe, a veteran of the Tokyo University meteorology department under Shigekata Syono—had arrived in the United States in 1954 to join the Department of Oceanography and Meteorology at Texas A&M. He moved to NCAR in 1963 following a year at the Courant Institute of Mathematical Sciences, where numerical analysis for nonlinear equations, with particular attention to shock waves, was a specialty. Washington, still writing his PhD thesis on objective analysis techniques in numerical weather prediction, arrived soon afterward. NCAR’s founding director, Walter Orr Roberts, informed them that he wanted to mount a global circulation modeling effort. Roberts told Washington: “I really want you to work about half the time on helping us get started on modeling. The other half, work on what you think is important.”⁴⁸

Kasahara and Washington began by studying the advantages and drawbacks of the three existing GCM efforts (GFDL, UCLA, and LAM), which both already knew well. They also reconsidered Lewis Richardson’s 1922

effort, looking at it “more carefully, because we thought that Richardson’s model didn’t have all the problems [of] the sigma-type models.”⁴⁹ They made an early decision to “go global,” and they adopted a z-coordinate system, in which the vertical coordinate is height rather than a pressure-related quantity. This allowed their model to function more realistically with orography (mountain ranges).

The Kasahara-Washington modeling group focused a great deal of attention on numerical schemes for finite-difference approximations. In addition, much work was done on problems of computational error arising from truncation. Two major GCM series were eventually constructed; these are summarized in boxes 7.3 and 7.4.

Box 7.3

The Kasahara-Washington GCM Series

NCAR 1 A two-layer global model with a 5° horizontal resolution.^a

NCAR 2 Completed around 1970, this version added considerable flexibility. The basic model had a 5° horizontal resolution and six vertical layers, but it could also be run at resolutions as fine as 0.625° horizontal over a limited domain, with up to 24 vertical layers.^b

NCAR 3 Around 1972, NCAR began work on a third-generation GCM incorporating improved finite-difference schemes. This model also allowed multiple resolutions, including a user-specifiable vertical increment. Although under evaluation as early as 1975, this model did not see “production” use until the end of the decade.^c

a. A. Kasahara and W. M. Washington, “NCAR Global General Circulation Model of the Atmosphere,” *Monthly Weather Review* 95, no. 7, 1967: 389–402.

b. J. E. Olinger et al., *Description of NCAR Global Circulation Model*, National Center for Atmospheric Research, 1970; A. Kasahara and W. M. Washington, “General Circulation Experiments with a Six-Layer NCAR Model, Including Orography, Cloudiness and Surface Temperature Calculations,” *Journal of the Atmospheric Sciences* 28, no. 5, 1971: 657–701; A. Kasahara et al., “Simulation Experiments with a 12-Layer Stratospheric Global Circulation Model. I. Dynamical Effect of the Earth’s Orography and Thermal Influence of Continentality,” *Journal of Atmospheric Sciences* 30, no. 7, 1973: 1229–51.

c. W. M. Washington et al., “Preliminary Atmospheric Simulation with the Third-Generation NCAR General Circulation Model: January and July,” in *Report of the JOC Conference on Climate Models: Performance, Intercomparison, and Sensitivity Studies*, ed. W. Lawrence, WMO/ICSU Joint Organizing Committee and Global Atmospheric Research Programme, 1979.

Box 7.4

The NCAR Community Climate Model Series

CCM-0A The initial version of the Community Climate Model was based on the spectral model of the Australian Numerical Meteorological Research Centre.^a A member of the ANMRC team, Kamal Puri, brought the model to NCAR during an extended visit. Later it was extensively revised.

CCM-0B A second version of the Community Climate Model was developed in 1981. This version combined medium-range and long-range global forecasting (from three days to two weeks) and climate simulation in a single set of model codes. A modular design permitted flexible choices of resolution and other features. Initial code for CCM-0B came from an early version of the ECMWF model. Physical parameterizations (including the radiation and cloud routines of Ramanathan) and numerical approximations were added from CCM-0A.^b Energy balance and flux prescriptions similar to GFDL models were used. The vertical and temporal finite-difference schemes were derived from the Australian spectral model that was also the basis for CCM-0A.^c

CCM-1, 2, and 3 Evolved from CCM-0B, coming into use in 1987. The primary differences were changed parameterizations, new horizontal and vertical diffusion schemes, and changes to moisture adjustment and condensation schemes. CCM versions 2 and 3 were developed in the early 1990s.

CCSM In 1994, NCAR initiated work on a Community Climate System Model (CCSM), coupling atmosphere, ocean, land surface, and sea ice models. Greater efforts were made to involve NCAR's extended community of users in model development.

a. W. Bourke, "A Multi-Level Spectral Model. I. Formulation and Hemispheric Integrations," *Monthly Weather Review* 102 (1974): 687–701; Bourke et al., "Global Modeling of Atmospheric Flow by Spectral Methods," in *General Circulation Models of the Atmosphere*, ed. J. Chang (Academic Press, 1977); B. J. McAvaney et al., "A Global Spectral Model for Simulation of the General Circulation," *Journal of Atmospheric Sciences* 35, no. 9 (1978): 1557–83.

b. V. Ramanathan et al., "The Response of a Spectral General Circulation Model to Refinements in Radiative Processes," *Journal of Atmospheric Sciences* 40, 1983: 605–30.

c. D. L. Williamson, ed., *Report of the Second Workshop on the Community Climate Model* (NCAR, 1988).

Along with most other major GCM groups, after 1975 NCAR gradually abandoned its finite-difference models in favor of spectral models. Spectral models ameliorate one of the most difficult problems in Earth system modeling: representing wave motion on a sphere. All early weather and climate models used rectangular latitude-longitude grids. However, these grids encountered difficulties similar to the well-known distortions of Mercator and other world map projections, especially at higher latitudes, where the distance between longitude lines shrinks—eventually to zero at the poles. Many solutions were devised, including stereographic projections and spherical, hexagonal, and icosahedral grids, but none proved ideal.⁵⁰ Spectral transform methods offered a useful alternative to grid-point schemes.

The technical details of spectral mathematics lie beyond the scope of this book, but their essence may be expressed briefly as follows. Atmospheric motion can be conceived as numerous waves of varying frequency and amplitude; the superimposition of these waves upon one another produces highly complex patterns. To visualize this, imagine dropping a stone into a completely still pond, then dropping several other stones of various sizes into the same pond at other points. The first stone produces a single set of simple, concentric waves, but as other stones fall the interacting waves rapidly create a complex surface with much more complicated patterns.

Horizontal atmospheric motion can be described as a set of interacting waves, like ripples crossing each other on the surface of a pond. These can be analyzed in “wave space.” Mathematical techniques—Fourier transforms, reverse transforms, and others—convert model variables back and forth between physical space (the familiar Cartesian grid) and wave space, a mathematical construct that is difficult to visualize (figure 7.3). Spectral techniques can also handle the vertical dimension (interaction between horizontal model layers), but usually modelers retain physical grids for this part of the analysis.

The idea of using spectral methods to analyze planetary atmospheric waves was explored as early as 1954.⁵¹ Their mathematical advantages rapidly became obvious. As noted above, all grid-point schemes inevitably face problems related to Earth’s spherical shape. Since they do not compute wave interaction in physical space, spectral methods avoid these difficulties. Other mathematical properties of this technique, including the simplification of certain nonlinear partial differential equations and the reduction of nonlinear computational instability, also offer substantial advantages over finite-difference schemes. By the latter half of the 1950s experiments with two-dimensional spectral models had begun, but three-

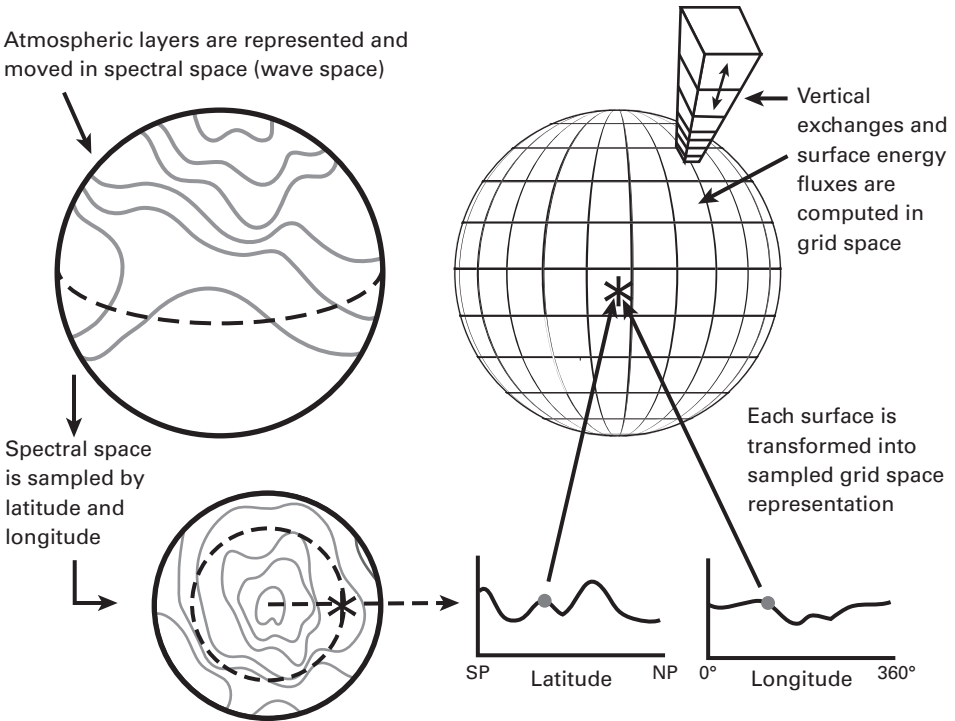


Figure 7.3
Spectral models handle horizontal motion in mathematical “wave space” and vertical motions in physical grid space. Gridpoint values are computed by sampling the wave space.
Graphic by Courtney Ritz and Trevor Burnham.

dimensional models posed greater difficulties.⁵² Initially the method required far more calculation than finite-difference techniques, so it was not favored for use in GCMs. However, by 1973 spectral methods had become more efficient than finite-difference schemes, since computers had gotten faster and algorithms had been improved.⁵³ In the early 1970s both NWP and GCM developers began to adopt these techniques.

One spectral model, NCAR’s Community Climate Model (CCM) series, has been especially important because a relatively large number of researchers were able to use it. As its name implies, NCAR intended the CCM to serve not only modelers working at NCAR but also its large constituency at universities affiliated with its parent organization, the University Corporation for Atmospheric Research. The CCM’s construction was highly

collaborative and international. The first two model versions, CCM-0A and CCM-0B, were based on, respectively, a spectral model constructed at the Australian Numerical Meteorological Research Center model and an early version of the European Centre for Medium-Range Weather Forecasts model. Several other groups adopted versions of the CCM in the late 1980s; NCAR's strong focus on documentation and modularity made this relatively easy. In an early manifestation of what might today be called "open source" development, NCAR made user manuals and code documentation available for all elements of the models beginning with CCM-0B.

The General Circulation of Circulation Models

Modelers, dynamical cores, model physics, numerical methods, and computer code soon began to circulate around the world, like ripples moving outward from the three pioneering climate modeling groups (the Geophysical Fluid Dynamics Laboratory, the US National Center for Atmospheric Research, and UCLA's Department of Meteorology). By the early 1970s, a large number of institutions had established new programs in general circulation modeling. Computer power had grown to the point that major weather forecast centers began moving to hemispheric, and later global, GCMs for operational use. Figure 7.4 illustrates the genealogy of atmospheric GCMs from Phillips's prototype up to the early 1990s.

Figure 7.4 is merely a sketch, of course. It tells only part of the story, it includes only three weather forecast GCMs (NMC, ECMWF, and UKMO), and it does not capture any details of relationships among models. In some cases, one lab imported another's computer code with only minor changes; in others, one lab adopted another's *mathematical* model but programmed it for a different computer. Often labs imported only one part of an existing model (for example, a dynamical core, a grid scheme, or a cloud parameterization) and built the rest themselves. An exhaustive account of modeling groups, model variations, and the relationships among them after the 1960s would require a volume of its own. Here I will simply highlight certain interesting features of the circulation of circulation models (so to speak), as they traveled from lab to lab around the world.

The Australian GCM story, and especially Australia's contribution to spectral modeling, is perhaps the most dramatic case in point. Several labs had briefly considered spectral transform techniques in the 1950s, but computer capacity and numerical methods limitations rendered them impractical until the late 1960s, when André Robert began developing spectral models at the Canadian Meteorological Centre (CMC). In 1970–71,

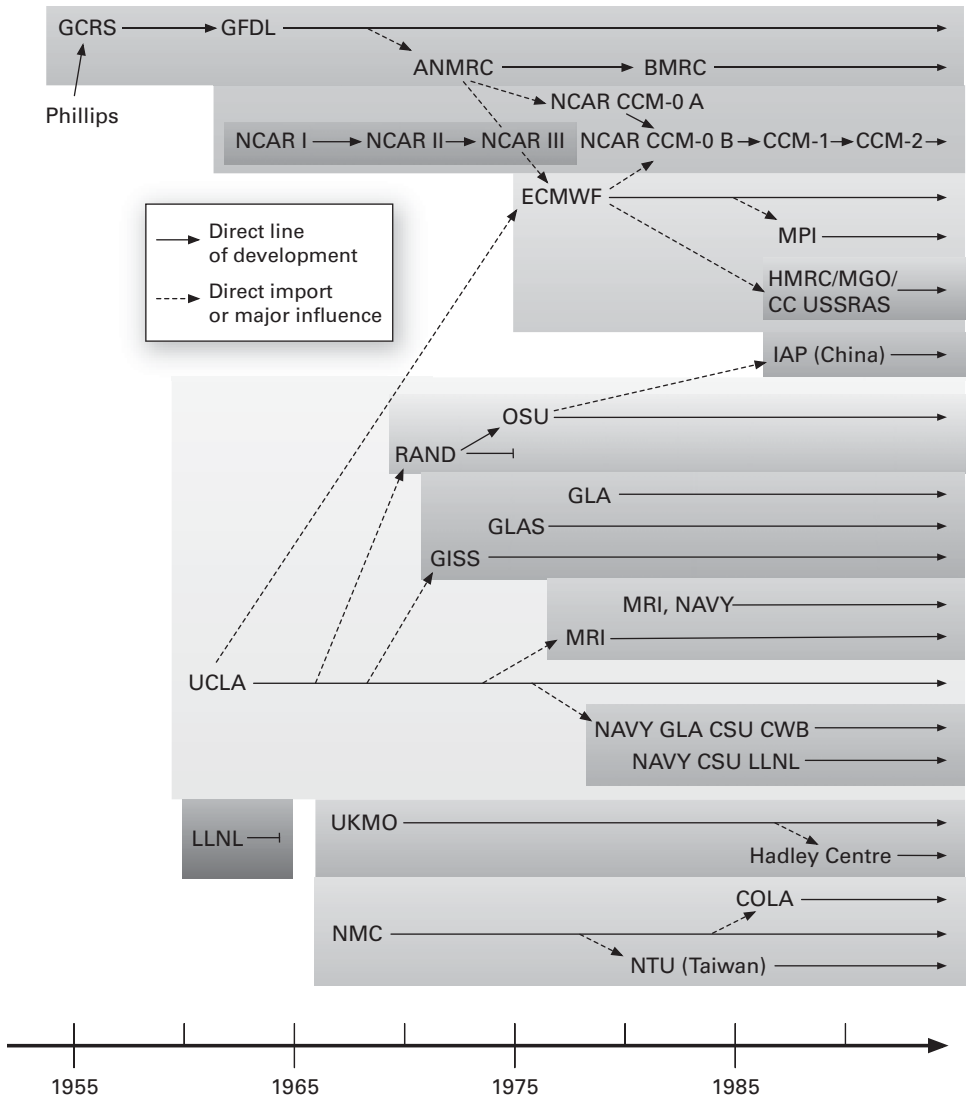


Figure 7.4
The AGCM family tree. Revised and expanded from P. N. Edwards, “A Brief History of Atmospheric General Circulation Modeling,” in *General Circulation Development, Past Present and Future*, ed. D. A. Randall (Academic Press, 2000).
Graphic by Trevor Burnham.

seeking to deepen its expertise in weather modeling, Australia's new Commonwealth Meteorology Research Centre (CMRC) seconded its modeler William Bourke to McGill University and the CMC. At the CMC, Bourke learned Robert's spectral techniques.⁵⁴ Bourke recalled the ninth Stanstead Seminar, held in Montreal in 1971,⁵⁵ as a watershed for spectral modeling techniques.⁵⁶

A couple of years earlier, in 1969, another Australian researcher, Doug Gauntlett, had visited GFDL and the US National Meteorological Center. Gauntlett had returned to Australia with code for the GFDL N30 nine-level hemispheric GCM (a finite-difference model). The CMRC adapted this to the southern hemisphere in hopes of using it for NWP, but it took four times as long to make a prediction as the existing baroclinic model, so it was never used operationally.⁵⁷ When Bourke returned to Australia in 1971, he joined with Gauntlett and others to build the CMRC's seven-level spectral GCM, which replaced its gridpoint model for operational forecasting in 1976.⁵⁸ Bourke, Bryant McAvaney, Kamal Puri, and Robert Thurling also developed the first global spectral GCM.⁵⁹ McAvaney recalled that this work was mostly completed in 1974–1975, but that “it took a while to publish.”⁶⁰ Later, Puri carried code for the Australian spectral model to NCAR, where it became the principal basis of CCM0-A.

McAvaney's six-month visit to the Soviet Union in 1977 also contributed to spectral modeling. Though the Soviet modelers lacked the computer capacity to implement their models operationally, on the level of theory and mathematical methods “they were as good, definitely as good as anybody,” McAvaney recalled when I interviewed him in 2001. “Certainly their numerical techniques were up there with anything . . . in the US or anything that we'd done. . . . They were using a spectral approach for diagnostic work, and had done a lot of spectral decomposition of atmospheric fields and particularly interaction between atmospheric fields.”⁶¹

A similar story surrounds GCM development at the European Centre for Medium-Range Weather Forecasts. Conceived in the latter half of the 1960s, the ECMWF opened its doors at Shinfield Park, England, in 1974, with Aksel Wiin-Nielsen as director. Wiin-Nielsen, a Dane, had joined Rossby's International Meteorological Institute in Stockholm in 1955. He moved to the JNWP Unit in the United States in 1959 and, soon afterward, worked at the US National Center for Atmospheric Research during its earliest years. His career thus embodied the international movement of people and ideas typical of meteorology during this period.

From the outset, the ECMWF's goal was to forecast weather for up to 10 days: the “medium range.” This would require a global GCM. The US

National Meteorological Center had introduced a hemispheric forecast GCM several years earlier, but after periods beyond a few days this and other hemispheric models developed problems related to the artificial handling of computations at their equatorial “edge.” Using a global model would avoid such problems. Rather than build the ECMWF’s global forecast GCM from scratch, Wiin-Nielsen contacted Smagorinsky at GFDL and Arakawa and Mintz at UCLA, requesting copies of their models. Both institutions agreed to share their code, with no conditions attached other than appropriate credit—impressive generosity, considering that each model had taken more than a decade to develop.

Acquiring the code called for in-person visits. In 1975, Robert Sadourny, a French modeler who had studied with Arakawa and Mintz in the 1960s, spent four weeks at UCLA. Meanwhile, Tony Hollingsworth made his way to GFDL. Both returned to ECMWF bearing model code and documentation, as well as personal knowledge gained during the visits. ECMWF comparison tested the two models before settling on the GFDL scheme. Soon, however, the Centre replaced the GFDL model physics with a new physics package of its own, retaining only the dynamical core. Later this too was replaced with a spectral core developed internally.⁶²

This circuitous exchange of concepts, mathematical techniques, and computer code became entirely typical of computational meteorology and climatology after the mid 1960s. Rather than start from scratch, virtually all the new modeling groups began with some version of another group’s model. Veterans and graduate students from the three original GCM groups left to form new groups of their own, taking computer code with them. Others coded new models, most often modified versions of the physical equations and parameterizations used in existing models. The availability of a widely shared, well-standardized scientific computer language (FORTRAN, short for FORMula TRANslation) facilitated these exchanges substantially, as did the scientific-internationalist culture of meteorology.

Yet, as I have mentioned, the number of modeling groups remained small. The count can be expanded or contracted under various criteria, but a reasonable upper limit might be the 33 groups that submitted GCM output to the Atmospheric Model Intercomparison Project (AMIP), an ongoing effort to compare climate models systematically.⁶³ A smaller figure comes from the Coupled Model Intercomparison Project (CMIP), an AMIP follow-on, which evaluated 18 coupled atmosphere-ocean GCMs.⁶⁴

Notably, all the CMIP simulations came from modeling groups based in Europe, Japan, Australia, and the United States, the historical leaders in climate modeling. The AMIP models (simpler and less computer-intensive than coupled AOGCMs) also included entries from Russia, Canada, Taiwan, China, and Korea. But the elite world of global climate simulation still includes no members from South or Central America, Africa, the Middle East, or southern Asia. The barriers to entry in climate modeling remain high. They include not only the cost and complexity of supercomputers, but also the human infrastructure required to support advanced research of this nature. In the political arena, this fact contributes to a widespread perception that the issue of climate change “belongs” to the developed countries, not only because they are the initial (and still principal) sources of fossil fuel emissions but also because they are the “owners” of knowledge about the problem.

Climate Modeling and Computational Friction

The mathematical complexity of general circulation modeling was one reason it did not spread further or faster. But a more important reason was access to supercomputers. These expensive, highly advanced machines used new techniques such as parallel processing (multiple instructions handled at the same time), reduced instruction sets, and vector processing (multiple data items handled at the same time). Today’s personal computers employ such methods routinely, but in the 1960s and the 1970s those techniques were seen as highly specialized, uniquely suited to scientific computing and not to much else. For programmers, working with these machines required specialized knowledge and training. Their operating systems were minimal; sometimes a new-model supercomputer was delivered to eager customers with no operating system at all. Typically, manufacturers sold at most a few dozen copies of any given model. Little or no commercial software was available for this minuscule customer base. While supercomputer manufacturers such as Control Data Corporation and Cray provided high levels of support, the highly specialized scientific programming of GCMs remained the province of a tiny elite.

As modelers sought to increase model resolution and include more physical processes directly in the models, their models required more and more computer power. Every group building GCMs either owned or had access to the largest, fastest supercomputers available. Greater computer power allowed longer runs, higher resolution, and larger numbers of runs.

Because modelers’ appetite for computer power constantly outstripped the available capacity, climate laboratories endured a nearly continuous cycle of re-purchasing, re-learning, and re-coding as successive generations of supercomputers arrived, typically every 3–5 years. The machines required a substantial, highly trained staff of operators, programmers, and technical support personnel. They also needed air-conditioned rooms and consumed prodigious quantities of electric power. (The Cray 1-A processor, for example, sucked down 115 kilowatts, and its cooling and disk storage systems devoured a similar amount.)

With a handful of exceptions, such operations lay beyond the means of academic institutions, which might otherwise have been expected to develop their own modeling programs.⁶⁵ Instead, until the 1990s most climate modeling activity was confined to national laboratories, weather services, and a few other large, well-financed institutions. As a result, the number of GCMs remained small. In the mid 1990s—four decades after Phillips’s pioneering prototype—just 33 groups worldwide submitted GCMs for the first Atmospheric Model Intercomparison Project.⁶⁶

Tables 7.1 and 7.2 illustrate the rapid growth of computer power at major modeling centers. As table 7.1 shows, the capabilities of GFDL’s best computers increased by a factor of 3000 between 1956 and 1974. Table 7.2 catalogs the vast performance improvements of ECMWF’s IBM POWER5+ computer (installed in 2006) over its Cray 1-A (installed in 1978), including a 90,000-fold increase in sustained computational performance. Virtually all climate laboratories could produce similar charts.

Table 7.1
Computers in use at GFDL, 1956–1982. Data from Geophysical Fluid Dynamics Laboratory, *Activities—FY 80, Plans—FY 81: With a Review of Twenty-Five Years of Research 1955–1980* (Geophysical Fluid Dynamics Laboratory, 1980).

	Time period	Relative performance
IBM 701	1956–1957	1
IBM 704	1958–1960	3
IBM 7090	1961–1962	20
IBM 7030 “STRETCH”	1963–1965	40
CDC 6600	1965–1967	200
UNIVAC 1108	1967–1973	80
IBM 360/91	1969–1973	400
IBM 360/195	1974–1975	800
Texas Instruments X4ASC	1974–1982	3000

Table 7.2
ECMWF’s latest supercomputer vs. its first one.

Specification	Cray-1A	IBM POWERS5+ system	Approximate ratio
Year installed	1978	2006	
Architecture	Vector processor	Dual cluster of scalar CPUs	
Number of CPUs	1	~5000	5000:1
Clock speed	80 megahertz	1.9 gigahertz	24:1
Peak performance of each CPU	160 megaflops	7.6 gigaflops	48:1
Peak performance of whole system	160 megaflops	~34 teraflops	200,000:1
Sustained performance	~50 megaflops	~4.5 teraflops	90,000:1
Memory	8 megabytes	~9 terabytes	1,000,000:1
Disk space	2.5 gigabytes	~100 terabytes	40,000:1

Source: European Centre for Medium-Range Weather Forecasts, “ECMWF Supercomputer History,” 2006, www.ecmwf.int. Flops are “floating-point operations per second,” a measure of calculating speed.

No fields other than nuclear weapons research and high-energy physics have ever demanded so much calculating capacity. As a result, like the nuclear weapons labs, the world’s major climate and weather modeling centers have consistently maintained state-of-the-art supercomputer facilities, and have significantly influenced the development path of the supercomputer industry. For example, in 1977 NCAR purchased the first production supercomputer from Cray Research, a Cray 1-A with serial number 3.⁶⁷ (A test model, serial number 1, had been delivered to the nuclear weapons laboratory at Los Alamos the previous year.) Toward the end of the 1970s, NCAR insisted for the first time that its computer suppliers deliver operating systems, compilers, and other basic software for the machines. Previously this had been the responsibility of customers rather than manufacturers. As a result, users—including scientists themselves as well as laboratory computing staff—wrote their own software, sometimes even operating systems. Manufacturers considered themselves responsible only for technical assistance with software development, while customers generally preferred to retain control of their highly specialized, lab-specific software.⁶⁸ According to Elzen and MacKenzie, NCAR’s break with this

traditional social contract helped force Cray Research to supply system software. A former Cray vice president, Margaret Loftus, recalled: "Before, we had difficulty selling software to the sophisticated scientific labs. Now, we have difficulty selling a Cray without software."⁶⁹ Packaged weather modeling software for workstations and personal computers has appeared in recent years,⁷⁰ but in meteorology the craft tradition persists even today, especially in the relatively small field of climate modeling.

The prestige attached to having built the fastest computer in the world, combined with the small customer base, sometimes injected a heavy dose of nationalism into the competition among supercomputer manufacturers. Between 1994 and 1996, NCAR held a competition for the contract to replace its aging Crays with new supercomputers. For the first time in history, the winning bidder was a non-US firm: the Japanese firm NEC, whose SX-4 registered the highest performance of any computer NCAR had ever evaluated.⁷¹ NCAR planned to lease four SX-4s at a price near \$35 million, but US-based Cray Computing challenged NEC's bid before the US Department of Commerce. Cray accused NEC of illegally "dumping" its machines below their cost. The Commerce Department ruled in favor of Cray, imposing a 454 percent tariff on NEC, a move which effectively prevented NCAR from acquiring the SX-4s. Many observers viewed the Commerce Department's decision as motivated by nationalism, under behind-the-scenes pressure from Congress (Edwards interviews). NEC retaliated by suing the Commerce Department in the US Court of International Trade, alleging that the agency had "revealed itself as a partisan ally of NEC's competitor [Cray] for the UCAR contract."⁷² The suit went to the Supreme Court, which in 1999 upheld the Commerce Department ruling without comment. NCAR mourned the decision: "We are denied access to the most powerful vector computing systems in the world."⁷³ Eventually it adopted an IBM machine, which it clearly viewed as a stopgap.

Because computers are so fundamental to modeling work, climate laboratories typically display a certain fetishism regarding their machines. In the late 1990s I spent time at more than a dozen weather and climate modeling centers, including NCAR, GFDL, ECMWF, the UK's Hadley Centre for Climate Prediction and Research, and the Australian Bureau of Meteorology Research Centre (BMRC). Almost invariably, and usually within an hour of my arrival, my hosts would offer a tour of the computer facility. Often such a facility occupies an entire floor, housing at least one supercomputer and numerous large disk drives, robotic tape libraries, and other peripherals. Some labs, such as NCAR and the BMRC, feature prominent viewing windows through which visitors can admire the machines,

quietly humming in their spotless rooms. Likewise, the websites and publications of climate laboratories virtually always highlight their computer capacity.⁷⁴

After flaunting the beautiful machines, climate modelers typically proceed to explain the difficult balancing act they must perform. In their accounts, a kind of Heisenberg principle of modeling results from computational friction. Modelers can increase model resolution by sacrificing complexity, or they can increase model complexity by decreasing resolution—but they cannot do both at once. Other tradeoffs can balance these limits differently; for example, modelers can “nest” a higher-resolution limited-area model within a lower-resolution global model. All solutions depend on the availability of central processing unit (CPU) time, data storage (for the very large model outputs), CPU speed, and other technical aspects of the machines and the software. This discourse of insufficient computer power is a basic trope of climatology, widely reported in journalistic treatments of the climate-change issue.

Yet computational friction appears in many other less public but more interesting and subtle forms. As one of many possible examples, consider the problem of round-off error in GCMs. In order to handle a vast range of numerical values, from the extremely small to the very large, scientific mathematics conventionally represents numbers in two parts: a mantissa and an exponent. The mantissa expresses the value, while an exponent of 10 (positive or negative) gives the scale. Thus 256859.6235 becomes 2.568596235×10^5 , and 0.000164757852 is rendered as $1.64757852 \times 10^{-4}$. Computer arithmetic employs a similar strategy. A computer’s word length is fixed at the hardware level, as the basic unit of addressable memory.⁷⁵ Floating-point notation divides each word into two parts, one for the mantissa and one for the exponent. Software techniques can increase the functional word length to almost any desired (finite) number of digits, but since they must work around the hardware constraint, these techniques impose a prohibitive computational cost on calculation-intensive operations such as GCMs. In modern supercomputers, word length is typically 64 or 128 bits, corresponding roughly to a precision limit of 16 or 32 decimal digits respectively.

Floating-point arithmetic handles irrational numbers such as π , and other numbers with mantissas longer than the available word length, by rounding them off at the last available digit. This limit on precision produces no noticeable effects for most purposes. But in simulations that require extremely long series of calculations, the tiny errors that occur with each rounding can accumulate to a problematic degree. Furthermore,

although standards issued by the Institute of Electrical and Electronics Engineers govern most computers' floating-point arithmetic, nonstandard conventions also exist. And as with most standards, *implementations* of IEEE standards vary slightly among manufacturers, so that different machines produce slightly different results. Scholars have argued that such differences can never be entirely eliminated, because designers base computer arithmetic on human arithmetic, whose conventions remain subject to debate and potentially to change.⁷⁶ Intel demonstrated one aspect of this problem to mass consumers in 1995 when it released its Pentium chip with a faulty floating-point unit that resulted in substantial division errors under a few rare circumstances. The floating-point algorithm used in the chip had been subjected to mathematical proof, but a (human) mistake in the proof led to errors in the chip design. The mistake led to a recall that cost Intel about \$475 million.⁷⁷

GCMs' enormously long series of interdependent calculations make them sensitive to round-off error. In 1973, NCAR considered adopting new supercomputers that would operate most efficiently at a lower precision than its existing CDC 6600 and 7600 machines (24-bit or 21-bit mantissas vs. the CDC's 48-bit mantissa). David Williamson and Warren Washington tested the effects of this lower precision on a GCM and found that predictability errors in the model itself—essentially, the effects of nonlinear chaotic behavior—exceeded round-off error so greatly that the lower precision of the new machines would not appreciably affect NCAR model results.⁷⁸ Errors in observational data also exceeded round-off error. Therefore, Williamson and Washington argued, the round-off error problem could be ignored for the time being. However, as model quality improved and model codes began to spread from one group to another, this and other issues of computational error emerged once again.

Between the 1960s and the 1990s, supercomputer architecture underwent two major changes. Cray computers, first released in 1975, embodied the first major innovation: vector processing, which permits the same operation to be performed simultaneously on many data elements. A second innovation followed in the late 1980s: massively parallel computers, with dozens to hundreds of processing units permitting multiple instruction streams to proceed simultaneously. Both changes presented difficult challenges—especially parallel processing, which required programmers to reconfigure instruction streams to take advantage of many processors. Supercomputing thus remained a highly specialized niche, requiring knowledge and technical skill entirely different from those well known (and well understood) in business and consumer computing. In these difficult conditions, climate modelers—or rather the programmers

who worked on climate modeling teams—had to “port” old GCM code to the new machines or else reprogram them from scratch, working from the mathematical model rather than the existing computer code.

Meanwhile, GCMs grew ever more complex. Resolution increased, and the typical length of GCM runs rose from a few months to 20–100 years or more. In the mid 1990s, as they prepared to convert to massively parallel architectures, James Rosinski and David Williamson of NCAR investigated the effects of round-off error, code branches, and other computer-related problems on GCMs, including the porting of old GCMs to new computers. They ran NCAR’s CCM2 twice on the same computer, the two runs identical except for a tiny difference in the specified initial temperature. Comparing the results, they saw “small, rounding-sized differences between model solutions grow rapidly, much faster than expected from the predictability error growth associated with nonlinear fluid flow.” They isolated this particular problem to effects of computer round-off error on an algorithm associated with cloud parameterization, and speculated that similar errors would affect other parameterizations. Round-off error also produced differences between the same model run on the same computer from identical initial conditions but using two different versions of a FORTRAN compiler and a code library of intrinsic functions (figure 7.5, two Cray lines). Finally, Rosinski and Williamson demonstrated differences between two runs of the same GCM with the same initial data on two different computers (figure 7.5, thick solid line).

Thus hardware and low-level software differences each created idiosyncratic errors that accumulated to a small but significant degree. Since each climate laboratory develops much of its own low-level software (such as the “new” and “old” libraries of intrinsic function codes indicated in figure 7.5), their individual computers have calculating “styles” or “personalities” (my terms) that show up as small differences in outcomes over long model runs. The effect is that the “same” model, when ported to a different computer, will behave somewhat differently for reasons related to how the machine implements computational processes, rather than to the model’s mathematics. Rosinski and Williamson suggested that although these computational differences cannot be eliminated, ported models can be statistically validated against original model results to ensure that computer “personalities” do not substantially alter model behavior.

2×CO₂: A Paradigmatic Modeling Experiment

As GCMs added vertical levels, going from two in Phillips’s prototype to nine levels or more by the mid 1960s, modelers had to work out how to

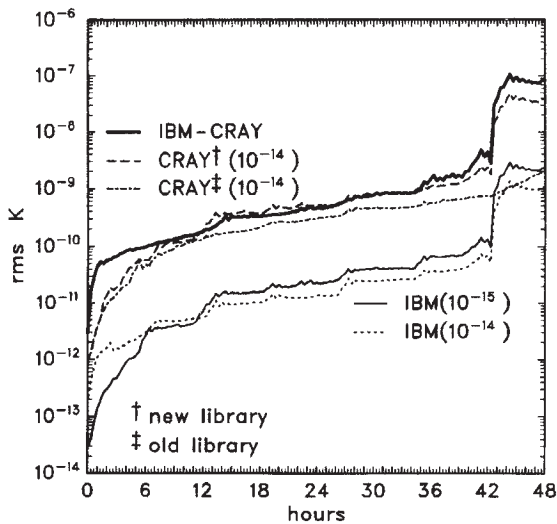


Figure 7.5

An illustration of differences between IBM and Cray runs of NCAR CCM2, differences between control and perturbed versions of CCM2 Cray and IBM runs, and differences between Cray runs using two versions (new and old) of an intrinsic code library. Original legend: "Global RMS [root mean square] temperature differences between IBM and Cray versions of CCM2 and various perturbation pairs on the IBM and Cray. The notation (10^{-x}) denotes an initial perturbation taken from a rectangular distribution bounded by $\pm 1.0 \times 10^{-x}$."

Source: J. M. Rosinski and D. L. Williamson, "The Accumulation of Rounding Errors and Port Validation for Global Atmospheric Models," *SIAM Journal on Scientific Computing* 18, no. 2 (1997), 560.

simulate transfers of energy, mass, and moisture from one level to another. Among other things, without such transfers GCMs would not reproduce large-scale vertical circulatory features, such as the giant Hadley, Ferrel, and polar cells (see figure 2.7). These features, which span tens of degrees of latitude and encircle the entire planet, could not simply be entered into the models. Instead, they would have to emerge from grid-scale processes. Research on vertical structures and processes became critical to the scientific agenda of modelers during this period.

Modelers focused much of their attention on *radiative transfer*.⁷⁹ Atmospheric gases absorb and re-radiate solar energy, heating and cooling the atmosphere. These energy transfers drive the entire climate system. The atmosphere consists mostly of nitrogen (78 percent), oxygen (21 percent),

and argon (1 percent). However, none of these gases absorbs much radiation in the infrared portion of the spectrum responsible for heating. Instead, the principal “radiatively active” gases are water vapor, ozone, and carbon dioxide. These and other radiatively active trace gases create the greenhouse effect, which maintains Earth’s average temperature at around 15°C.

Recall from chapter 4 that, just before World War II, G. S. Callendar had revived the carbon dioxide theory of climate change, first proposed by Tyndall, Arrhenius, and others in the nineteenth century. Climatologists initially received Callendar’s results quite skeptically, but Callendar doggedly continued to promote the idea despite its chilly reception.⁸⁰ By the 1950s, numerous scientists—many trained in fields other than meteorology—began to reconsider the carbon dioxide theory.

Among others, the physicist Gilbert Plass, inspired by World War II and early Cold War military research on radiation (he had worked on the Manhattan Project), revisited the work of Arrhenius and Callendar. In 1956, Plass published a series of articles reviewing the CO₂ theory of climate change.⁸¹ Unlike his predecessors, Plass had access to a computer (the MIDAC at the University of Michigan) and thus was able to calculate CO₂’s radiative transfer effects without resorting to the “many approximations . . . used . . . in earlier attempts to solve this complex problem.” Plass calculated radiation fluxes at 1-km intervals from the surface to an altitude of 75 km. He performed these calculations for the existing concentration of CO₂, then repeated them for half and for double the existing CO₂ concentration. His result: “The surface temperature must rise 3.6°C if the CO₂ concentration is doubled.”⁸² Plass warned of significant and enduring global warming by the twentieth century’s end. In 1957, Hans Suess and Roger Revelle published their famous paper on the carbon cycle, indicating that not all the carbon dioxide from combustion of fossil fuels could be absorbed by the oceans, so that the gas’s concentration in the atmosphere would continue to rise.⁸³ I discuss this work further in chapter 8.

As they began to construct their nine-level GCM a few years later, Manabe and his colleagues at the GFDL also examined the effects of doubling or halving CO₂ concentrations (using the one-dimensional model, not the GCM). Smagorinsky had assigned Manabe to create radiative transfer code for the model. Manabe recalled it this way when I interviewed him:

My original motivation for studying the greenhouse effect had very little to do with concern over environmental problems. But greenhouse gases . . . are the second

most important factor for climate next to the sun. Greenhouse gases on this planet change Earth's surface temperature by as much as 30°C. So in order to test the radiative computation algorithm, how effective it is to simulate the thermal structure of the atmosphere, you have to put this greenhouse gas in. . . . Here my job requirement to try to develop a radiation algorithm came in very handy. . . . So I was an opportunist. I took this opportunity to do this problem.

But then a funny thing happened. Fritz Möller, who was working with me, . . . found out that the methods of Callendar and Plass . . . start failing when . . . the temperature warms up in the atmosphere. When the temperature warms up, you get more water vapor in the atmosphere. And that means more downward flux of radiation. So when Möller started putting in what we call water vapor feedback, [previous] methods started failing miserably. . . . Sometimes when you doubled CO₂ you got a cooling of 10 degrees, depending upon temperature, but at another temperature you doubled CO₂ and you got a 15 degree warming. All kinds of crazy results, mainly because including Arrhenius, *all the pioneers who worked on greenhouse warming thought about only the radiation balance at Earth's surface*.⁸⁴

In other words, any given parcel of air not only receives radiant energy from incoming sunlight, but also re-radiates energy in all directions. This re-radiated energy is, in turn, absorbed, reflected, or re-radiated by other parcels of air. Therefore, to handle radiation in a nine-level model, Manabe needed his radiation code to work out these radiative transfers *within* the atmosphere, i.e., between model levels.

Furthermore, it was necessary to model the problem Möller had discovered: how changes in CO₂ would affect the concentration of water vapor (a problem known as “water vapor feedback”). Möller's 1963 calculation showed that cloud and water vapor feedbacks associated with CO₂ doubling could have huge effects, producing “almost arbitrary temperature changes” of up to 9.6°C, for which no existing model could account. He also argued that scientists had focused on CO₂ because they could measure its global concentration adequately with relative ease, whereas the extreme variability of clouds and water vapor made those phenomena almost impervious to empirical study at the global scale.⁸⁵ A warmer atmosphere at the surface causes greater evaporation, but more water vapor in the atmosphere can translate into more clouds, which may either cool or warm the atmosphere depending on their structure, altitude, and color. Finally, water vapor is implicated in moist convection, another process of vertical heat transfer. Working out the relationships among all these factors would take decades; some remain controversial today.

Throughout the 1960s, Manabe, collaborating with Möller, Smagorinsky, Robert Strickler, Richard Wetherald, Doug Lilly, and Leith Holloway, slowly

worked out a new, one-dimensional radiative-convective model. His group then used that model to create radiation code for the three-dimensional, nine-level GFDL GCM.⁸⁶ At first, they simply wanted to understand the model's sensitivity to changes in and relationships among key variables involved in vertical radiation transfer, including CO₂, water vapor, ozone, and cloudiness. In the first Manabe one-dimensional model, doubling the concentration of carbon dioxide produced an increase of 2.3°C in global average temperature. Revisions to the model later reduced the increase to 1.9°C.⁸⁷ In 1975, Manabe and Wetherald became the first investigators to test the climate's sensitivity to carbon dioxide doubling in a GCM. Their results indicated a rise of about 2.9°C at the surface, notably larger than the simple radiative-convective model's predictions.⁸⁸

Table 7.3 lists the most significant papers on carbon dioxide's temperature effects from Arrhenius's seminal work through Manabe and Wetherald's pioneering GCM calculation. Nearly all these papers used carbon dioxide doubling as a benchmark. (Many also calculated the effects of halving the concentration.) In view of the complexity of the problem, these results all fell within a strikingly restricted range. Leaving aside Arrhenius's early result (based on very approximate measures of CO₂'s radiative properties) and Möller's 1963 calculation of 9.6°C (by his own admission a model that produced "almost arbitrary temperature changes"), these calculations vary from a low of 0.8°C to a high of 4°C, approximately a factor of 4. Stephen Schneider, reviewing these and other results and comparing his own model with that of Manabe and Wetherald, argued for a likely climate sensitivity of 1.5–3°C.⁸⁹ Furthermore, *all the reported values are positive*. In other words, every single result pointed to warming from carbon dioxide doubling; the question was not whether, but how much. This striking consistency would help to place global warming theory on the political agenda, the subject of chapter 14. Thus climate sensitivity to carbon dioxide doubling had already become a paradigmatic modeling experiment by the 1950s. So it was not only natural, but necessary, to try the same experiment with GCMs. The "2×CO₂" simulation became a standard modeling exercise.

As Kuhn pointed out long ago, paradigmatic experiments—those that settle an issue and create a widely accepted framework for solving further problems—can unify a scientific field.⁹⁰ In this case, however, simulations of CO₂ doubling had a paradoxical dual effect. First, because virtually all simulations gave results within a fairly narrow range of positive values, they unified the field in something like the way Kuhn suggested, creating a set of puzzles to be solved within the dominant framework of simulation modeling and establishing a set of techniques for solving those puzzles.

Table 7.3

Selected estimates of the effects of carbon dioxide doubling on global average temperature, 1896–1975.

Investigator(s)	Year	Climate sensitivity to CO ₂ doubling	Remarks
Arrhenius	1896	5–6°C	2-D (zonal and vertical) radiative transfer model; hand calculation
Hurlburt	1931	4°C	Unnoticed until 1960s owing to general rejection of CO ₂ theory; Callendar unaware of Hurlburt's work until about 1942
Callendar	1938	1.5°C	1-D radiative transfer model; CO ₂ doubling not mentioned in text, but appears in graph; no convection
Callendar	1949	2.1°C	Revised version of his 1938 calculations; CO ₂ doubling explicitly mentioned
Plass	1956	3.8°C	1-D radiative transfer model; no convection or water vapor feedback
Möller	1963	1.5–9.6°C	1-D surface energy balance model; combined H ₂ O and CO ₂ absorption reduces overall warming, but water vapor feedback produces "almost arbitrary temperature changes"
Conservation Foundation	1963	3.8°C	Consensus statement by Plass, Keeling, and others
Manabe and Wetherald	1967	2.4°C	1-D radiative-convective model; humidity and cloudiness levels strongly influence CO ₂ effects
Manabe	1970	1.9°C	Revised version of Manabe and Wetherald 1967 1-D radiative-convective model; sensitivity is for "average" cloudiness
Rasool and Schneider	1971	0.8°C	1-D radiation balance model with fixed relative humidity and cloudiness
Manabe and Wetherald	1975	2.9°C	First use of a GCM to simulate effects of CO ₂ doubling

Yet, in contrast with the classic Kuhnian cases, they did not settle the issue. Instead, the range of results remained large enough to generate ongoing controversy for several decades. The “benchmark” aspect of this experiment became more salient as climate change became a policy issue. (See chapter 14.)

At the end of chapter 4, we saw that Callendar’s 1938 revival of the carbon dioxide theory foundered on the objections of C. E. P. Brooks, David Brunt, and other climatologists. They argued that Callendar could not connect the apparent warming trend with carbon dioxide levels, because the warming might be caused by circulatory effects that no one yet understood. Though Callendar did not live to see it (he died in 1964), GCMs would permit climatologists to analyze the connection of CO₂ and circulation in detail. In a real sense, climate modelers have been working on that problem ever since.

Data Friction, GCMs, and Climate Change

How do you distinguish a good simulation from a bad one? Of course your simulation should look like the reality it’s simulating. But before you can tell whether it is doing that, you need a reliable picture of that reality. You need a data image. The more detailed your simulation gets, the more precise your data image must become if you are going to evaluate your model’s quality. In the case of the planetary circulation, that picture of reality proved exceedingly hard to come by.

The long-term data record available at the dawn of the GCM era remained severely fragmented. No single data set covered both the oceans and the land surface. The standard “global” climate data—the Réseau Mondial and the *World Weather Records*—tracked only about 400 surface stations on land. Before 1938, upper-air data—critical to studies of the general circulation—remained extremely sparse. Collecting and publishing climate data still took years, even decades. Large libraries of digitized data had been collected in a few places, but the storage medium (punch cards) was too bulky, heavy, and fragile to be widely or readily shared. Large data voids remained, especially in the southern hemisphere and the extreme polar regions.

An example illustrates the extent of the problem. In 1965, Smagorinsky, Manabe, and their colleagues wanted to evaluate their hemispheric GCM. They could find no single data source containing sufficient information about the entire hemisphere at every altitude represented in the model. Instead, they had to combine observational data from numerous sources

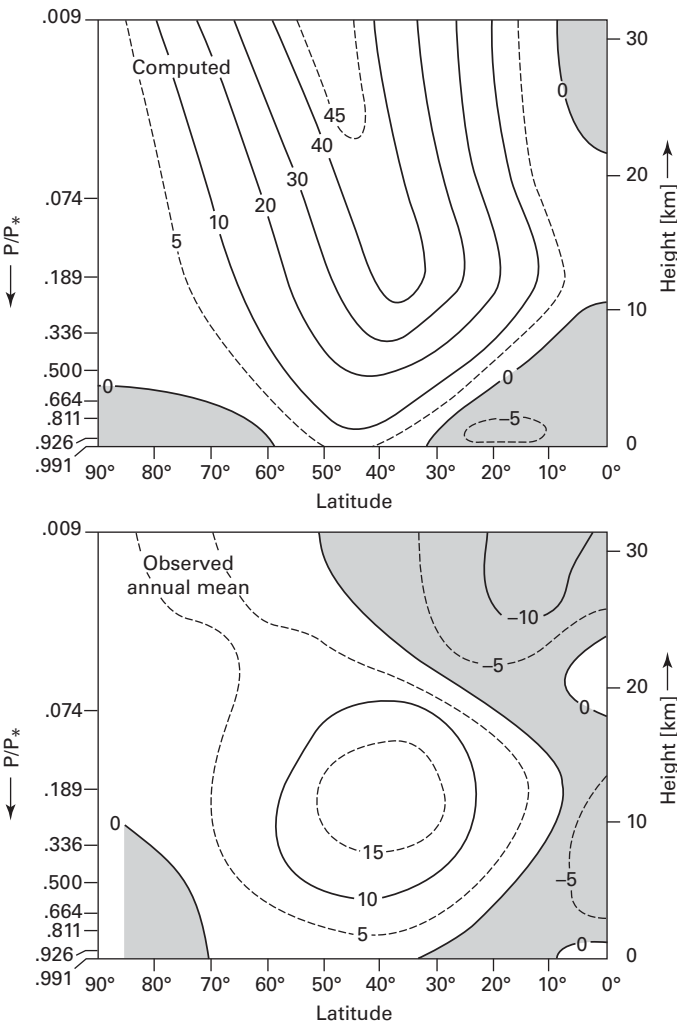


Figure 7.6
Zonal mean winds in the northern hemisphere as computed in the GFDL nine-level GCM (top) and as observed (bottom). The diagram represents a cross-section of the atmosphere taken from the equator to the north pole. The observed mean combines tropospheric winds for 1950 with stratospheric winds for 1957–58.
Source: J. Smagorinsky et al., “Numerical Results from a Nine-Level General Circulation Model of the Atmosphere,” *Monthly Weather Review* 93 (1965), 736.

in dubious ways. For instance, the best wind data for the troposphere came from H. S. Buch's analysis for the year 1950, which was based on 81 northern hemisphere wind stations. But these data did include the stratosphere, so Smagorinsky et al. had to combine them with data for a different year: Abraham Oort's data for the International Geophysical Year (1957–58), from 240 northern hemisphere radiosonde stations at three pressure levels. No traditional climatologist would have accepted combining data from two different years in this way; circulatory patterns varied too much. But all other data on the circulation above the surface exhibited similar limits, so the modelers had no real choice. To top it off, the nine-level GCM contained well over 10,000 gridpoints, a resolution that far exceeded those of all existing observational data sets.⁹¹

Fortunately, in 1965 no one expected much accuracy. Modelers just wanted to know whether they were in the ballpark. They would be happy if their crude GCMs reproduced even the most basic features of the circulation, such as the trade winds and the vertical temperature distribution. Comparing GCM outputs they expected to be inaccurate with data they knew to be imprecise worked well enough for the time being. But this strategy could not work in the long run. In time, modelers would need better data, especially in the vertical dimension. How else could they tell whether their models were improving?

Furthermore, by 1970 modelers were already becoming embroiled in emerging political controversies over anthropogenic climate change, provoked in part by their own research on carbon dioxide and aerosol effects. This made the demand for accurate global climate data much more urgent. It also changed the nature of the research problems modelers had to solve. As we have just seen, most theoretical models projected a 2–4°C temperature increase from CO₂ doubling. But CO₂ had not doubled; in fact, as of 1970 it had risen only about 13 percent above pre-industrial levels. Climate scientists therefore faced new questions that could only be answered by comparing simulations with observational data. For example, could they already detect a warming “signal” against the natural “noise”—as Callendar already believed in 1938? GCM simulations might serve as the “control” against which to detect that signal. If they did find a signal, could they prove that greenhouse gases were the cause? Again, simulations would be needed as controls. Could they project how climate would change as CO₂ continued to increase? CO₂ was not going to double overnight; instead, it would rise slowly. How would this “transient” increase affect the climate's response? In addition, how would particulate aerosols, chlorofluorocarbons, methane, and other anthropogenic pollutants affect the climatic

future? What about water vapor? Perhaps the increased evaporation caused by a warmer climate would ultimately paint the planet white with clouds, paradoxically reflecting so much heat back into space that temperatures would plummet, leading to an ice age. Or perhaps the cooling effect of particulate aerosols would cancel out carbon dioxide warming, stabilizing temperatures. How would temperature changes affect ocean circulation? Et cetera, et cetera, in a list that mushroomed along with the new field.

Answering all these questions would require much more, and more precise, climate data. To make their projections credible, modelers would have to show not only that they could simulate the present climate but also that they could reproduce its past. To do that, they would need to know much more about the history of the global atmosphere than anyone had yet attempted to discover. How much information could be wrung from the spotty, mostly two-dimensional historical record? Could new observing systems provide a sufficiently detailed picture of the vertical dimension? How long would it take to accumulate a truly global, three-dimensional climate record? In the following chapters, I trace the evolution of weather and climate data networks since World War II—the sources of the information meteorologists required in order to address these complex questions.

Chapter 7

1. R. Revelle and H. E. Suess, "Carbon Dioxide Exchange Between the Atmosphere and Ocean and the Question of an Increase of Atmospheric CO₂ During the Past Decades," *Tellus* 9, no. 1 (1957): 18–27.
2. Others, including Callendar, had already used the "experiment" metaphor, but Revelle's statement became the best known.
3. John von Neumann, quoted in Nebeker, *Calculating the Weather*, 136; see also Galison, "Computer Simulations and the Trading Zone."
4. Rossby, "The Scientific Basis of Modern Meteorology."
5. A weaker, subtropical jet stream also appears at around 30° latitude, the boundary between the Ferrel cell and the tropical Hadley cell. The jet streams occur in both hemispheres.

6. Sometimes the abbreviation is also said to stand for “global climate model,” but this applies only to long-term integrations.
7. “Proposal for a Project on the Dynamics of the General Circulation,” 1955, reproduced in Smagorinsky, “Early Recollections,” 31–33.
8. J. Gleick, *Chaos: Making a New Science* (Viking, 1987); E. N. Lorenz, “Deterministic Nonperiodic Flow,” *Journal of the Atmospheric Sciences* 20, no. 2 (1963): 130–48; Lorenz, *The Essence of Chaos* (University of Washington Press, 1993).
9. Lorenz, “Deterministic Nonperiodic Flow”; Lorenz, “A Study of the General Circulation and a Possible Theory Suggested By It,” in *Scientific Proceedings of the International Association of Meteorology* (Rome, 1954).
10. Lorenz, “Study of the General Circulation,” 603–04.
11. V. P. Starr, “What Constitutes Our New Outlook on the General Circulation?,” *Journal of the Meteorological Society of Japan* 36, no. 5 (1958), 168–169, sentences re-ordered and emphasis added.
12. Nebeker, *Calculating the Weather*. See also chapter 4.
13. S. Arrhenius, “On the Influence of Carbonic Acid”; Uppenbrink, “Arrhenius and Global Warming.”
14. Callendar, “The Artificial Production of Carbon Dioxide.”
15. S. H. Schneider and R. E. Dickinson, “Climate Modeling,” *Reviews of Geophysics and Space Physics* 12, no. 3 (1974), 456–60. For a more complex version of the model hierarchy, see K. McGuffie and A. Henderson-Sellers, *A Climate Modeling Primer* (Wiley, 2005).
16. S. Manabe and F. Möller, “On the Radiative Equilibrium and Heat Balance of the Atmosphere,” *Monthly Weather Review* 89 (1961): 503–32; S. Manabe and R. F. Strickler, “Thermal Equilibrium of the Atmosphere with a Convective Adjustment,” *Journal of the Atmospheric Sciences* 21 (1964): 361–85; S. Manabe and R. Wetherald, “Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity,” *Journal of the Atmospheric Sciences* 24 (1967): 241–59.
17. McGuffie and Henderson-Sellers, *A Climate Modeling Primer*, chapter 2.
18. M. Ghil and A. W. Robertson, “Solving Problems with GCMs: General Circulation Models and Their Role in the Climate Modeling Hierarchy,” in *General Circulation Model Development: Past, Present, and Future*, ed. D. A. Randall (Academic Press, 2000), 285–326; J. T. Houghton et al., *An Introduction to Simple Climate Models Used in the IPCC Second Assessment Report: IPCC Technical Report* (Intergovernmental Panel on Climate Change, 1997).
19. For a longer discussion, see S. R. Weart, *The Discovery of Global Warming: A Hypertext History of How Scientists Came to (Partly) Understand What People Are Doing to Cause Climate Change* (American Institute of Physics, 2008), www.aip.org.

20. N. A. Phillips, "The General Circulation of the Atmosphere: A Numerical Experiment," *Quarterly Journal of the Royal Meteorological Society* 82, no. 352 (1956): 123–64.
21. J. M. Lewis, "Clarifying the Dynamics of the General Circulation: Phillips's 1956 Experiment," *Bulletin of the American Meteorological Society* 79, no. 1 (1998): 39–60.
22. Phillips, "The General Circulation of the Atmosphere," 123.
23. *Ibid.*, 124, partially paraphrased.
24. These and other questions Phillips raised lead into technical terrain that is beyond the scope of this book, so I will discuss only a few of them, with the goal of imparting the flavor of this work rather than its details. For an excellent semi-technical discussion and assessment, see Lewis, "Clarifying the Dynamics of the General Circulation."
25. Lewis ("Clarifying the Dynamics," 48) notes that, according to Aksel Wiin-Nielsen, Phillips would have had to run his model for a simulated 14 years in order for it to reach equilibrium. Only much later would computer power be sufficient to allow simulations lasting so long.
26. Lewis, "Clarifying the Dynamics," 54.
27. A. Arakawa, "A Personal Perspective on the Early Years of General Circulation Modeling At UCLA," in *General Circulation Model Development*, ed. D. A. Randall (Academic Press, 2000), 10.
28. Smagorinsky, "Early Recollections."
29. J. Smagorinsky, "On the Numerical Integration of the Primitive Equations of Motion for Baroclinic Flow in a Closed Region," *Monthly Weather Review* 86, no. 12 (1958): 457–66.
30. P. N. Edwards, interviews with Syukuro Manabe (American Institute of Physics, 1998) and Richard Wetherald (1995, 1998, unpublished).
31. J. Smagorinsky et al., "Numerical Results from a Nine-Level General Circulation Model of the Atmosphere," *Monthly Weather Review* 93 (1965): 727–68. Manabe and Wetherald, "Thermal Equilibrium of the Atmosphere."
32. Smagorinsky et al., "Numerical Results from a Nine-Level General Circulation Model," 728.
33. S. Shackley, "Epistemic Lifestyles in Climate Change Modeling," in *Changing the Atmosphere: Expert Knowledge and Environmental Governance*, ed. C. A. Miller and P. N. Edwards (MIT Press, 2001); Edwards, interviews.
34. Smagorinsky, "Early Recollections."

35. S. Manabe and K. Bryan, "Climate Calculations with a Combined Ocean-Atmosphere Model," *Journal of the Atmospheric Sciences* 26, no. 4 (1969): 786–89.
36. S. Manabe et al., "A Global Ocean-Atmosphere Climate Model: Part I. The Atmospheric Circulation," *Journal of Physical Oceanography* 5, no. 1 (1975): 3–29.
37. S. Manabe, "The Dependence of Atmospheric Temperature on the Concentration of Carbon Dioxide," in *Global Effects of Environmental Pollution*, ed. S. F. Singer (Reidel, 1970); S. Manabe, "Estimates of Future Change of Climate Due to the Increase of Carbon Dioxide," in *Man's Impact on the Climate*, ed. W. H. Mathews et al. (MIT Press, 1971).
38. Manabe and Bryan, "Climate Calculations with a Combined Ocean-Atmosphere Model."
39. S. Manabe and R. J. Stouffer, "Multiple-Century Response of a Coupled Ocean-Atmosphere Model to an Increase of Atmospheric Carbon Dioxide," *Journal of Climate* 7 (1994): 5–23.
40. "In Memoriam—Yale Mintz, Atmospheric Sciences: Los Angeles," University of California, 1993, www.calisphere.universityofcalifornia.edu.
41. Y. Mintz, "Design of Some Numerical General Circulation Experiments," *Bulletin of the Research Council of Israel* 76 (1958): 67–114.
42. D. R. Johnson and A. Arakawa, "On the Scientific Contributions and Insight of Professor Yale Mintz," *Journal of Climate* 9, no. 12 (1996): 3211–24.
43. A. Arakawa, oral history interview with P. N. Edwards (American Institute of Physics, 1997); Arakawa, "A Personal Perspective on the Early Years of General Circulation Modeling At UCLA," in *General Circulation Model Development: Past, Present, and Future*, ed. D. A. Randall (Academic Press, 2000).
44. C. E. Leith, oral history interview with P. N. Edwards (American Institute of Physics, 1997).
45. C. E. Leith, "Numerical Simulation of the Earth's Atmosphere," in *Methods in Computational Physics*, ed. B. Alder et al. (Academic Press, 1965), 1–28; Leith, oral history interview.
46. Leith, oral history interview.
47. W. M. Washington, oral history interview with P. N. Edwards (American Institute of Physics, 1998).
48. Ibid.
49. This phrase refers to the sigma coordinate system, in which the vertical coordinate is pressure normalized by its value at the surface (as opposed to its value relative to sea level). This system simplifies the model equations compared to using sea-level

pressure or height as the vertical coordinate, making it easier to introduce land surface topography into the models.

50. Kurihara, "Numerical Integration of the Primitive Equations on a Spherical Grid"; R. Sadourny et al., "Integration of the Nondivergent Barotropic Vorticity Equation with an Icosahedral-Hexagonal Grid for the Sphere," *Monthly Weather Review* 96, no. 6 (1968): 351–56.

51. I. Silberman, "Planetary Waves in the Atmosphere," *Journal of the Atmospheric Sciences* 11, no. 1 (1954): 27–34; G. W. Platzman, "The Spectral Form of the Vorticity Equation," *Journal of Meteorology* 17, December (1960): 635–44.

52. Manabe, oral history interview.

53. A. J. Robert, "The Integration of a Spectral Model of the Atmosphere By the Implicit Method," in *Proceedings of the WMO IUGG Symposium on Numerical Weather Prediction in Tokyo, Japan, November 26–December 4, 1968* (Meteorological Society of Japan, 1969), VII-9–VII-24; S. A. Orszag, "Transform Method for the Calculation of Vector-Coupled Sums: Application to the Spectral Form of the Vorticity Equation," *Journal of the Atmospheric Sciences* 27 (1970): 890–95; Orszag, "Fourier Series on Spheres," *Monthly Weather Review* 102, no. 1 (1974): 56–75; E. Eliassen et al., *On a Numerical Method for Integration of the Hydrodynamical Equations with a Spectral Representation of the Horizontal Fields*, Report No. 2, Institut for Teoretisk Meteorologi, Københavns Universitet, 1970; W. Bourke et al., "Global Modeling of Atmospheric Flow By Spectral Methods," in *General Circulation Models of the Atmosphere*, ed. J. Chang (Academic Press, 1977); Bourke, "A Multi-Level Spectral Model. I."

54. E. Eliassen et al., *On a Numerical Method for Integration of the Hydrodynamical Equations with a Spectral Representation of the Horizontal Fields*, Report No. 2, Institut for Teoretisk Meteorologi, Københavns Universitet, Denmark (1970); Orszag, "Transform Method."

55. P. E. Merilees, ed., *Proceedings of the Ninth Stanstead Seminar* (Department of Meteorology, McGill University, 1972).

56. W. Bourke, "History of NWP in Australia—1970 to the Present," in *The Past, Present and Future of Numerical Modeling: The 16th BMRC Modeling Workshop* (Melbourne, 2004), 4, note 1.

57. D. J. Gauntlett and D. R. Hincksman, "A Six-Level Primitive Equation Model Suitable for Extended Operational Prediction in the Southern Hemisphere," *Journal of Applied Meteorology* 10, no. 4 (1971): 613–25.

58. Bourke, "History of NWP in Australia."

59. Bourke et al., "Global Modeling of Atmospheric Flow"; McAvaney et al., "A Global Spectral Model."

60. B. McAvaney, interview with P. N. Edwards, 2001.

61. Ibid.

62. A. Woods, *Medium-Range Weather Prediction: The European Approach* (Springer, 2006), chapter 7.

63. World Climate Research Programme Working Group on Numerical Experimentation, "Atmospheric Model Intercomparison Project" (Lawrence Livermore National Laboratories, Program for Climate Model Diagnosis and Intercomparison: 1999), www-pcmdi.llnl.gov.

64. C. Covey et al., "An Overview of Results from the Coupled Model Intercomparison Project," *Global and Planetary Change* 37, no. 1–2 (2003): 103–33.

65. To make supercomputer power available to academic institutions, the National Science Foundation funded five supercomputer centers in the 1980s. The agency required each center to provide computer time and networking support, free of charge, for any institution that wished to use its facilities. Without this support virtually no academic laboratories could have afforded the most advanced computers. The NSFNET, created for accessing the supercomputer centers, went on to become the backbone of the Internet in the United States. See J. Abbate, *Inventing the Internet* (MIT Press, 1999).

66. W. L. Gates, *AMIP: The Atmospheric Model Intercomparison Project*, Report 7, Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory, 1997.

67. NCAR Supercomputer Services Group, "Supercomputer Services Group—History" (University Corporation for Atmospheric Research, 2004), www.cisl.ucar.edu.

68. In the 1950s and the early 1960s, most computing facilities developed their own software in house. By the mid 1970s, however, computer users in most fields could assume that computer manufacturers and third-party software developers would provide operating systems and packaged software for many basic operations. Supercomputing was an exception to this rule.

69. B. Elzen and D. MacKenzie, "The Social Limits of Speed: The Development and Use of Supercomputers," *IEEE Annals of the History of Computing* 16, no. 1 (1994), 50–51.

70. See e.g. Digital Atmosphere by Weather Graphics Technologies (www.weathergraphics.com), or nCast and eCast by Atmospheric and Environmental Research, Inc. (www.aer.com). In general such desktop or workstation models use data generated by analysis models at major forecast centers such as ECMWF.

71. B. Henson, "What Next for SCD? Buzbee's Thoughts," 1997, www.ucar.edu.

72. US Federal Circuit Court of Appeals, 98–1020, *NEC Corporation and HNSX Supercomputers, Inc. vs. United States and Dept. of Commerce*, 98–1020 (1998).

73. R. A. Anthes, "President's Report for October 1999 UCAR Board of Trustees, Member Representatives and University Relations Committee Meetings" (University Corporation for Atmospheric Research, 1999), www.ucar.edu.

74. See e.g. NCAR Scientific Computing Division Digital Information Group, "History of Supercomputing at the National Center for Atmospheric Research" (University Corporation for Atmospheric Research, 2002), www.cisl.ucar.edu.

75. A computer "word" is made up of a number of "bytes." Historically, one byte represented one character (a number, letter, punctuation mark, etc.). Bytes have ranged in length from five to twelve bits, depending on the size of the character set to be represented. Typical personal computers today use a word length of 32 or 64 bits, corresponding respectively to four or eight eight-bit bytes.

76. D. MacKenzie, "Negotiating Arithmetic, Constructing Proof: The Sociology of Mathematics and Information Technology," *Social Studies of Science* 23, no. 1 (1993): 37–65. See also Collins, *Artificial Experts*.

77. D. Price, "Pentium FDIV Flaw: Lessons Learned," *IEEE Micro* 15, no. 2 (1995): 86–88.

78. D. L. Williamson and W. M. Washington, "On the Importance of Precision for Short-Range Forecasting and Climate Simulation," *Journal of Applied Meteorology* 12, no. 8 (1973): 1254–58.

79. The other major focus of modeling efforts was cumulus convection, the process responsible for the well-defined, puffy clouds such as thunderheads. In a tacit division of labor, Manabe's group at GFDL focused on radiative transfer, while Arakawa's group at UCLA specialized in understanding and parameterizing cumulus convection. See A. Arakawa and W. H. Schubert, "Interaction of a Cumulus Cloud Ensemble with the Large-Scale Environment, Part I," *Journal of the Atmospheric Sciences* 31 (1974): 674–701; S. J. Lord and A. Arakawa, "Interaction of a Cumulus Cloud Ensemble with the Large-Scale Environment. Part II," *Journal of the Atmospheric Sciences* 37 (1980): 2677–92; Arakawa, "A Personal History"; Arakawa, "The Cumulus Parameterization Problem: Past, Present, and Future," *Journal of Climate* 17, no. 13 (2004): 2493–525. I will not discuss this further, except to note that the problem of cumulus convection remains a major area of climate modeling research.

80. Callendar, "Can Carbon Dioxide Influence Climate?"; Callendar, "On the Amount of Carbon Dioxide in the Atmosphere"; Callendar, "Temperature Fluctuations and Trends Over the Earth." For a full account, see Fleming, *The Callendar Effect*.

81. G. N. Plass, "Effect of Carbon Dioxide Variations on Climate," *American Journal of Physics* 24 (1956): 376; Plass, "The Carbon Dioxide Theory of Climate Change," *Tellus* 8, no. 2 (1956): 140–54; Plass, "The Influence of the 15 μ Carbon-Dioxide Band

on the Atmospheric Infrared Cooling Rate," *Quarterly Journal of the Royal Meteorological Society* 82, no. 353 (1956): 310–24.

82. Plass, "Effect of Carbon Dioxide Variations on Climate," 141–42.

83. Revelle and Suess, "Carbon Dioxide Exchange."

84. Manabe, oral history interview, edited for readability and emphasis added.

85. F. Möller, "On the Influence of Changes in the CO₂ Concentration in Air on the Radiation Balance of the Earth's Surface and on the Climate," *Journal of Geophysical Research* 68 (1963): 3877–86.

86. Manabe and Möller, "On the Radiative Equilibrium and Heat Balance of the Atmosphere"; Manabe and Strickler, "Thermal Equilibrium of the Atmosphere"; S. Manabe et al., "Simulated Climatology of General Circulation with a Hydrologic Cycle," *Monthly Weather Review* 93, no. December (1965): 769–98; Manabe and R. Wetherald, "Thermal Equilibrium of the Atmosphere."

87. Manabe, "Estimates of Future Change."

88. S. Manabe and R. T. Wetherald, "The Effects of Doubling the CO₂ Concentration on the Climate of a General Circulation Model," *Journal of Atmospheric Sciences* 32, no. 1 (1975): 3–15.

89. S. H. Schneider, "On the Carbon Dioxide–Climate Confusion," *Journal of the Atmospheric Sciences* 32, no. 11 (1975): 2060–66.

90. Kuhn, *The Structure of Scientific Revolutions*.

91. Smagorinsky et al., "Numerical Results from a Nine-Level General Circulation Model."

I will, in what follows, try to maintain the position that there is nothing wrong with viewing man as an information processor (or indeed as anything else) nor with attempting to understand him from that perspective, providing, however, that we never act as though any single perspective can comprehend the whole man. See-ing man as an information-processing system does not in itself de-humanize him, and may very well contribute to his humanity in that it may lead him to a deeper understanding of one specific aspect of his human nature. It could, for example, be enormously important for man's understanding his spirituality to know the limits of the explanatory power of an information-processing theory of man. In order for us to know those limits, the theory would, of course, have to be worked out in considerable detail.

Before we discuss what an information-processing theory of man might look like, I must say more about theories and especially about their relation to models. A theory is first of all a text, hence a concatenation of the symbols of some alphabet. But it is a symbolic construction in a deeper sense as well; the very terms that a theory employs are symbols which, to paraphrase Abraham Kaplan, grope for their denotation in the real world or else cease to be symbolic.³ The words "grope for" are Kaplan's, and are a happy choice—for to say that symbols "find" their denotation in the real world would deny, or at least obscure, the fact that the symbolic terms of a theory can never be finally grounded in reality.

Definitions that define words in terms of other words leave those other words to be defined. In science generally, symbols are often defined in terms of operations. In physics, for example, mass is, informally speaking, that property of an object which determines its motion during collision with other objects. (If two objects moving at identical velocities come to rest when brought into head-on collision, it is said that they have the same mass.) This definition of mass permits us to design experiments involving certain operations whose outcomes "measure" the mass of objects. Momentum is defined as the product of the mass of an object and its velocity (mv), acceleration as the rate of change of velocity with time ($a = dv/dt$), and finally force as the product of mass and acceleration ($f = ma$). In a way it is wrong to say that force is "defined" by the equation $f = ma$. A more suitable definition given in some physics texts is that force is any influence capable of producing a change in the motion of a body.⁴ The difference between the two senses of "definition" alluded to here illustrates that so-called operational definitions of a theory's terms provide a basis for the design of experiments and the discovery of general laws, but that these laws may then serve as implicit definitions of the terms occurring in them. These and still other problematic aspects of definition imply that all theoretic terms, hence all theories, must always be characterized by a certain openness. No term of a theory can ever be fully and finally understood. Indeed, to once more paraphrase Kaplan, it may not be possible to fix the content of a single concept or term in a sufficiently rich theory (about, say, human cognition) without assessing the truth of the whole theory.⁵ This fact is of the greatest importance for any assessment of computer models of complex phenomena.

A theory is, of course, not merely any grammatically correct text that uses a set of terms somehow symbolically related to reality. It is a systematic aggregate of statements of laws. Its content, its very value as theory, lies at least as much in the structure of the interconnections that relate its laws to one another, as in the laws themselves. (Students sometimes prepare themselves for examinations in physics by memorizing lists of equations. They may well pass their examinations with the aid of such feats of memory, but it can hardly

be said that they know physics, that, in other words, they command a theory.) A theory, at least a good one, is thus not merely a kind of data bank in which one can "look up" what would happen under such and such conditions. It is rather more like a map (an analogy Kaplan also makes) of a partially explored territory. Its function is often heuristic, that is, to guide the explorer in further discovery. The way theories make a difference in the world is thus not that they answer questions, but that they guide and stimulate intelligent search. And (again) there is no single "correct" map of a territory. An aerial photograph of an area serves a different heuristic function, say, for a land-use planner, than does a demographic map of the same area. One use of a theory, then, is that it prepares the conceptual categories within which the theoretician and the practitioner will ask his questions and design his experiments.*

Ordinarily, of course, when we speak of putting a theory to work, we mean drawing some consequences from it. And by that, in turn, we mean postulating some set of circumstances that involves some terms of the theory, and then asking what the theory says those particular circumstances imply for others of the theory's terms. We may describe the state of the economy of a specific country to an economist, for example, by giving him a set of the sorts of economic indices his particular economic theory accommodates. He may ask us some questions which, he would say, emerge directly from his theory. Such questions, by the way, might give us more insight into whether he is, say, a Marxist or a Keynesian economist than any answers he might ultimately give us, for they would reveal the structure of his theory, the network of connections between the eco-

* It must not be thought that this heuristic function of theory is manifest only in science. To name but one of the possible examples outside the sciences, Steven Marcus, the American literary critic, used theories of literary criticism freshly honed on the stone of psychoanalytic theory to do an essentially anthropological study of that "foreign, distinct, and exotic" subculture that was the sexual subculture of Victorian England. See his *The Other Victorians* (New York: Basic Books, 1966). More recently he wrote in the preface of his *Engels, Manchester, and the Working Class* (New York: Random House, 1974), "The present work may be regarded as part of a continuing experiment . . . to ascertain how far literary criticism can help us to understand history and society; to see how far the intellectual discipline that begins with the work of close textual analysis can help us understand certain social, historical, or theoretical documents." In neither book was a theory of literary criticism "applied," as, for example, a chemical theory may be applied to the chemical analysis of a compound; instead, Marcus' theories were used heuristically, as travelers use maps to explore a strange territory.

nomic laws in which he believes. Finally, we expect to be told what his theory says, e.g., that the country will do well, or that there will be a depression. More technically speaking, we may say that to put a theory to work means to assign specific values, by no means always numerical, to some of its parameters (that is, to the entities its terms signify), and then to methodically determine what values the theory assigns to other of its parameters. Often, of course, we arrive at the specifications to which we wish to apply a theory by interrogating or measuring some aspect of the real world. The input, so to speak, to a political theory may, for example, have been derived from public-opinion polls. At other times our specifications may be entirely hypothetical, as, for example, when we ask of physics what effect a long journey near the speed of light would have on the timekeeping property of a clock. In any case, we identify certain terms of the theory with what we understand them to denote, associate specifications with them, and, in effect, ask the theory to figure out the consequences.

Of course, a theory cannot "figure out" anything. It is, after all, merely a text. But we can very often build a model on the basis of a theory. And there are models which can, in an entirely nontrivial sense, figure things out. Here I am not referring to static scale models, like those made by architects to show clients what their finished buildings will look like. Nor do I mean even the scale models of wings that aerodynamicists subject to tests in wind tunnels; these are again static. However, the system consisting of both such a wing and the wind tunnel in which it is flown is a model of the kind I have in mind. Its crucial property is that it is itself capable of behaving in a way similar to the behaving system it represents, that is, a real airfoil moving in a real airmass. The behavior of the wing in the wind tunnel is presumably determined by the same aerodynamic laws as govern the behavior of the wings of real airplanes in flight. The aerodynamicist therefore hopes to learn something about a full-scale wing by studying its reduced-scale model.

The connection between a model and a theory is that a model *satisfies* a theory; that is, a model obeys those laws of behavior that a corresponding theory explicitly states or which may be derived from it. We may say, given a theory of a system *B*, that *A* is a

model of *B* if that theory of *B* is a theory of *A* as well. We accept the condition also mentioned by Kaplan that there must be no causal connection between the model and the thing modelled; for if a model is to be used as an explanatory tool, then we must always be sure that any lessons we learn about a modeled entity by studying its model would still be valid if the model were removed.

People do, of course, derive consequences from theories without building explicit models like, say, scaled-down wings in wind tunnels. But that is not to say that they derive such consequences without building models at all. When a psychiatrist applies psychoanalytic theory to data supplied to him by his patient, he is, so to speak, exercising a mental model, perhaps a very intuitive one, of his patient, a model cast in psychoanalytic terms. To state it one way, the analyst finds the study of his mental model (*A*) of his patient (*B*) useful for understanding his patient (*B*). To state it another way, the analyst believes that psychoanalytic theory applies to his patient and therefore constructs a model of him in psychoanalytic terms, a model to which, of course, psychoanalytic theory also applies. He then transforms (translates is perhaps a better word) inferences derived from working with the model into inferences about the patient. (It has to be added, lest there be a misunderstanding, that however much the practicing psychoanalyst is committed to psychoanalytic theory and however much his attitudes are shaped by it, psychoanalytic therapy consists in only small part of direct or formal application of theory. Nevertheless, it is plausible that all of us make all our inferences about reality from mental models whose structures, and to a large extent whose contents as well, are strongly determined by our explicitly and implicitly held theories of the world.)

Computers make possible an entirely new relationship between theories and models. I have already said that theories are texts. Texts are written in a language. Computer languages are languages too, and theories may be written in them. Indeed, for the present purpose we need not restrict our attention to machine languages or even to the kinds of "higher-level" languages we have discussed. We may include all languages, specifically also natural languages, that computers may be able to interpret. The point is

precisely that computers do *interpret* texts given to them, in other words, that texts determine computers' behavior. Theories written in the form of computer programs are ordinary theories as seen from one point of view. A physicist may, for example, communicate his theory of the pendulum either as a set of mathematical equations or as a computer program. In either case he will have to identify the terms of his theory—his “variables,” in technical jargon—with whatever they are to correspond to in reality. (He may say l is the length of the pendulum's string, p its period of oscillation, g the acceleration due to gravity, and so on.) But the computer program has the advantage not only that it may be understood by anyone suitably trained in its language, just as a mathematical formulation can be readily understood by a physicist, but that it may also be run on a computer. Were it to be run with suitable assignments of values to its terms, the computer would *simulate* an actual pendulum. And inferences could be drawn from that simulation, and could be directly translated into inferences applicable to real pendulums. A theory written in the form of a computer program is thus both a theory and, when placed on a computer and run, a model to which the theory applies. Newell and Simon say about their information-processing theory of human problemsolving, “the theory performs the tasks it explains.”⁶ Strictly speaking, a theory cannot “perform” anything. But a model can, and therein lies the sense of their statement. We shall, however, have to return to the troublesome question of what the performance of a task can and cannot explain.

In order to aid our intuition about what it means for a computer model to “behave,” let us briefly examine an exceedingly simple model: We know from physics, and indeed it follows from the equation $f = ma$ that we mentioned earlier, that the distance d an object will fall in a time t is given by

$$d = at^2/2,$$

where a is the acceleration due to gravity. In most elementary physics texts, a is simply asserted to be the earth's gravitational constant, namely, 32 ft/sec^2 , where the unit of distance is feet and that of time is seconds. The equation itself is a simple mathematical model of a

falling object. If we assume, for the sake of simplicity, that the acceleration a is indeed constant, namely, 32 ft/sec², we can compute how far an object will have fallen after, say, 4 seconds: $4 \times 4 = 16$ and $16 \times 32 = 512$ and $512 \div 2 = 256$. The answer, as schoolchildren would say, is therefore 256 feet.

Mathematicians long ago fell into the habit of writing the so-called variables that appear in their equations as single letters. Perhaps they did this to guard against writer's cramp or to save chalk. Whatever their reasons, their notation is somewhat less than maximally mnemonic. Because computer programs are often intended to be read and understood by people, as well as to be executed by computers, and since computers are, within limits, indifferent to the lengths of the symbol strings they manipulate, computer programmers often use whole words to denote the variables that appear in their programs. Other considerations make it inconvenient to use juxtaposition of variables, as in xy , to indicate multiplication. Instead the symbol "*" is used in many programming languages. Similarly, "**" is used to indicate exponentiation. Thus, where the mathematician writes t^2 , the programmer writes $t**2$. The equation

$$d = at^2/2$$

when transformed into a program statement* may thus appear as

$$\text{distance} = (\text{acceleration} * \text{time} **2)/2.$$

Let us now complicate our example just a little. Suppose an object is to be dropped from a stationary platform, say, a helicopter

* A significant technical point must be made here. Although the "statement" shown here is a transliteration of the equation to which it corresponds, it is not itself an equation. In technical parlance, it is an "assignment statement." It assigns a value to the variable "distance." "Distance," in turn, is technically an "identifier," the name of a storage location in which is stored the value which has been assigned to the corresponding variable. In mathematics, a variable is an entity whose value is not known, but which has a definite value nonetheless, a value that can be discovered by solving the equation. In programs, a variable may have different values at different stages of the execution of the program. In ordinary mathematics, e.g., in high-school algebra, the "equation" " $x = x + 1$ " is nonsense. The same string of symbols appearing as an expression in a program has meaning, namely, that 1 is to be added to the contents of the location denoted by "x" and those contents replaced by the resulting sum.

hovering at some altitude above the ground. The object's height above the ground after it has fallen for some time would then be given by

$$\text{height} = \text{altitude} - (\text{acceleration} * \text{time} ** 2) / 2.$$

Finally, suppose that the helicopter is flying forward at some constant velocity while maintaining its altitude. If there were no aerodynamic effects on the object dropped from the helicopter, it would remain exactly below the helicopter during its entire journey to the ground. The object's horizontal displacement from the point over which it was dropped would therefore be the same as the helicopter's horizontal displacement from that point, that is,

$$\text{displacement} = \text{velocity} * \text{time},$$

where by "velocity" we here, of course, mean the helicopter's velocity.

We now have, from one point of view, two equations, from another point of view, two program statements, from which we can compute the horizontal and vertical coordinates of an object dropped from a moving helicopter. We can combine them and imbed them in a small fragment of a computer program, as follows:

```
FOR time = 0 STEP .001 UNTIL height = 0 DO;  
    height = altitude - (acceleration * time**2) / 2 ;  
    displacement = velocity * time ;  
    display (height, displacement) ;  
END.
```

This is an example of a so-called *iteration statement*. It tells the computer to do a certain thing until some condition is achieved. In this case, it tells the computer to first set the variable "time" to zero, then to compute the height and displacement of what we would interpret to be the falling object, then to display the coordinates so computed—I shall say more about displaying in a moment—and, if the computed height is not zero, to add .001 to the variable "time"

and do the whole thing again, that is, to iterate the process. (This program contains an error which, for the sake of simplicity, I have let stand. As it is, it may run forever. To repair it, the expression "height = 0" should be replaced by "height < 0." The reason for this is left to the reader to discover.)

We have assumed here that the computer on which this program is to run has a built-in display apparatus and the corresponding display instruction. We may imagine the computer's display to be a cathode-ray tube like that of an ordinary television set. The display instruction delivers two numbers to this device, in this example, the values of height and displacement. The display causes a point of light to appear on its screen at the place whose coordinates are determined by these two numbers, i.e., so many inches up and so many inches to the right of some fixed point of origin.

If we now make some additional assumptions about for example, the persistence of the lighted dot on the screen and the overall timing of the whole affair, we can imagine that the moving dot we see will appear to us like a film of the object falling from the helicopter (see Figure 5.1). It is thus possible, even compelling, to think of the computer "behaving," and for us to interpret its behavior as modeling that of the falling object.

It would be very easy for us to complicate our example step by step, first, for example, by extending it to cover the trajectory of a missile fired from a gun and, with that as a base, to extend it to the flight of orbiting satellites. We would then have described at least

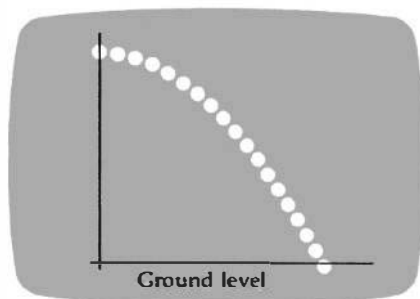


Figure 5.1.
Cathode simulation of the
trajectory of an object
dropped from a flying
helicopter.

the most fundamental basis on which the orbital simulations we often see on television are developed. But that is not my purpose. Simple as our example is, we can learn pertinent lessons from it.

To actually use the model, an investigator would initialize it by assigning values to the parameters altitude and velocity, run it on an appropriate computer, and observe its behavior on the computer's display device. There would, however, be discrepancies between what the model, so to speak, says a falling object would do and the behavior of its real counterpart. The model, for example, makes the implicit assumption that there are no aerodynamic effects on the falling object. But we know that there would certainly be air resistance in the real situation. Indeed, if the object dropped were a parachute, its passenger's life would depend on air resistance slowing its fall. A model is always a simplification, a kind of idealization of what it is intended to model.

The aim of a model is, of course, precisely not to reproduce reality in all its complexity. It is rather to capture in a vivid, often formal, way what is essential to understanding some aspect of its structure or behavior. The word "essential" as used in the above sentence is enormously significant, not to say problematical. It implies, first of all, purpose. In our example, we seek to understand how the object falls, and not, say, how it reflects sunlight in its descent or how deep a hole it would dig on impact if dropped from such and such a height. Were we interested in the latter, we would have to concern ourselves with the object's weight, its terminal velocity, and so on. We select, for inclusion in our model, those features of reality that we consider to be essential to our purpose. In complex situations like, say, modeling the growth, decay, and possible regeneration of a city, the very act of choosing what is essential and what is not must be at least in part an act of judgment, often political and cultural judgment. And that act must then necessarily be based on the modeler's intuitive mental model. Testing a model may reveal that something essential was left out of it. But again, judgment must be exercised to decide what the something might be, and whether it is "essential" for the purpose the model is intended to serve. The ultimate criteria, being based on intentions and pur-

poses as they must be, are finally determined by the individual, that is, human, modeler.

The problem associated with the question of what is and what is not “essential” cuts the other way as well. A model is, after all, a different object from what it models. It therefore has properties not shared by its counterpart. The explorers we mentioned earlier may have built a functional model of the computer they found by using light-carrying fibers and light valves, whereas the real computer used wires and the kind of electronic gates we considered in Chapter III. They could then easily have come to believe that light is essential to the operation of computers. Their computer science might have included large elements of physical optics, and so on. It is indeed possible to build computers using light-carrying fibers, etc. Their logical diagrams, that is, their paper designs, would, up to a point, be indistinguishable from those of the corresponding electronic computers, because the former would have the same structure as the latter. What is essential about a computer is the organization of its components and not, again up to a point, precisely what those components are made of. Another example: there are people who believe it possible to build a computer model of the human brain on the neurological level. Such a model would, of course, be in principle describable in strictly mathematical terms. This might lead some people to believe that the language our nervous system uses must be the language of our mathematics. Such a belief would be an error of the kind we mean. John von Neumann, the great computer pioneer, touched briefly on this point himself:

“When we talk mathematics, we may be discussing a *secondary* language, built on the *primary* language truly used by the central nervous system. Thus the outward forms of *our* mathematics are not absolutely relevant from the point of view of evaluating what the mathematical or logical language *truly* used by the central nervous system is.”⁷

One function of a model is to test theories at their extreme limits. I have already mentioned that computers can generate films that model the behavior of a particle at extreme limits of relativistic

velocities. Our own simple model of falling objects could be used in its present form to simulate, hence to calculate, the fall of an object from a spaceship flying near the surface of the moon. All we would have to do is to initialize acceleration to the number appropriate for the gravity existing on the moon's surface (providing, of course, that the spaceship is not so high above the surface of the moon that the effect of the moon's gravitational field would have been significantly changed—another implicit assumption). For that simulation exercise we would not have to have any components in our model corresponding to air resistance or other aerodynamic effects: the moon has no atmosphere. (Recall that an astronaut simultaneously dropped a feather and a hammer onto the moon's surface and that they both reached the ground at the same time.)

It is a fact, however, that the moon's gravitational field varies from place to place. These variations are thought to be due to so-called masscons, that is, concentrations of mass within the moon that act somewhat like huge magnets irregularly buried deep within the moon. The masscon hypothesis was advanced to account for observed irregularities in the trajectories of spacecraft orbiting the moon. It is, in effect, an elaboration of the falling-body model we have discussed. The elaborated model is the result of substituting a complex mathematical function (in other words, a subroutine) for the single term "acceleration" of our simple model. I mention it to illustrate the process, in this case properly applied, of elaborating a model to account for new and unanticipated observations. But the masscon elaboration was not the only possible extension of either the theory or its computer model. It could have been hypothesized, for example, that the moon is surrounded by a turbulent ether mantle whose waves and eddies caused the spaceship's irregular behavior. There are dozens of very good reasons for rejecting this hypothesis, of course, but a good programmer, given a lot of data, could more or less easily elaborate the model with which we started by adding "ether turbulence subroutines" so that, in the end, the model behaved just as the spaceship was observed to behave. Such a model would, of course, no longer look simple. Indeed, its very complexity, plus the precision to which it carried its calculations, might lend it a certain credibility.

Earlier I said that the value of a theory lies not so much in the aggregation of the laws it states as in the structure that interconnects them. The trouble with the kind of model elaboration that would result from such an "ether turbulence" hypothesis is that it simply patches one more "explanation" onto an already existing structure. It is a patch in that it has no roots in anything already present in the structure. Computer models have, as we have seen, some advantages over theories stated in natural language. But the latter have the advantage that patching is hard to conceal. If a theory written in natural language is, in fact, a set of patches and patches on patches, its lack of structure will be evident in its very composition. Although a computer program similarly constructed may reveal its impoverished structure to a trained reader, this kind of fault cannot be so easily seen in the program's performance. A program's performance, therefore, does not alone constitute an adequate validation of it as theory.

I have already alluded to the heuristic function of theories. Since models in computer-program form are also theories (at least, some programs deserve to be so thought of), what I have said about theories in general also applies to them, perhaps even more strongly, in this sense: in order for us to draw consequences from discursive theories, even to determine their coherence and consistency, they must, as I have said, be modeled anyway, that is, be modeled in the mind. The very eloquence of their statements, especially in the eyes of their authors, may give them a persuasive power they hardly deserve. Besides, much time may elapse between the formulation of a theory and its testing in the minds of men. Computer programs tend to reveal their errors, especially their lack of consistency, quickly and sharply. And, in skilled hands, computer modeling provides a quick feedback that can have a truly therapeutic effect precisely because of its immediacy. Computer modeling is thus somewhat like Polaroid photography: it is hard to maintain the belief that one has taken a great photograph when the counterexample is in one's hands. As Patrick Suppes remarked,

The attempt to characterize exactly models of an empirical theory almost inevitably yields a more precise and clearer understand-

ing of the exact character of a theory. The emptiness and shallowness of many classical theories in the social sciences is well brought out by the attempt to formulate in any exact fashion what constitutes a model of the theory. The kind of theory which mainly consists of insightful remarks and heuristic slogans will not be amenable to this treatment. The effort to make it exact will at the same time reveal the weakness of the theory.”⁸

The question is, of course, just what kinds of theories are “amenable to this treatment?”

Lines of Sight: On the Visualization of Unknown Futures

Louise Amoore

Department of Geography

University of Durham

South Road

Durham DH1 3LE

UK

louise.amoore@durham.ac.uk

tel: 00 (+44) 0191 334 1969

fax: 00 (+44) 0191 334 1801

Abstract

The article considers the specific mode of visualization that is at work in contemporary border security practices. Taking inspiration from art historian Jonathan Crary's genealogies of attention, it situates homeland security visuality in a particular economy of attention or attentiveness to the world. How is it that we come to focus on some elements of our way of life, establish them as normal and designate deviations from the norm? How does this algorithmic attentiveness break up the visual field, 'pixelating' sensory data so that it can be reintegrated to project a picture of a person? The pre-emptive lines of sight emerging in contemporary security practice, like the heroine in Richard Flanagan's novel *The Unknown Terrorist*, become precisely a means of visualizing the unknown future. The article concludes with reflections on the creative artistic forms of attention that flourish even where the lines of sight of the consumer, the citizen, the border guard, the traveller, the migrant appears ever more directed and delimited. It is in these more creative modes of attention that we find one of the most important resources to contemporary political life – the capacity to question the 'better picture', to disrupt what we see as ordinary or out of the ordinary and confront the routines of our lives anew.

Lines of Sight: On the Visualization of Unknown Futures¹

We use this data to *focus on* behavior, not race and ethnicity. In fact, what it allows us to do is move beyond crude profiling based on prejudice, and *look at* conduct and communication and actual behavior as a way of determining who we need to take a *closer look at*. (US Secretary for Homeland Security Michael Chertoff 2007, *emphasis added*).

“The thing about raster graphics”, Tariq was saying, “is that you can precisely manipulate an image by altering a single dot at a time [...] What they’d like to do with real people if they could. I work on bitmaps to make better pictures. That’s raster graphics [...]”

She remembered what Tariq had said to her – how it was what they would like to do with real people if they could. But Tariq only changed images, dot by dot [...] They were doing something far bolder: turning her from a woman into cartoons, headlines, opinions, fears, fate. They were morphing her pixel by pixel into what she wasn’t, the unknown terrorist. (Richard Flanigan, *The Unknown Terrorist* 2006: 76, 260).

Introduction: Making better pictures

Following the conviction and sentencing of the British ‘fertilizer bombers’ in May 2007, the US Secretary for Homeland Security, Michael Chertoff, spoke publicly about the need to create better pictures of unknown terrorists in advance of their arrival on US shores. In his lecture at Johns Hopkins University, Chertoff placed his emphasis on how to decide what to *focus on*, who to *look at*, which suspicious behaviour is deserving of *attention*. The significance of his comments far exceeds the specific context of airline passenger data that he is addressing here,² embodying a novel and politically significant move in the very visuality of the war on terror. What do these data represent that they can be assumed to so nearly capture a picture of someone who has not yet been seen, who would not otherwise be recognised? If

Chertoff is correct and these pixelated people are not seen through racial or other categorises that are prejudicial, then what are the implications of living with a digital alter ego that, with the contemporary faith in techno-science, cannot be spurned?

The short answer is that the individuated items of data that have become the mainstay of the homefront of the war on terror appear as the ‘dots’ that, if only they can be successfully joined up, are assumed to reveal a picture of an unknown terrorist. Most often derived from the residue of daily life left in the patterns of travel, financial and consumer transactions (Amoore and de Goede 2005; 2008), these abstracted items of data become the nodal points that, when joined in association with other items, are assumed to become an indisputable visualization of a person. It is not strictly, then, a picture or a snapshot of a person that is taken – an image from a specific and limited temporal standpoint – rather, it is a projected line of sight that seeks to capture the “unknown unknowns”.³ As in Richard Flanigan’s startlingly observant novel, *The Unknown Terrorist*, just as the contemporary consumer is targeted via simulated or projected images of her dreams and desires, so the citizen who becomes terrorist suspect finds her real self eclipsed by the projected picture of a dangerous and disturbed body, “morphing pixel by pixel”, “becoming what she was not”. Like the screened visualizations of migrants and travellers that allow the “border guard to become the last and not the first line of defence”, or the London Underground pedestrian surveillance systems that “mean you don’t have to watch the screen all the time”, how we see, who we see, to what we give our attention, takes on renewed significance (Department of Homeland Security 2004; New Scientist 2003).

As decisions based on human lines of sight are integrated with computer encoded visualizations, authorities begin to claim that the calculated projections of a person could never be racialized or otherwise violent or prejudicial, and are no longer a matter of profiling. In fact, Chertoff’s claims for the data visualizations of an air passenger were made in the context of a stark choice he presented between denying British citizens “of Pakistani origin” the right to visa waiver – categorizing British citizenship into degrees of risk, singling out those “potentially dangerous people” to whom “we should pay greater attention”, – and the acceptance of a system of data mining that already identifies past travel to Pakistan and specific name algorithms, among many other associations, as “dangerous” (Chertoff 2007b). The choice here,

of course, is no choice at all, for the algorithmic calculation of who should be looked at more closely simply redraws the lines between those with entitlement (to visa, to cross a border, to be in a public place without disclosure of purpose) and those without. In short, the visa waiver effectively already is withdrawn from many British citizens by other means – via a picture “based on behaviour not background” (Chertoff 2007b).

The deployment in the war on terror of ways of life, broadly defined – conduct, behaviour, social custom, movement across a railway platform or airport terminal – is, in many ways, nothing new or significant. Recall in the aftermath of 9/11 how the routines of daily life were called up as a source of resilience. “We were told to shop”, says Susan Willis, “shop to show we are patriotic Americans. Shop to show our resilience over death and destruction” (2003: 122). The London bombings on July 7 met with similar celebrations of the “vibrant and resilient city, getting back to normal, going back to work, getting back on the Tube”. Yet, there is a need to be cautious with the treatment of culture in the practices of homeland security. Culture, Derek Gregory explains “is never a mere mirror of the world”, we can never simply hold up the looking glass of culture to shed new light on contemporary economy or society. Rather, “culture involves the production, circulation and legitimation of meanings through representations, practices and performances that enter fully into the constitution of the world” (2004: 11). In the specific and situated circumstances I am interested in here, culture embodies and advances an economy – a means of apportioning, segregating, singling out for our collective attentions. How do ways of life come to be known and recognised as such? How is a ‘normal’ way of life settled out, and how does it identify deviations from norm? What does the call to attentiveness to ‘conduct’ or ‘behaviour’ ask us to pay attention to? How do we know what it is that we should pay attention to? As in contemporary profiling of consumers in the marketplace – where the as-yet-unencountered unknown consumer is the holy grail sought via fragments of data on their conduct and behaviour – so in today’s homeland security practice, the unknown terrorist is rendered knowable through the fractured bits and bytes of a way of life.

In this article, I consider this economy of attention or attentiveness to the world, how it is that we come to focus on some elements of our way of life, establish them as

normal and designate deviations from the norm. How does this attentiveness break up the visual field, ‘pixelating’ sensory data so that it can be reintegrated to build a picture of a person? Throughout, I am inspired by the work of art historian Jonathan Crary, whose careful and detailed genealogies of attention and its role in human subjectivity have urged us to consider that modern sensory stimuli are not primarily about making a subject *see*, but about “strategies of isolation and separation” (1999: 3). Understood in this way, lines of sight are not only about the vigilant modes of visual culture I have discussed elsewhere (Amoore 2007), but they are also lines that segregate and divide, “dividing practices” that render ways of life economic, make them amenable to management, trading, or exchange.

I begin by thinking through what it means to ‘pay attention’ in the context of calculable lines of sight that coalesce commercial and security practices. I then move to consider how individuated ‘dots’ of data become reintegrated into the visualization of a person, how it is precisely that the unknown risk comes to be perceived. Throughout, I am interested in how this mode of attentiveness targets, how it draws disparate elements of life into close association in order to designate the ‘norm’ and to project what is abnormal or out of the ordinary. Finally, I conclude by reflecting on the creative forms of attention that flourish even where the attentiveness of the consumer, the citizen, the border guard, the traveller, the migrant appears ever more directed and delimited. It is in these more creative modes of attention that we find one of the most important resources to contemporary political life – the capacity to question the ‘better picture’, to disrupt what we see as ordinary or out of the ordinary and confront the routines of our lives anew.

Because culture has an economy: are you paying attention?

Among the careful plastic-windowed advertising posters on the London Underground – “register for Oystercard and get 10% off in London’s museums and galleries”; enter an art competition and design a future Tube station; download coupons to your mobile phone – the Metropolitan Police Anti-terrorist hotline posters call us to attention: “if you suspect it, report it”; “look out for unusual or suspicious activity”; “use all your senses”; “you are that someone”. In so many ways already part of the prosaic and

unnoticed sensory backdrop to the daily commute, the specific call for attention at the homefront of the war on terror asks us to single out, from the cacophony of background noise in public spaces, that which demands a closer *look*, that which is out of the *ordinary*. How should we understand this mode of attentiveness? Indeed, is it of significance at all? As art historian Jonathan Crary has argued, the significance of attention and attentiveness to the world is not merely cultural, not confined in its implications to the histories of visual culture. Rather, modes of attention and attentiveness are also acutely material – central in modern times to the way that ways of life, culture and cultural difference are made governable. What we see, how we see, what is made visible, how visualization occurs – these are not simply the cultural dimensions of a material life, but instead they are the very essence of an economy of culture. That is to say, practices of attention themselves embody an economy – a means of representing and acting on the world such that it can be apportioned, segregated, annexed, exchanged or interchanged. As Crary writes on attentiveness, it is “not primarily concerned with looking at images but rather with the construction of conditions that individuate, immobilize, and separate subjects, even within a world in which mobility and circulation are ubiquitous” (1999: 74). In this sense, practices of attention are one specific means of instituting the dividing practices at the heart of contemporary techniques of government.⁴

As the contemporary global economy has sought to incorporate practices of attention, perception and affective judgement ever more closely into circuits of production and consumption – promoting touch-button ‘interactivity’, placing the screen in the palm of the hand, engaging playfully with the consumer – so, at the same time the state’s security practices have sought to mobilize culture broadly defined – ways of life, looking out for the out of the ordinary, sifting the patterns of life left in transit or consumer transactions, providing hotlines for people’s reported unease or suspicion. Thus, London Metropolitan police’s ‘if you suspect it’ campaigns offer the transaction receipt as one fragment of a picture of a person that could be built; the mobile phone images and video clips from the 2005 London bombings are translated from “careless cinema” into the data-driven analysis of actionable intelligence (Sinclair 2005); the flotsam residue of our travel bookings on global reservations databases are extradited to the US authorities.⁵ Across these apparently disparate domains there is a resonance in ever more finite targeting of behaviours, conduct, the actions and inferred

intentions of people. Someone as yet unknown is apparently identified and made visible, literally ‘brought to attention’, singled out and immobilized while all around him moves on.

Though the emergence of novel forms of attentiveness stretches across a spectrum of practices – from appeals to citizen ‘readiness’ and states of alert (Isin 2004; Hay and Andrejevic 2006), to the algorithmic calculations made on the screens of counter-terror ‘hotlines’, and the vast screening of prosaic daily transactions for the ever-attentive ‘watch list’ – there are a number of points of resonance that enter all of these different modes of attention.

Contemporary forms of attentiveness are predominantly *screened* ways of perceiving and attending to the world. The interface of the screen – whether windscreen, mobile phone or PDA screen, computer screen, or security ‘pre-screening’ – has become an important site where sovereign decisions (who belongs to the nation, who is dangerous to ‘us’, what the ‘other’ looks like) are made. “The screen”, writes Kaja Silverman, “is the site at which social and historical difference enters the field of vision” (1996: 135). It is not only that the screen becomes the mode of visual communication of difference, though of course this is important. Instead, the screen itself enters into the constitution and performance of difference. So, when the British government rejects the US move to deny visas to Britons of Pakistani ‘origin’, but accepts instead “screening at their end, sharing intelligence with the Americans” and “deporting Britons who failed screening once they arrived at an airport in the US” (New York Times 2007), they defer a decision based on racial categories into a screened calculation based on ever more finite classifications of difference. The computer screen, understood this way, as Anne Friedberg has shown, “is both a ‘page’ and a ‘window’, at once opaque and transparent”. The flat surface of the screen, the ‘page’ that represents the calculation in this instance, is given depth by the layers and leaves of data, the multiple other screens and screenings that may appear transparent to the viewer but remain opaque to the person who is displayed there. The surface of the screen has, then “a deep virtual reach to archives and databases, indexed and accessible with barely the stroke of a finger” (Friedberg 2006: 19).

The screened forms of attention that are dominating contemporary homeland security practice function through a process of 'screening out'. That is to say, they take large quantities of data, multiple sources of stimuli, and they sort and classify that which will appear on the surface. Inside the 34 'surface' items of airline passenger data in passenger name records, for example, are multiple layers of pieces of a persons life, integrated together via pre-screening programmes such as USVISIT, to produce a picture of a person's posed risk to security. It is, of course, only pixelated fragments that enter the visualization, vast quantities of data simultaneously fall out of the calculation, become 'background noise' and are screened out. In many ways this focusing of attention via the annulment of other sensory data is integral to the histories of practices of perception:

Whether it is how we behave in front of the luminous screen of a computer or how we experience a performance in an opera house, how we accomplish certain productive or creative tasks or how we more passively perform routine activities like driving a car or watching television, we are in a dimension of contemporary experience that requires that we effectively cancel out or exclude from consciousness much of our immediate environment (Crary 1999: 1).

For Crary, the way that we have come to focus our attention on particular items, tasks or people cannot be understood without also acknowledging the processes that cancel out or exclude other stimuli. When we attend to one set of sensory data, in order to make it count we necessarily discount other sources. Crary identifies a critical turning point in the mid nineteenth century, when scientific knowledge about how an embodied observer sees and perceives the world "disclosed possible ways that vision was open to procedures of normalization" (1999: 12; see also Crary 1992). It is precisely this normalization within practices of attention that is at work in the visibility of homeland security. When the call is to look for that which is abnormal, out of the ordinary, or when the data on an individual is sorted according to patterns of normality and deviation, most of the detail behind the data is cancelled out. Conduct and behaviour that could, if attended to or seen differently, be an integral part of the 'norm', becomes part of the conduct and behaviour designated deviant from norm and rendered suspicious. Thus, what might be expected to be 'normal'

patterns of travel or financial transactions for a British citizen with family in Pakistan – travel to visit relatives, wire transfers of monetary gifts, telephone calls – will, within the screened attentiveness to passenger data, be designated suspicious. Like Richard Flanagan’s protagonist, ‘the Doll’ in his novel *The Unknown Terrorist*, whose careful earnings from lapdancing are hidden in her apartment – savings to buy a house, to find the security and prosperity that is promised to the prudent citizen – what would be the norm becomes deviant, the cash becomes evidence of “a cell financing its activities through drug running and the sex industry” (2006: 231).

In close association: attending to difference

In the immediate aftermath of 9/11, the homeland face of the war on terror identified an enemy whose probable future actions were already visible in the traces of life left in existing data. Giving evidence at a US Congressional hearing only five months after 9/11, IBM’s federal business manager testified that “in this war, our enemies are hiding in open and available information across a spectrum of databases” (Intelligent Enterprise 2002: 8). Technology consultants and IT providers such as IBM have made the generation of probabilistic association rules the forefront of homeland security practices. The idea is that locating regularities in large and disparate patterns of data can enable associations to be established between apparently ‘suspicious’ people, places, financial transactions, cargo shipments and so on (Ericson 2007). Rules of association are produced by algorithms – models or “decision trees” for a calculation (Quinlan 1986). In effect, algorithms precisely function as a means of directing and disciplining attention, focusing on specific points and cancelling out all other data, appearing to make it possible to translate *probable* associations between people or objects into *actionable* security decisions. In 2003, for example, a US joint inquiry concluded that “on September 11, enough relevant data was resident in existing databases”, so that “had the dots been connected”, the events could have been “exposed and stopped” (2003: 14). It is precisely this ‘connecting of dots’ that is the work of the algorithm. By connecting the dots of probabilistic associations, the algorithm becomes a means of foreseeing or anticipating a course of events yet to take place:

If we learned anything from September 11 2001, it is that we need to be better at *connecting the dots* of terrorist-related information. After September 11, we used credit card and telephone records to identify those linked with the hijackers. But wouldn't it be better to identify such connections before a hijacker boards a plane?

(US Secretary of Homeland Security, Michael Chertoff 2006).

The algorithm appears to make possible the conversion of ex post facto evidence in the war on terror into a judgement made in advance of the event. The significant point here is that diverse data points or specified 'pixels' in a digital image are drawn together in association, producing a recognisable whole. Though the visualized image may bear no resemblance to the actual way of life of the person depicted, this scarcely matters because the digital alter ego becomes the de facto person. As the US Inspector General concluded in his survey of government applications of algorithmic techniques, "association does not imply a direct causal connection", but instead it "uncovers, interprets and displays relationships between persons, places and events" (Department of Homeland Security 2006: 10). It is the specific visualization of threat, then, that marks out the algorithm as a distinctive mode of calculation – to be displayed on the screens of border guards, stored on subway travel cards, shared between multiple public and private agencies. In this sense, the algorithm produces a screened visualization of suspicion, on the basis of which 'other' people are intercepted, detained, stopped and searched.

The origins of algorithmic techniques for visualizing people lie, perhaps not surprisingly, in commercial techniques for imagining the consumer. In the early 1990s IBM mathematicians began to work on using bar code data on consumer purchases to project probabilistic judgements about the ways of life of the customer in a given scenario (cf. Agrawal et al 1993). The point here was not to be able to *predict* future patterns on the basis of past data, indeed the commercial clients categorically did not want predictability or to capture an already predictable customer. Instead, the dream was to visualize the impulse buyer, the capricious lifestyle of the unknown consumer who might be drawn into the targeting of the marketers. Though the uncertainties of future patterns are not treated as strictly knowable, they are seen to be at least amenable to pre-emptive decision making based on the visualized person.

It is precisely this model of pre-emptive visualization of an unknown person that is now running through the logics of homeland security, indeed IBM's same team is now leading the "mathematical sciences role in homeland security" (BMSA 2004), with IBM prominent contractors on Heathrow airport's *MySense* biometrics programme and on the trials for the UK's e-borders *Semaphore* and *Iris* programmes (DHS 2005; Computing 2004: 1). Though programmes of this kind have attracted attention for their surveillant nature, with the implications for privacy and civil liberties this holds, I want to suggest that they are not primarily surveillant modes of seeing. Rather than strictly technologies that 'watch', taking a metaphorical snapshot or photograph in a specific spatio-temporal context, these are techniques of visualization. They project an image and they project it forward in time, displaying their mobility on the ubiquitous screen. As Friedrich Kittler has argued compellingly, projections are produced from fragments of visual data, from individually isolated characteristics that are then selected, differentiated and reintegrated into a visual whole (1997). Of course, gaps persist between the lines that join the pixilated dots. These gaps, though, are filled with mobile and projected images that produce a seamless whole. Describing the illusion of a moving picture that is produced in the cinematic process of projecting still frames, Anne Friedberg suggests "for motion to be reconstituted, its virtual rendition relies on a missing element, a perceptual process that depends on the darkness between the frames" (2006: 92; see also Friedberg 2002). To state my argument simply here, a visualized image of a person requires some gaps and invisibilities, these are simply filled in by the observer. The projected image, then, is extraordinarily difficult to challenge or expose – as Richard Flanigan's 'Doll' discovers, when the fragments of her life are reintegrated to project an unrecognizable whole, "she becomes what she is not".

It is important at this point to emphasise the ambiguity of practices of attention and attentiveness. It is not the case that these are wholly disciplinary practices that act on and through us and our lives. As Crary has argued, though industrialization and the market economy saw "perception function in a way that insures a subject is productive, manageable, and predictable, able to be socially integrated and adaptive", simultaneously the management of attention reached limits characterised by more "creative states of deep absorption and daydreaming" (1999: 4-5). So, whilst the

conduct of commerce and trade required particular attentive habits, it stimulated also the more creative and subjective ways of seeing that flourished in the arts (1999: 52).

Arguably, in terms of attentiveness and the visualization of people, something interesting and politically challenging is also happening at the intersection of these ‘productive’ and ‘creative’ domains of attention. There can be little doubt that projected futures are experienced as both dangers and desires. As media theorist Jordan Crandall has argued:

Being-seen is an ontological necessity; we strive to be accounted for within the dominant representational matrices of our time. We are not only talking about a gaze that is intrusive and controlling. We are talking about a gaze that provides the condition for action – the gaze for which one acts (2005: 20).

Consider, for example, the luxury fashion brand *Prada* and, specifically, the architectures of their New York flagship store. The glass walled building, stretching one block and opening up inside with spaces to walk around, see and be seen, the store replaces displays of visible products with technologies that connect the consumer’s sense of identity to future *Prada* projections of the person. The radio frequency identification (RFID) tags inside the clothing send radio signals to a screen in the fitting rooms, triggering images of the clothing as seen on the catwalk. The glass walls of the dressing room change in phases from transparent to opaque, and large video screens “replace mirrors to show your back and side views live” (Kang and Cuff 2005: 121). The miniaturized sensor technologies embedded in the clothing and in store cards and credit cards provide focal points to be connected together in the visualization of the consumer. As these same RFID technologies are now inserted into passports and immigration documents, providing a route of identification into a visualized person, we see both commercial and security drives to become attentive to the element of surprise, the unpredictable or impulsive act.

In this sense, algorithmic techniques for making visible mobile people, and indeed products, goods and money, embody what Samuel Weber calls a “target of opportunity”, a competitive “seizing” of “targets that were not foreseen or planned”

(2005: 4). The targets of opportunity in the war on terror, then, involve the depiction of unknown and mobile enemies:

However different the war on terror was going to be from traditional wars, with their relatively well-defined enemies, it would still involve one of the basic mechanisms of traditional hunting and combat, in however modified and modernized a form: namely “targeting”. The enemy would have to be *identified* and *localized*, *named* and *depicted*, in order to be made into an accessible target... None of this was, per se, entirely new. What *was*, however, was the mobility, indeterminate structure, and unpredictability of the spatio-temporal *medium* in which such targets had to be sited... In theatres of conflict that had become highly mobile and changeable, “targets” and “opportunity” were linked as never before.

(Weber 2005: 3-4, *emphasis in original*).

Samuel Weber’s key point of discussion is the theatre of war, though his argument sheds significant light on the modes of attentiveness that I depict here. The *identification*, *localization*, *naming* and *depiction* of mobile targets is, in this war by other means, conducted in and through daily life, in advance of any possible future strike or intervention. The targeting of unknown people is, put simply, becoming a matter of both positioning in the sights (targeting and identifying) and visualizing through a projected line of sight (pre-empting, making actionable). Just as *Prada’s* customers are targeted via electronic tag identifiers and visualized via screened future images of their clothing, so the migrant or traveller is both targeted and anticipated – identified via their personal data and projected forward so that their digital shadow arrives at the border before they do. Algorithmic ‘decision trees’ draw even the most overloaded sensory domains into apparent management: the busy and noisy border crossing is stilled on the border guard’s screened list of ‘selectees’ to single out for further attention; the crowded subway ticket hall quietly selects anomalous smartcard data and intercepts at the barrier; the RFID data from a football fan’s swipecard transmits an automatic signal to the local police. From the visualization of a person is derived the possibility to act on that person. “Ideally, I would like to know”, said Michael Chertoff, “did Mohamed Atta get his ticket paid on the same credit card. That

would be a huge thing. And I really would like to know that in advance, because that would allow us to identify an unknown terrorist” (New York Times 2006b).

In fact, of course, the algorithmic ‘decision trees’ do not take decisions at all, they merely defer decision into a calculation that is pre-programmed.⁶ While they appear to visualize a picture of a person that is culturally nuanced – every minute and prosaic “behaviour”, every aspect of a way of life potentially becoming a part of the classification – they actually efface difference in their drive for identification. The logic of association rules appears to be peculiarly dependent on culture, yet it is a representation of culture that attends too (and makes us attentive to) some aspects of sameness and difference, whilst always failing to confront the agonistic difference at the heart of political life (Connolly 1991: 170-171). The claims that visualizations used in place of ‘face-to-face’ pictures avoid racial profiling and other prejudicial judgements cannot be upheld. It is always through the visualization of the identity of the ‘other’ that the sanctity of ‘we the nation’, ‘we the people’ is sustained. As Connolly puts it, the “self reassurance of identity” is made “through the construction and otherness” and this otherness is readily adopted as the “definition of difference” (1991: 9). The algorithmic attentiveness, then, becomes the “multicultural”⁷ society’s technology of choice precisely because it gives the appearance of living alongside difference, of deciding without prejudice – “we are interested in behaviour not background”; “this is not racial profiling”; “we prefer screening to visa restrictions”; “no more border guards taking decisions based on appearance” – when in fact it categorizes, isolates and annexes in ways that conceal the violence inside the glossy wrapper of techno-science.

There is an intensely important political problem here, then. We are faced with a technique of governing that makes humane, responsible or ethical ways of paying attention to the world extraordinarily difficult. Consider, for example, Waverly Cousin, former police officer and one of the 43 000 “screeners” employed by the US Transportation Security Administration to deploy the “screening passengers by observation technique” (SPOT) at airports, ports and border crossings. “The observation of human behaviour is probably the hardest thing to defeat”, explains Waverley, “you just don’t know what I am going to see” (New York Times 2006a). We do not know what he is going to see because the ‘SPOT’ calculation, while it

engages all of the time in the visualization of what Dana Cuff (2003) calls an “object of interest”, is itself always invisible and never an object of interest. Because in algorithmic modes of attention every ordinary everyday act becomes itself a means of settling out the norm and identifying the other that is anomalous, a responsible decision that, in Derrida’s (1994) terms, “advances where it cannot see”, is particularly elusive. What becomes important politically, I want to suggest in my concluding section, is the capacity precisely to intervene in what we do not know in what we see, and to mobilize a different form of attentiveness that is perhaps always already co-present.

Attention in a state of distraction: what the artist saw

I have argued that theories of attention and attentiveness derived from histories of art are capable of revealing something significant about the contemporary economy of homeland security culture: that it is not primarily a way of seeing or surveilling the world, but rather a means of dividing, isolating, annexing in order to visualize what is “unknown”. Yet, it is not only in concepts from the arts, but also in the *practices of artistic intervention* that we find a potentially valuable ethics and responsibility in how we pay attention to ourselves and other people. An “absorbed attentiveness”, writes Crary, is not only a “necessary part of the individual’s functioning within a modern world of economic facts and quantities”, but is always also essential for the “creative exceeding of the limits of individuality” (1999: 53). Because relations of power inextricably contain the possibility of resistance, there could never be a fully efficient attentive subject whose attention to the world is entirely amenable to management. Indeed, as Crary has it, “the more one investigated, the more attention was shown to contain within itself the condition for its own undoing” (1999: 45-6).

Art theory and practice is all too readily overlooked as “merely cultural” by the social sciences, accused of “substituting a trivial form of politics” that focuses on “transient events, practices and objects” in place of a “serious” political economy of transformation (Butler 1998). I want to suggest here that, even for those who wish to pursue what they see as “serious” political economies of transformation – and I consider questions of culture to be among the most serious, – artistic interventions in

theory and practice are best placed to reflect on many aspects of an emergent economy of culture. The embedding of technologies into everyday objects; the visualization of unknown futures; the screened projection of mobile bodies; the economies of the mundane and the surprising in public space: these are not novel ideas to many contemporary artists. Indeed, far from focusing on trivial and transient events, innovative artistic practice engages in a deeply historical process of reflection on perspective, human subjectivity, and cognition. Put simply, the “resonances” (Connolly 2005) that so many of our contemporary philosophers, social theorists and political economists are observing across science, technology, politics and culture, have long been at the heart of leading edge artistic interventions. I will focus here on three areas where I consider artist interventions to open up clear space for questions of ethical and political responsibility in face of technical depoliticization.

Modes of attentiveness in contemporary homeland security practice, as I have argued, are particularly dependent on algorithmic logics that designate anomaly on the basis of a screening of the norm. The cultural practices of the visual arts precisely invert the logic of ‘looking out for the out of the ordinary’ – that which transgresses the norm – in order to identify danger, suggesting instead that the act of being surprised by the extraordinary can make us see the norm anew. Even in quite mainstream installations of temporary artworks in public spaces, there is an emphasis on surprise as a means of seeing daily life differently. In the spaces of the London Underground, for example, Platform for Art has confronted, to a degree, the post 7/7 fear of the unexpected, inviting international artists to install their work on the Piccadilly line stations, platforms and trains. In the *Thin Cities* project, the artist’s installations were produced in “unexpected places on the Tube network”, offering new ways of seeing the daily commute, “revealing new perspectives on London” and “promoting greater understanding” (Platform for Art 2006).

In this sense, artistic interventions have capacity to call the norm into question, reminding us of what we do not pay attention to, creating what Tom Mitchell says “looks like a picture of something we could never see” (2005: 260). This is, argues Crary, “experimental activity” that “involves the creation of unanticipated spaces and environments in which our visual and intellectual habits are challenged and disrupted” (2003: 7). In contrast to an attentiveness that tries to anticipate on the basis of the

fragments that are seen, then, some installation artwork in public space offers us new ways of attending to the very images we had already screened out as normal. American artist Rozalinda Borcila's *Geography Lessons*, for example, seeks to "intervene in apparently controlled spaces" that are "policed through technologies of visualization and information management" (Borcila 2006). Making "counter surveillance" videos of airport security and urban transport systems (and deported from the Netherlands when she video recorded Schipol airport's security), Borcila projects her multiple screen films, rendering extraordinary what has become the ordinary practice of searching, removing shoes, interrogating, detaining (see figure 1).

The question of responsibility in attentive practices of security arises only in terms of the responsibility for vigilance, for paying attention and not becoming distracted. As I have argued, and following Derrida, there is an absence of responsibility in the sense that these forms of attentiveness seek to anticipate, to foresee an unknown future on the basis of an algorithmic calculation. If Derrida is correct, then a responsible decision would have to "advance where it cannot see", confronting the difficulty and undecidability of all decisions, and recognising that calculation cannot substitute for a judgement that may have to be made in the absence of pre-programmed information (1992; see also 2001). Artistic interventions, I want to suggest, embody the potential to confront the political difficulty of decision and to intervene in ways that are 'unanticipatory', advancing where they cannot see.

What is particularly interesting about artistic practices that engage with some of the emergent technologies of attention, is that they do not seek out a *resolution* to the political difficulties posed. Instead, they create a plural space for the articulation of difference, "integrating technological tools into plural zones of creative activity" and providing ways of imaging the problem outside of narratives of security or consumption (Crary 2003: 9). By way of example, consider New York artist Meghan Trainor, whose work integrates RFID tags – ubiquitous in the visualization of consumers and security 'threats' – into public installations and performances (see figure 2). The installation "lets viewers encounter RFID tags in an application outside of its common commercial or surveillance context", explains Trainor, "allowing for different reactions to its current and expanding ubiquity in our lives" (Trainor 2004). Rather than seek to resolve the paradoxes and contradictions of these technological

forms of attentiveness, then, the artworks function “as catalyst” to the exposure of paradox and contradiction (De Oliveira 2003). They remind us that within apparently disciplined and securitized modes of attention there are also interstitial spaces of “inattention”, “enchantment” or “reverie” that may work against prejudicial and individualised practices (Bennett 2001). The background images and data that are discarded by security practices of visualization are potentially recovered by the changed perspectives of artistic interventions.

Finally, visionary work in artistic practice has, as its *raison d’être*, a form of critique that runs ‘against the grain’ of dominant knowledge about how we pay attention to the world. In Edward Said’s last book before his death, he documents the ‘late’ work of visionary artists and musicians as not that which has “harmony and resolution”, but that which embodies “intransigence, difficulty, and unresolved contradiction” (2006: 14). In contrast to a line of sight that sees clearly and rationally, then, art against the grain is that which transgresses prevailing modes of thought in order to see the world differently. Thomas Keenan conjures a comparable alternative ‘line’ of sight against the grain when he speaks of politics “on the bias”, where there is “a withdrawal of the rules or the knowledge on which we might rely to take our decisions for us” (1997: 166).

In order for responsibility to be reintroduced to the decision, then, it is necessary for us to consider this diagonal line of sight that cuts across prevailing ways of attending to the world. A final example of such a cut across the grain can be seen in British artist Michael Landy’s three year project, *Break Down*. Situating his work in a disused department store on London’s Oxford Street, Landy made an inventory of his life – dismantling, weighing and cataloguing every item that he owned. Simulating the breaking up, classifying and profiling of individuals through their data, Landy stripped his pixelated profile down to nothing, publicly displaying the 7000 disassembled objects on a moving production line. Because codified data can be used to visualize a person, no matter how absurd or tenuous, the artists who experiment with alternative ways to visualize a person do so against the grain, offering new modes of attention that attend also to the calculation that is made.

Conclusion: citizenship and unknown futures

In one reading of the implications of vigilant and anticipatory lines of sight for citizenship, a specific embodiment of the citizen is produced: an attentive, watchful and watched citizen whose actions and transactions in daily life are called up to secure the homeland security state. It is perhaps for this reason that so much attention has been paid in recent times, across the social sciences, to the surveillant practices of an apparently ‘post 9/11 world’. And yet, as Foucault warned in his lectures on the emerging security apparatus, the panopticon is “completely archaic”, and “the oldest dream of the oldest sovereign” (2007: 66). In contrast to the “exhaustive surveillance of individuals”, a “discipline” that “concentrates, focuses and encloses”, Foucault observes an “apparatus of security” that “opens up” to “let things happen” (2007: 44-5). Where disciplinary modes of surveillance produce particular pictures of people, drawn from the ‘survey’ in the conventional sense of ‘surveiller’, what I have depicted in this article is a projected picture of a person – one that preempts, visualizes and anticipates unknown futures. The citizen appears, then, not only as a *surveilled* picture of a way of life to be verified, checked against criteria and documentation, authenticated, but also and perhaps more importantly, as a *visualization of a potential person* who is never quite seen. In terms of material effects, the projected people who find themselves on selectee lists for secondary checks, or on no-fly lists, or with their assets frozen, are left confronting a digitized doppelganger whose associations and profile have become more ‘real’ than even the conventions of passport or visa can attain.

There can be little doubt, at least in my sense of the emerging landscape, that much of contemporary security practice is assembling around a line of sight that conceals racialized and prejudicial judgements inside an apparently ‘expert’ and techno-scientific visualization. Indeed, as I have suggested, the processes of screening and projection precisely rely upon the gaps that are ‘left out’ of association analysis. We might even say that misidentification, so-called ‘false positives’ and false hits have become essential parts of the accidents that make citizenship and the denial of citizenship possible (Nyers 2006). For the British citizens “of Pakistani origin” who find themselves projected as as-yet-unknown terrorists, their visualization is achieved only via the constant and consistent screening out of other identity claims they could make. It is for this reason that I find artistic interventions particularly interesting in terms of recovering what is screened out, retrieving the lived detail and rendering it

visible. One possible step to take in the political and ethical interventions in security visualizations, I have argued, is to expose the distractions and inattentiveness that make vigilant visualities possible.

References

- Agrawal, Rakesh, Tomasz Imielinski and Arun Swami (1993) 'Mining Association Rules Between Sets of Items in Large Databases', *SIGMOD Proceedings* pp.914-925.
- Amoore, L (2006) 'Biometric Borders: Governing Mobilities in the War on Terror,' *Political Geography* 25: 336-351.
- Amoore, Louise (2007) 'Vigilant Visualities: The Watchful Politics of the War on Terror', *Security Dialogue* 38: 2, pp.139-156.
- Amoore, Louise and Marieke de Goede (2005) 'Governance, Risk and Dataveillance in the War on Terror', *Crime, Law and Social Change* 43: 2, pp.149-173.
- Amoore, Louise and Marieke de Goede (2008) 'Introduction: Governing by Risk in the War on Terror', in Louise Amoore and Marieke de Goede (eds) *Risk and the War on Terror*. London: Routledge.
- Bennett, Jane (2001) *The Enchantment of Modern Life: Attachments, Crossings, Ethics*, Princeton NJ: PUP.
- BMSA (2004) *The Mathematical Sciences' Role in the War on Terror*, National Academies Press.
- Borcila, Rozalinda (2006) 'Geography Lessons', videos available at www.borcila.tk/geographie/index.html. Last accessed April 2007.
- Butler, Judith (1998) 'Merely Cultural', *New Left Review* 227, January/February.
- Chertoff, Michael (2007a) 'Remarks by Secretary Michael Chertoff to the Johns Hopkins University Paul H. Nitze School of Advanced International Studies', May 3 2007. Available at: www.dhs.gov/xnews/speeches/sp_1178288606838.shtm. Last accessed May 2007.
- Chertoff, Michael (2007b) 'Need better tools' speech following meeting John Reid**.
- Connolly, William (1991) *Identity/Difference: Democratic Negotiations of Political Paradox*, Minneapolis: University of Minnesota Press.
- Crandall, Jordan (2005) 'Envisioning the Homefront: Militarization, Tracking and Security Culture,' *Journal of Visual Culture* 4 (1): 17-38.
- Crary, Jonathan (1992) *Techniques of the Observer: On Vision and Modernity in the 19th Century*, Cambridge MA: MIT.
- Crary, Jonathan (1999) *Suspensions of Perception: Attention, Spectacle, and Modern Culture*, Camb. Mass: MIT Press.
- Crary, Jonathan (2003) 'Foreword', in Nicolas De Oliveira, Nicola Oxley and Michael Perry (eds) *Installation Art in the New Millennium: The Empire of the Senses*, London: Thames and Hudson.
- De Goede, Marieke (2003) 'Beyond Economism in International Political Economy', *Review of International Studies*, 29, pp.79-97.
- De Goede, Marieke (2005) *Virtue, Fortune and Faith: A Genealogy of Finance*, Minneapolis: University of Minnesota Press.
- De Oliveira, Nicolas (2003) (ed.) *Installation Art in the New Millennium: The Empire of the Senses*, London: Thames and Hudson.
- Department of Homeland Security (2004) 'Testimony of Secretary Tom Ridge before the Senate Budget Committee', 25 February 2004, US Senate: Washington DC.
- DHS (2006) 'Survey of DHS Data Mining Activities', Washington DC: Office of the Inspector General.
- Derrida, Jacques (1992) 'Force of Law: The "Mystical Foundations of Authority"', in Drucilla Cornell, Michael Rosenfeld and David Gray Carlson (eds) *Deconstruction and the Possibility of Justice*,

- Derrida, J (1994) (in conversation with Richard Beardsworth) 'Nietzsche and the Machine', *Journal of Nietzsche Studies* (7): 7-65.
- Derrida, J. (2001) *On Cosmopolitanism and Forgiveness*. London: Routledge.
- Ericson, Richard (2007) *Crime in and Insecure World*. Cambridge: Polity.
- Flanagan, Richard (2006) *The Unknown Terrorist*, London: Atlantic Books.
- Foucault, Michel (1991) 'Governmentality', in Graham Burchell, Colin Gordon and Peter Miller (eds) *The Foucault Effect: Studies in Governmentality*, Chicago: Chicago University Press.
- Friedberg, Anne (2002) 'Urban Mobility and Cinematic Visuality', *Journal of Visual Culture*
- Friedberg, Anne (2007) *The Virtual Window: From Alberti to Microsoft*, Camb. Mass: MIT Press.
- Gregory, Derek (2004) *The Colonial Present*, Oxford: Blackwell.
- Guild, E. and E. Brouwer (2006) 'The Political Life of Data: The ECJ Decision on the PNR Agreement between the EU and the US', *CEPS Policy Brief* 109, www.libertysecurity.org/IMG/pdf/1363.pdf
- Hay, James and Andrejevic, Mark (2006) 'Toward an Analytics of Governmental Experiments in These Times: Homeland Security as Social Security', *Cultural Studies* 20: 4-5, pp.331-348.
- Intelligent Enterprise (2002) 'For Want of a Nail', 5:7, p.8.
- Isin, Engin (2004) 'The Neurotic Citizen', *Citizenship Studies* 8:3, pp.217-235.
- Kang, Jerry and Dana Cuff (2005) 'Pervasive Computing: Embedding the Public Sphere', *Public Law Research Paper Series* no.04-23, Los Angeles: University of California.
- Keenan, Thomas (1997) *Fables of Responsibility: Aberrations and Predicaments in Ethics and Politics*, Stanford CA: Stanford University press.
- Kittler, Friedrich (1997) *Literature, Media, Information Systems: Essays*, Amsterdam: Arts Limited.
- Michael Chertoff (2006) 'A Tool we Need to Stop the Next Airliner Plot', *Washington Post*, August 29: A15.
- Miller, Peter and Nikolas Rose (1990) 'Governing Economic Life', *Economy & Society* 19: 1, pp.1-31.
- New Scientist (2003) 'Smart Software Linked to CCTV Can Spot Dubious Behaviour', 11 July 2003.
- New York Times (2006a) 'Faces Too, are Searched at US Airports', August 17 2006: 8.
- New York Times (2006b) 'Officials seek broader access to airline data', August 23 2006: 3.
- New York Times (2007) 'US Seeks Closing of Visa Loophole for Britons', May 2 2007: 5.
- Nyers, Peter (2006) 'The Accidental Citizen: Acts of Sovereignty and (Un)making Citizenship', *Economy & Society* 35:1, pp.22-41.
- Platform for Art (2006) *Thin Cities: 100 Years of the Piccadilly Line*, London: Platform for Art.
- Quinlan J.R. (1986) 'Induction of Decision Trees', *Machine Learning* 1, pp.81-106.
- Rumsfeld, Donald (2002) 'Press conference by US Secretary of Defence Donald Rumsfeld', NATO, Brussels June 6-7 2002. Available at: www.nato.int/docu/speech/2002/s020606g.htm. Last accessed April 2007.
- Said, Edward (2006) *On Late Style: Music and Literature Against the Grain*, London: Pantheon.
- Silverman, Kaja (1996) *The Threshold of the Visible World*, New York: Routledge.
- Sinclair, Iain (2005) 'The Theatre of the City', *The Guardian*, July 14 2005.
- US Joint Enquiry (2003) 'Report of the Joint Inquiry into the Terrorist Attacks of September 11, 2001', Washington DC: House Permanent Select Committee on Intelligence (HPSCI) and the Senate Select Committee on Intelligence (SSCI).
- Weber, S (2005) *Targets of Opportunity: On the Militarization of Thinking*. New York: Fordham University Press.
- Willis, Susan (2003) 'Old Glory', in Frank Lentricchia and Stanley Hauerwas (eds) *Dissent from the Homeland*, Duke University Press.

Zizek, Slavoj (2006) *The Universal Exception*, London: Continuum.

Figures

1. Rozalinda Borcila – *Geography Lessons*



2. Meghan Trainor – *With Hidden Numbers*



NOTES

¹ The author acknowledges the UK Economic and Social Research Council (ESRC) funding of award RES 155 25 0087 'Contested Borders: Non-Governmental Public Action and the Technologies of the War on Terror'. Performance artists Rozalinda Borcila and Meghan Trainor have been much valued collaborators and have given generously of their time and images.

² In May 2006 the European Court of Justice ruled that the EU-US agreement on the sharing of airline passenger data be annulled (Guild and Brouwer 2006). The Passenger Name Record (PNR) agreement

of 2004 required that airlines submit 34 items of data on each passenger (including , for example, credit card details, past travel data and in-flight meal choices, car hire, hotel bookings and other personal information) within 15 minutes of flight departure for the US. The PNR data has become central to pre-emptive border controls, where risk ratings are assigned to individuals in advance of their arrival at a border (Amoore 2006).

³ In a speech to the NATO in 2002, Donald Rumsfeld pondered the importance of taking decisions on the basis of an absence of evidence, of taking into account the “unknown unknowns”:

“The message is that there are no ‘knowns’. There are things we know that we know. There are known unknowns. That is to say there are things we know that we don’t know. But there are also unknown unknowns. There are things we don’t know we don’t know[...] There is another way to phrase that and that is the absence of evidence is not evidence of absence”.

Hence, the sense that attention is to be paid to that which is not seen, has not been seen, but can nonetheless be ‘projected’.

⁴ In common with others who have sought to push economy “beyond economism” – that is, beyond *the* economy as a pre-discursive, pre-political and self-evident material reality – economy is used here to denote a field of intervention and a specific means of rendering political life governable (de Goede 2003; 2005; Miller and Rose 1990). “The art of government”, writes Foucault, “is essentially concerned with answering the question of how to introduce economy – that is to say, the correct manner of managing individuals, goods and wealth within the family – how to introduce this... into the management of the state” (1991: 92). Foucault finds in economy a continuity of the art of governing the state, such that the “very essence of government” has come to mean “the art of exercising power in the form of economy” (93).

⁵ Reservations databases Amadeus, Galileo and Sabre, used by the major airlines and hotel and other travel groups, are now the conduit for the routine submission of passenger data to the US authorities before a flight departs for the US.

⁶ For Jacques Derrida, a decision is not a decision if it simply redeploys calculative practices in order to decide. A decision cannot, in Derrida’s reading, be determined by the acquisition of knowledge, for then it is not a decision but “simply the application of a body of knowledge of, at the very least, a rule or norm” (1994: 37). An apparent decision taken on the basis of what is ‘seen’ evidentially, via the calculations of experts, or in the screened results of algorithmic visualization, is not a decision at all. “The decision, if there is to be one”, writes Derrida, “must advance towards a future which is not known, which cannot be anticipated” (1994: 37).

⁷ As Slavoj Žižek has it: “multiculturalism is a disavowed, inverted, self-referential form of racism, a ‘racism with a distance’ – it respects the Other’s identity, conceiving of the Other as a self-enclosed ‘authentic’ community towards which he, the multiculturalist, maintains a distance rendered possible by his privileged universal position” (2006: 171). Thus, the decision based on a visualized calculation is precisely a self-referential form of racism, a racism that disavows itself by stripping out its own role in identifying the Other that is threatening and dangerous.

Chapter Title: Citizen Sensing in the Smart and Sustainable City: From Environments to Environmentalism

Book Title: Program Earth

Book Subtitle: Environmental Sensing Technology and the Making of a Computational Planet

Book Author(s): JENNIFER GABRYS

Published by: University of Minnesota Press

Stable URL: <https://www.jstor.org/stable/10.5749/j.ctt1b7x5gq.11>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <https://about.jstor.org/terms>



This content is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (CC BY-NC-ND 4.0). To view a copy of this license, visit <https://creativecommons.org/licenses/by-nc-nd/4.0/>.



University of Minnesota Press is collaborating with JSTOR to digitize, preserve and extend access to *Program Earth*

JSTOR

Urban Sensing



Figure 7.1. Connected Sustainable Cities project video. A collaborative and speculative smart city project developed across the MIT Mobile Experience Lab and Cisco. Screen capture.

Citizen Sensing in the Smart and Sustainable City

From Environments to Environmentality

CITIES THAT ARE INFUSED WITH and transformed by computational processes seem to be the object of continual reinvention. While informational or cybernetically planned cities have been underway since at least the 1960s,¹ proposals for networked or computable cities began to appear as regular features in urban-development plans from the 1980s onward.² From designing for the plasticity of urban architecture to envisioning the city as a zone for technologically spurred economic growth, digital city developments have remade urban spaces as networked, distributed, and flexible sites for capital accumulation and urban experience.

More recent and commercially led proposals for “smart cities” have focused on how networked urbanisms and participatory media might achieve “greener” or more efficient cities that are simultaneously engines for economic growth. Smart city proponents commonly make the case for the necessity of these developments by signaling toward trends in increasing urbanization. While cities are centers of economic growth and innovation, they are also, smart city advocates argue, sites of considerable resource use and greenhouse-gas emissions and are therefore important zones for implementing sustainability initiatives. In these proposals decaying or yet-to-be-built infrastructures are identified as sites of prime smart city development. Smart cities are presented as a neatly packaged way to meet these generalized challenges, thereby ensuring that future cities—whether retrofitted or new—are more sustainable and efficient than ever before.

Although cities infused by digital technologies and imaginaries are not a new development, their implementation to achieve sustainability directives under the guise of smart cities is a more recent tactic for promoting digital technologies. In many smart city proposals, computational technologies are meant to synchronize urban processes and infrastructures to improve resource efficiency, distribution of

services, and urban participation. Digital technologies, and specifically ubiquitous computing, have become a recurring theme in articulating how sustainable urbanisms might be achieved; yet the intersection of smart and sustainable urbanisms is an area of study that has yet to be examined in detail, particularly in relation to what modalities of urban environmental citizenship are emphasized or even eliminated in the smart city.

This chapter addresses another aspect of the becoming environmental of computation through the becoming environmental of power that unfolds within smart cities projects.³ To elaborate upon this particular focus on the becoming environmental of computation *and* power, I take up the emergence of the smart city as a sustainable city by looking at one particular case study, the Connected Sustainable Cities (CSC) project developed by MIT and Cisco within the Connected Urban Development (CUD) initiative. The CSC aspect of the project consists of design proposals developed between 2007 and 2008 by William Mitchell and Federico Casalegno in the MIT Mobile Experience Lab working in conjunction with Cisco CUD. The Cisco CUD initiative was a partnership initiated in 2006 in response to the Clinton Global Initiative for addressing climate change. Pairing with eight cities worldwide, from San Francisco to Madrid, Seoul, and Hamburg, CUD ran until 2010 and has influenced Cisco's ongoing project Smart + Connected Communities, which continues to produce smart city plans, from development underway in Songdo to proposals to develop a "Sustainable 21st Century San Francisco."⁴

Situating this design proposal within a range of smart city projects that include sustainability in their development plans, I examine how this speculative and early smart city project proposes to achieve more sustainable and efficient urbanisms through a number of ubiquitous computing scenarios to be adapted to existing and hypothetical cities. The CSC project proposal bears strong resemblances to many smart city developments still underway and, with its connection to Cisco, one of the primary developers of network architecture for cities, is an influential demonstration of smart city imaginings. Many of the tools developed through the CUD project consist of planning documents, white papers, eco toolkits, multimedia demonstrations, and speculative designs meant to guide smart city development.⁵ As an important but perhaps overlooked part of the process of promoting smart cities, these designs, narratives, and documents have played a key role in rearticulating the smart city as a sustainable city. However, this chapter focuses on these proposals not simply as *discursive* renderings of cities but as elements within an urban computational *dispositif*, or apparatus,⁶ which performs material-political and environmental relations across speculative designs, technological imaginaries, urban development plans, democratic engagements through participatory media, and networked infrastructures, many of which are folded into present-day urban development plans and practices, even when the smart city is an ever-elusive project to be realized.

Smart city plans and designs, as proposed and uncertainly realized, articulate distinct materialities and spatialities as well as formations of power and governance. By considering Foucault's concept of *environmentality* in this context, I examine the ways in which the CSC project performs distributions of governance within and through proposals for smart environments and technologies. I emphasize this aspect of Foucault's discussion of environmentality in order to open up and develop further his unfinished questioning of how environmental technologies as spatial modes of governance might alter material-political distributions of power and possible modes of subjectification.⁷ Revisiting and reworking Foucault's notion of environmentality not as the production of environmental *subjects* but as a spatial-material distribution and relationality of power through environments, technologies, and ways of life, I consider how practices and operations of citizenship concretize that are a critical part of the imaginings of smart and sustainable cities. This reading of environmentality in the smart city recasts who or what counts as a "citizen" and attends to the ways in which citizenship is articulated *environmentally* through the distribution and feedback of monitoring and urban data practices, rather than as an individual subject to be governed.

The primary way in which sustainability is to be achieved within smart cities is through more efficient processes and responsive urban citizens participating in computational sensing and monitoring practices. Urban citizens become sensing nodes—or citizen sensors—within smart city proposals. This is a way of understanding citizen sensing not as a practice synonymous with citizen science but as a modality of citizenship that concretizes through interaction with computational sensing technologies used for environmental monitoring and feedback. In this context, I take up the proposals for smart cities as developed in the CSC project to ask: What are the implications of computationally organized distributions of environmental governance that are programmed for distinct functionalities and are managed by corporate and state actors that engage with cities as datasets to be manipulated? Which articulations of environmentality concretize within sustainable smart city proposals and developments when governance is performed through environments that are computationally programmed? And when sensing citizens become operatives within urban computational systems, how might environmental technologies delimit citizen-like practices to a series of actions focused on monitoring and managing data? Might this mean that citizenship is less about a fixed human subject and more about an operationalization of citizenship that largely relies on digital technics to become animate?

REMAKING SMART CITIES

As might be gathered from the multiple literatures and projects directed toward smart cities, there are numerous interpretations for what even counts as a smart city.⁸ It could involve new media districts or automated infrastructures equipped

with networked digital sensors, it could refer to the correspondence between online and offline worlds, or it might encompass augmented urban experiences made possible through mobile devices. While earlier research on computational urbanisms may have focused on the relationship between the digital and physical city and the ways in which “virtual” digital technologies might respatialize or represent physical cities,⁹ increasingly these approaches have transformed into the ways in which cities are now being remade and marketed through both software and the material infrastructures of digital technologies.¹⁰ Ubiquitous computing remakes cities, rather than displacing or virtually representing them, by generating considerable amounts of data to manage urban processes, as well as by directly embedding devices in urban infrastructures and spaces.

“Smartness,” while a generalized reference to computational urbanisms, increasingly refers to urban sustainability strategies that hinge on the implementation of ubiquitous urban computing, or the “fourth utility,” as Cisco has termed it.¹¹ In an industry white paper, “A Theory of Smart Cities,” IBM authors involved with the Smarter Planet initiative suggest that the term “smart cities” derives from “smart growth,” a concept used in urban planning in the late 1990s to describe strategies for curtailing sprawl and inefficient resource use, which later changed to describe IT-enabled infrastructures and processes oriented toward such objectives.¹² This recurring theme within government and industry white papers on smart cities addresses the ways in which networked sensor technologies are meant to optimize urban processes and resources, including transport, buildings, electricity, and industry, and make them more efficient. Sensor-operationalized and automated environments perform a distinct version of sustainability, where efficiency is the overall goal that influences the merging of economic growth with green objectives. Indeed, smart cities are frequently identified as a hoped-for source of considerable new revenue generation; and in a report funded by the Rockefeller Foundation, the Institute for the Future suggests that smart cities are likely to be a “multi-trillion dollar global market.”¹³

The current wave of smart and sustainable cities projects proposed and underway includes numerous proposals located throughout the world that bear similar objectives, plans, and designs related to economic growth through smart and sustainable computational urbanisms. From Abu Dhabi to Helsinki, and from Smart Grids in India to PlanIT Valley in Portugal, many urban development projects are guided by the implementation of networked sensor environments that are marketed through the logics of efficiency and sustainability. Smart city projects are often set up as public-private partnerships between multinational technology companies including Cisco, IBM, and Hewlett Packard, along with city governments, universities, and design and engineering firms. Proposals may involve retrofitting urban infrastructures in New York or London; developing new cities on greenfields in Songdo, Korea, or Lake Nona, Florida; or intensifying network

utilities in midsized cities like Dubuque, Iowa, as test sites for networked sensor applications. The focus here is on the ways in which smartness influences articulations of urban sustainability. But rather than fix a definition of the smart city, I work between suggestions that the ways in which informationalized cities are mobilized can be indicative of political and economic interests¹⁴ and that digitally informed cities may be figures that continually change in their imagining, implementation, and experiencing.¹⁵ Although smart cities could be rather generic and universalizing in their approach to urbanism, many smart cities also emerge through the materially and politically contingent spaces and practices of urban design, policy, and development, while also forming commitments to specific—if speculative—urban ways of life.

REMAKING CITIZENS IN SMART CITIES

The computational technologies proposed and developed in smart city projects are meant to in-form urban environments and processes, along with the interactions and practices of urban citizens. Citizen-sensing and participatory platforms are often promoted in smart city plans and proposals as enabling urban dwellers to monitor environmental events in real time through mobile and sensing technologies. Yet proposals focused on enabling citizens to monitor their activities convert these citizens into unwitting gatherers and providers of data that may be used not just to balance energy use, for instance, but also to provide energy companies and governments with details about everyday living patterns. Monitoring and managing data in order to feed back information into urban systems are practices that become constitutive of citizenship. Citizenship transforms into citizen sensing, embodied through practices undertaken in response to (and communication with) computational environments and technologies.

Citizen sensing as a form of engagement is a consistent, if differently emphasized, reference point both for development-led and for creative-practice engagements with smart cities. DIY projects propose citizen involvement through the use of participatory media and sensing technologies, and these citizen-sensing projects stress the difference between grassroots and more large-scale smart city developments. Yet an interesting confluence of imaginaries and practices occurs at the point of tooling up citizens, even to the point of “alter[ing] the subjectivity of contemporary citizenship” by enabling urban dwellers to use sensing technologies to interact with urban environments.¹⁶ What subjectivity is this, and might computational environments be one place to turn to consider how (and where) this subjectivity and citizenship is altered? In other words, when urban processes and architectures shift through ubiquitous computing deployed for efficiency and sustainability, how do urban material politics and possibilities for democratic engagement also transform?¹⁷ My interest in these modalities of citizen sensing within smart cities is not to denounce these proposals and projects as

tools of control, which might form a typical technological critique, but rather to understand more precisely the ways in which computational materializations distribute power through urban spaces and processes. As Foucault has suggested, rather than attempt to imagine a space free of power it may be more productive to consider how power is distributed as a way to critique modes of governance by imagining how it might be possible not to be governed quite so much—or in that way.¹⁸

ENVIRONMENTALITY

I take up questions about transformations in urban process, form, and inhabitation in order to analyze in greater detail the ways in which the environmental technologies of ubiquitous computing influence urban governance and citizenship. “Environmentality” is a term I use to describe these urban transformations, which I revisit and rework through a reading of Foucault’s unfinished discussion of this concept in one of his last lectures in *The Birth of Biopolitics*. Foucault signals his interest in environmentality and environmental technologies as he moves from a historical to a more contemporary and neoliberal consideration of biopolitics in relation to the milieu and environment as sites of governance. Here, he suggests the subject or population may be less relevant for understanding the exercise of biopolitical techniques, since alterations of environmental conditions may become a new way to implement regulation.¹⁹ Foucault’s discussion of environmentality emerges from an analysis of criminality, where in one example he considers how approaches to regulating the supply of drugs may have had a greater impact on conditions of addiction in comparison with strategies that have targeted individual addicted users or populations of addicted users. Working less with an explanation and more with an open-ended suggestion of what he sees as a growing trend toward *environmental* governance rather than subject-based or population-based distributions of governance, he notes, “Action is brought to bear on the rules of the game rather than on the players, and finally in which there is an environmental type of intervention instead of the internal subjugation of individuals.”²⁰ Moving beyond this example, Foucault gestures toward a broader notion of environmentality where influencing the “rules of the game” through the modulation and regulation of environments may be a more current description of governmentality, above and beyond direct attempts to influence or govern individual behavior or the norms of populations. Behavior may be addressed or governed, but the technique is environmental.

Foucault closes his lecture by indicating that in the following week he would examine in greater detail these questions of environmental regulation. However, he does not develop this strand of thought further, and instead, his six pages outlining his approach to environmentality are included as a footnote in *The Birth of Biopolitics* lectures.²¹ Consisting more of an unanswered question than a

theoretical roadmap, Foucault's discussion of environmentality ranges from a historical analysis of the governing of populations to a consideration of more contemporary modes of governance that may have been unfolding or already underway at the time of his lecture. While his specific concept of environmentality remains a footnote to his discussion of neoliberal modes of governance, it is a provocation for thinking through the effects of the increasing promotion and distribution of computational technologies in order to manage urban environments. In what ways do smart city proposals for urban development articulate and enact distinctly environmental modes of governance, and what are the spatial, material, and citizenly contours of these modes of governance?

The use of the term "environmentality" that I am developing and transforming based on the biopolitics lectures is rather different from the ways in which it has often been taken up based on Foucault's earlier work, from the making of environmentally aware subjects for the purposes of forest conservation in India,²² to the use of environmentality as a term to capture the "green governmentality" of environmental organizations.²³ Environmentality as a concept does offer up ways of thinking about governance toward environmentalist objectives. But it is important to bear in mind the translations that are made across environmentality and *environmentalism*. Foucault's analysis of environmentality does not directly pertain to environmentalism as such, but rather to an understanding of governance through the *milieu*.²⁴ In fact, Foucault's interest in environmental modes of governance touches on strategies of "environmental technology and environmental psychology,"²⁵ fields that could include designing survival systems or shopping-mall experiences.²⁶ Environmental modes of governance are also as likely to emerge from the failure to meet environmentalist objectives. Events such as Hurricane Katrina, as Massumi suggests in his analysis of environmentality, generate distinct modes of crisis-oriented governance that emerge in relation to the uncertainty of climate change—a condition of "war and weather" that sets in motion a spatial politics of ongoing disruption and response.²⁷

BIOPOLITICS 2.0

Foucault's discussion of environmentality, however abbreviated, addresses the role of environmental technologies in governance and in many ways relates to his abiding attention to the *milieu* (no doubt an influence from Canguilhem) as a site of biopolitical management. Biopolitics, or the governing of life, as he analyzed it in its late eighteenth- and nineteenth-century formations, was concerned with "control over relations between the human race, or human beings insofar as they are a species, insofar as they are living beings, and their environment, the *milieu* in which they live."²⁸ If we further take biopolitics to include those distributions of power that influence not just *life*, but also *how to live*,²⁹ then how are *ways of life* governed through these particular environmental distributions? Indeed, the

phrase “ways of life,” which Foucault deploys to discuss biopolitical arrangements and distributions of power, is taken up by Revel to suggest that biopolitics is a concept that is not exclusively concerned with “control,” as perhaps has been overemphasized through readings of Foucault’s earlier work, but that focuses on the spatial–material conditions and distributions of power that are characteristic of and relatively binding within any given time and place.³⁰ “Ways of life,” or “life lived,” is a biopolitical concept and approach that also moves beyond understandings of life as a given *biological entity* (this reading of biopolitics may have more to do with Agamben’s work on biopolitics and bare life)³¹ and instead suggests that *ways of life* are situated, emergent, and practiced through spatial and material power relations. Such a concept does not describe a totalizing schema of power but points to understandings of how power emerges and operates within ways of life, as well as suggesting possibilities for generating alternative ways of life.

A different formation of biopolitics emerges in the context of environmental-ity, since biopolitics unfolds in relation to a milieu that is less oriented toward control over *populations* and instead performs through environmental modes of governance. In order to capture and examine the ways of life that materialize within the CSC smart city proposal, I use the term *biopolitics 2.0* (with a hint of irony) to refer to the participatory or “2.0” digital technologies at play within smart cities and to examine specific ways of life that unfold within the smart city. Biopolitics 2.0 is a device for analyzing biopolitics as a historically situated concept, a point that Foucault stressed in his development of the term. The 2.0 of biopolitics captures the situatedness of this term, which includes the proliferation of user-generated content through participatory digital media that is a key part of the imagining of how smart cities are to operate; it also includes the *versioning* of digital technologies through the transition of computation from desktops to environments,³² whether in the shape of mobile digital devices or sensors embedded in urban infrastructure, objects, and networks—something that is captured by the term “City 2.0,” which circulates as a parallel term to the smart city.

The biopolitical milieu concretizes material–spatial arrangements in which and through which distinct *dispositifs*, or apparatuses, operate. The apparatus of computational urbanism can be analyzed through networks, techniques, and relations of power that extend from infrastructure to governance and planning, everyday practices, urban imaginaries, architectures, resources, and more. But this “heterogeneous ensemble” can be described through the “nature of the connection” that unfolds across these elements.³³ In his discussions on biopolitics, the apparatus, and the milieu, Foucault repeatedly suggests that the ways in which relations are articulated are key to understanding how modes of governance, ways of life, and political possibilities emerge or are sustained.

Computational monitoring and responsiveness characterize the “nature of the connection” across environments and citizens in smart cities. Biopolitical 2.0

relations are performed through the need to promote economic development while addressing impending environmental calamity, conditions characterized by an *urgency* that Foucault critically identifies as being crucial to the historical situation of the apparatus and, consequently, to the operation of biopolitics.³⁴ Within smart city proposals and projects, cities are presented as urgent environmental, social, and economic problems that the digital reorganization of urban infrastructures is meant to address by increasing productivity while achieving efficiency. By drawing together Foucault's understanding of how power might operate environmentally and biopolitically, I shift the emphasis toward understanding urban spaces and citizenship within relational or connective registers, with an emphasis on the computational practices and processes that are meant to remake and influence smart city ways of life. In reading and contextualizing these aspects of Foucault as less focused on disciplined or controlled subjects or populations, I also bring environmentality into a space where it is possible to consider how smart cities qualify environmentality by recasting what counts as "the rules of the game."

To say that smart cities might be understood through a biopolitics 2.0 analysis is not so much to suggest that digital technologies are simply tools of control as to examine how the spatial and material programs that are imagined and implemented within smart city proposals generate distinct types of power arrangements and modes of environmentality that entangle urban dwellers within specific performances of citizenship. But within these programs for computational urbanism, the processual and practiced ways of life that unfold or are proposed to unfold inevitably materialize in multiple ways. The "rules of the game" that Foucault

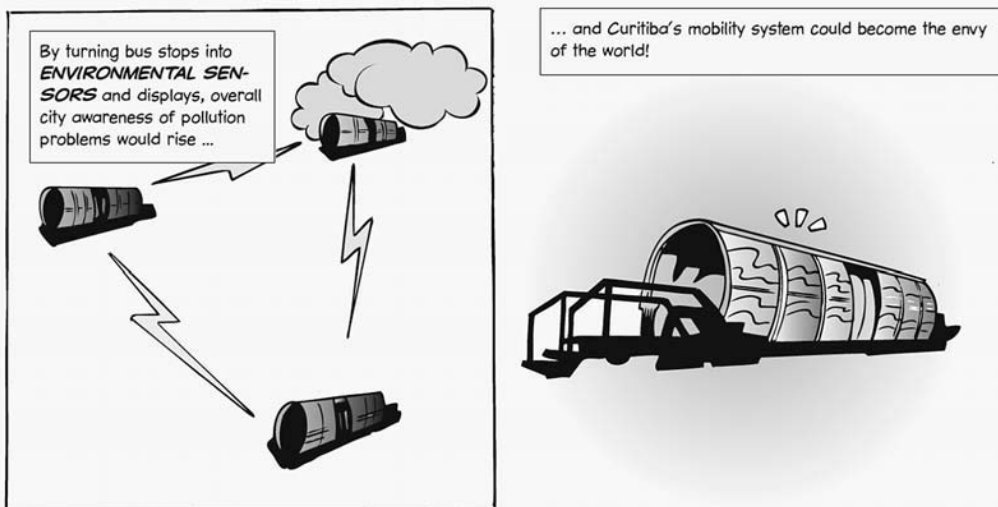


Figure 7.2. Connected Sustainable Cities project scenario for sensors detecting pollution in Curitiba, from the *Connected Sustainable Cities* pamphlet written by Mitchell and Casalegno. Screen capture.

described as central to environmentality might need to be revised as a less static or deterministic rendering of how governance works. Smart city design proposals, on one level, establish propositions and programs for how computational urbanisms are to operate; but on another level, programs never go according to plan and are never singularly enacted. Environmentality might be advanced by considering smart cities not as the running of code in a command-and-control logic of governing space but as the multiple, iterative, and even faltering materializations of imagined and lived computational urbanisms.

CONNECTED SUSTAINABLE CITIES

Working at this juncture of environmental modes of governance, environmental technologies, and sustainability as they are operationalized in smart cities, the CSC project within the CUD puts forward a vision for a near future of ubiquitous urban computing oriented toward increased sustainability. The project proposal materials advocate the smart city as the key to addressing issues of climate change and resource shortages, where sustainable urban environments may be achieved through intelligent digital architectures. The CSC design proposals and policy tools, as well as the core visioning document—*Connected Sustainable Cities*, by Mitchell and Casalegno—develop scenarios for everyday life enhanced, and even altered, by smart information technologies, which “will support new, intelligently sustainable urban living patterns.”³⁵

Within the CSC design proposals, the technology that most operationalizes smart environments and the programmed interactions between city and citizens is ubiquitous computing in the form of “continuous, fine-grained electronic sensing” through “sensors and tags” that are “mounted on buildings and infrastructures, carried in moving vehicles, integrated with wireless mobile devices such as telephones, and attached to products.”³⁶ Sensor devices are distributed throughout and monitor the urban environment. The continual generation of data provides “detailed, real-time pictures” of urban practices and infrastructures that can be managed, synched, and apportioned to support “the optimal allocation of scarce resources.”³⁷ Digital sensor technologies perform urban processes as a project of efficiency, where environments are embedded with computational technologies that provide urban management and regulation.

Like many smart city proposals, the CSC sites are made smart through several common areas of intervention largely oriented toward increasing productivity while enhancing efficiency. A video lays out the rationale for the project and the core areas it addresses, including platforms developed to aid commuting, home recycling, self-managing one’s carbon footprint, facilitating flexibility in urban spaces, and collaborative decision-making as model areas in which improved efficiency by means of digital connectivity and improved visibility of environmental data may save resources and lower greenhouse gas emissions. While many of the

applications envisaged in the proposal are already in use within cities, from electronic bicycle rental schemes to smart meters for managing energy use, the project suggests a further coordinated dissemination of sensor technologies and platforms for achieving more efficient urban processes.

In the CUD project video and CSC design document, urban design and planning proposals take place not at the scale of the master plan but at the scale of the scenario. From Curitiba to Hamburg, the episodic urban patterns addressed in these designs and policies include urban services, eco-monitoring toolkits, and speculative platforms intended to achieve smart and “seamless” automated living. Yet in many cases the urban interventions take place in a hypothetical city or in a specified city that is rendered sufficiently general as to be receptive to computational interventions within a universalized language of the everyday. In a design scenario sketched out for “managing homes” in Madrid, numerous capabilities are proposed to make homes more efficient. Mobile phones are GPS-enabled to communicate with sensor-equipped kitchen appliances, so that a family dinner may be cooked by balancing location and timing. The home thermostat will similarly sync with GPS and calendars on mobile phones, so that the home is heated in time for the family’s arrival. The organization of activities unfolds through programmed and activated environments so as to realize the most productive and efficient use of time and resources. In the Madrid scenario, monitoring residents’ behaviors in detail through sensors and data is essential for achieving efficiency. With this information, environments are meant to become self-adjusting and to perform optimally.

The CSC efficiency initiatives promise to “streamlin[e] the management of cities,” lessen environmental footprints, and “enhanc[e] how people experience urban life.”³⁸ By tracking locations and daily activities, smart technologies present the possibility that dinners will self-cook and homes will self-heat. These “enabling technologies” perform new arrangements of environments and ways of life: “smart” thermostats couple with calendars, locations, and even “a human body’s ‘bio-signals,’” and “skin temperature and heart rate” may be monitored through sensors to ensure optimum indoor temperatures. Similarly, communication with kitchen appliances is proposed to occur through “Toshiba’s ‘Femininity’ line of home network appliances.” These technologies ensure the home will be warm, safe, and provided with the latest recipes.³⁹

The importance of the everyday as a site of intervention signals the ways in which smart city proposals are generative of distinct ways of life, where a “micro-physics of power” is performed through everyday scenarios.⁴⁰ Governance and the managing of urban milieus occur not through delineations of territory but through enabling the connections and processes of everyday urban inhabitations within computational modalities. The actions of citizens have less to do with individuals exercising rights and responsibilities and more to do with operationalizing

the cybernetic functions of the smart city. Participation involves computational responsiveness and is coextensive with actions of monitoring and managing one's relations to environments, rather than advancing democratic engagement through dialogue and debate. The citizen is a data point, both a generator of data and a responsive node in a system of feedback. The program of efficiency assumes that human participants will respond within the acceptable range of actions, so that smart cities will function optimally. Yet programs for efficiency that are multiply distributed will inevitably be multiply enacted across human and more-than-human registers, so that smart bicycles are left in creeks and sensing devices are hacked to surreptitiously monitor domestic environments or intervene in them. This smart city proposal raises questions as to how these orchestrated ways of life would be actually lived, thereby rerouting programs of efficiency and productivity.

PROGRAMMING CITIES

As specifically rendered through smart technologies, the motivating logic of sustainability becomes oriented toward saving time and resources. This in turn informs proposals for how to embed smart technologies within everyday environments in order to ensure more efficient ways of life. Monitoring is a practice enabled by sensors, and so it becomes a central activity in articulating the sustainability and efficiency of smart cities. The sensing that takes place in the smart city involves continually monitoring processes in order to manage them. The urban sense data generated through smart city processes are meant to facilitate the regulation of urban processes within a human-machine continuum of sensing and acting, such that "the responsiveness of connected sustainable cities can be achieved through well-informed and coordinated human action, automated actuation of machines and systems, or some combination of the two."⁴¹ Humans may participate in the sensor city through mobile devices and platforms, but the coordination across "manual and automated" urban processes unfolds within programmed environments, which organize the inputs and outputs of humans and machines.

"The programmed city" is a speculative and actual project that has been critical to the ongoing development of ubiquitous computing but which has also demonstrated the complicated and uncertain ways in which programmable environments are realized.⁴² Programming as described in the CSC document has multiple resonances, signaling the architectural sense of programming space for particular activities as well as the programming of urban development and policy and the computational programming of environments.⁴³ Within smart city proposals, programming of environments is a way in which the "nature of the connection" within the computational *dispositif* is performed across a spatial arrangement of digital devices, software, cities, development plans, citizens, practices, and more.

The notion of programming, while specific to computation, is further coupled with notions of what the environment is and how it may be made programmable. As discussed in the introduction to *Program Earth*, some of the early imaginings of sensor environments speculate on how everyday life may be transformed with the migration of computation from the desktop to the environment.⁴⁴ While many of these visions are user focused, environmental sensors also transform notions of how or where sensing takes place to encompass more distributed and nonhuman modalities of sensing.⁴⁵ The programming of environments is then perhaps one of the key ways in which “the milieu” is now best described as “the environment,” where the postwar rise of the term “the environment” typically corresponds with more cybernetic approaches to systems and ecology,⁴⁶ as well as referring to the conditions in which computation can operate.

A growing body of research in the area of software studies now focuses on the intersection of computation and space, making the point that computing—often in the form of software or code—has a considerable influence on the ways in which spatial processes unfold or even cease to function when software fails.⁴⁷ While software is increasingly in-forming spatial and material processes, I situate the performativity of software within (rather than above or prior to) the material-political-technical operations of the computational *dispositif*, since programmability necessarily signals more than the unfurling of scripts that act on the world in a discursive architecture of command-and-control. Software is also not so easily separated from the hardware it would activate.⁴⁸ Instead, as I suggest here, programmability points to the ways in which *computational operations unfold across material-political situations*, even at the level of speculative designs or imaginings of political processes (where computational approaches to perceived urban “problems” may in-form how these issues are initially framed *in order to be computable*), while indicating how actual programs may not run according to plan.

The computational articulations of governance and citizenship within the CSC proposals are uncertain indicators for how urban practices might actually unfold, even when processes are meant to be automated for efficiency—but it is exactly the faltering and imperfect aspects of programmed environments that might become sites for political encounters in smart cities. Some smart city initiatives are finding that the less “modern” political structures of city councils, for instance, do not make for easily compatible smart city development contexts. Urban governance may be divided into multiple wards or councils across and through which the seamless flow of data and implementation of digital infrastructures may be complicated or halted. “Realizing programs of action” within software development “is complicated and contested,” as Mackenzie notes.⁴⁹ Code is also not singularly written or deployed but may be a hodgepodge of just-effective-enough script written by multiple actors and running in momentarily viable ways on specific platforms. Beyond the realm of software development, I argue that the

smart city is another realm in which programming does not unfold as an easy execution of code. A change to any element of the code, hardware, or interoperability with other devices may shift the program and its effects. When code is meant to reprogram urban environments, it also becomes entangled in complex urban processes that interrupt the simple enactment of scripts.

The CSC proposals demonstrate the ways in which the programmed environments of the smart city give rise to—and even require—distinct urban materialities in order to be operable. The several modalities of sensing and programming that emerge within the CSC documentation are expressive of programs to sense and monitor in order to manage and regulate the material processes of the smart city environment, from the circulation of people and goods to processes of participation, all of which are seen to interconnect through the “digital nervous system” of the smart city.⁵⁰ In the CSC scenarios the metabolic circuit of inputs and outputs that is made optimally efficient simplifies the processes necessary to transform urban materialities—through electronicizing, tagging, and monitoring—in order to make them programmable and efficient. Yet ubiquitous urban computing would require a considerable outlay of materials and resources in order for cities to operate in these modalities. Urban materialities are then doubly elided through the dematerializing logic of digital technology, since automation, improved timing, and coordination seem to minimize—and even eliminate—the resource requirements and wastes of smart cities; electronic technologies also seem to have no resource requirements, whether in their manufacture, operation, or disposal. Resource requirements and material entanglements are apparently minimized through the improved flow offered by smart technologies.

Digital technologies—and the digital apparatus—are generative of processes of materialization that do not so much elide materialities as transform them through computational modalities.⁵¹ The uneven and material ways in which computation unfolds within cities breaks with this kind of frictionless understanding of how computation might seamlessly perform a set of efficiency objectives. Smart cities could be characterized largely by the gaps and accidents of computational technologies, which are also part of the “experience” of how these devices and systems perform and are implemented.⁵²

PROGRAMMING PARTICIPATION

The infrastructures at play in the CSC vision partially consist of grids and services remade into smart electrical grids, smart transport, and smart water. But they also consist of participatory and mobile citizen-sensing platforms through which urban dwellers are to monitor environments and engage with smart systems. Participatory media and environmental devices facilitate this more sustainable city by enabling forms of participation that are compatible with it. The smart infrastructures and citizen-sensing platforms in the CSC project enable monitoring

practices while structuring responses that regulate or recalibrate everyday practices. Sustainable transit options become more viable through the deployment of “urban citizenship engagement points” that allow for personalized planning of bus routes, carpooling, and bicycle rental.⁵³ Energy contributions may be made at the intersection of smart transit systems or architectural surfaces and mobile monitoring devices. Urban spaces may be easily reconfigured or adapted to allow working and networking in any location at any time and to facilitate the “intensification of urban land use.” The way in which these practices are activated occurs across the programs embedded within urban environments and mobile devices. Digitally enhanced infrastructure and citizens are articulated as corresponding nodes, where technologies and strategies for environmental efficiency become coextensive with citizen participation—and “changed human behavior.”⁵⁴

While additional design scenarios address traffic in Seoul and work-anywhere-anytime proposals for Hamburg, as well as coordinate public transit in San Francisco and use mobile platforms to organize daily health monitoring, one scenario based in an unnamed North American urban location focuses on “taking personal responsibility” through the narrative of a love contest between two male friends vying for the attentions of an eco-female.⁵⁵ This scenario demonstrates how “the biggest variable in sustainability”—that is, “human behavior”—may be monitored and advanced effectively through ICT applications. The male competitors in this scenario engage in logging their daily travel plans online to produce carbon footprints for comparison, installing a home monitoring system to measure electricity use, and monitoring water use to create a water budget. As the scenario outlines:

Monitor, monitor, monitor . . . that’s a lot of what both men do. They realize that the key to winning Joan’s heart is to show her they’re making the right decisions, and that means they need a lot of clear information that is meaningful—and actionable.⁵⁶

Monitoring behavior and generating data are seen to be the basis for making sound decisions to advance everyday sustainable practices. Programs of responsiveness are critical to the ways in which sustainable practices are designed to emerge in this smart city proposal. In order for these schemes to function, urban citizens need to play their part, whether by partaking in transport systems or by generating energy through their continual movement within urban environments. Urban environmental citizens are responsible for making “informed, responsible choices.”⁵⁷ Yet these proposals explicitly outline the repertoire of actions and reflections that the smart city will enable, in which the sensing citizen becomes an expression of productive infrastructures. Mitchell and Casalegno stress the benefits of informed participation in urban processes facilitated by participatory media and ubiquitous computing—technologies that, they argue, make a heightened sense of

responsibility possible.⁵⁸ Urban citizenship is remade through these environmental technologies, which mobilize urban citizens as operatives within the processing of urban environmental data; citizen activities become extensions and expressions of informationalized and efficient material–political practices. Citizens who sense and track their own consumption patterns and local environmental processes have a set of citizen-like actions at their disposal, enabled by environmental technologies that allow them to be participants within the smart city.

The balancing of smart systems with citizen engagement is typically seen as a necessary area to address when considering the issues of surveillance and control that smart cities may generate. As the previously cited Rockefeller-funded report suggests, global technology companies such as IBM and Cisco may have a rather different set of objectives than “citizen hacktivists,” and yet both of these companies have vested interests in contributing to emerging smart city proposals.⁵⁹ Digital technologies are seemingly liberating tools, allowing citizens to engage in ever more democratic actions; and yet, the monitoring and capture of sensor data within nearly every aspect of urban life vis-à-vis devices deployed by global technology companies suggest new levels of control. But could it be that this apparent dichotomy between sensing citizen and smart city is less clear-cut? In many ways, participatory media are already tools of variously restricted political engagement,⁶⁰ while smart urban infrastructures never quite manifest (if at all) in the totalizing visions presented.

The sensing citizen is an expression of the ideal mode of citizen participation in smart city visions, rather than a resisting agent to them. Sensing citizens are the necessary participants in smart cities—where smart cities are the foregone conclusion. Dumb citizens in smart cities would be a totalitarian overshoot, since they would be entities subject to monitoring without participating in the flow of information (a situation that will be addressed in chapter 8). The smart city raises additional questions about the politics of urban exclusion, about who is able to be a participating citizen in a city that is powered through access to digital devices. Yet the participatory agency that is embedded within smart city developments does not settle on an individual human subject, and citizenship is instead articulated through environmental operations. Within the CSC proposals there exists the possibility that—given a possible failure or limitation of human responsiveness (a lack of interest in participating in the smart city)—the system may operate on its own. In these scenarios, due to a lack of “human attention and cognitive capacity” as well as a desire not to “burden people with having to think constantly about controlling the systems that surround them,” it may be relevant to deploy “automated actuation,” the project authors suggest. This would mean that urban systems become self-managing such that “buildings and cities will evolve towards the condition of rooted-in-place robots.”⁶¹ Citizens would be figures responding within the program of environmentality. However, the smart city program is able

to operate independently by sensing environments as well as actuating them and intervening in them to the point where environmental technologies may override citizens if they do not perform according to preset functions—or the rules of the game.

Processes of regulating urban environments within smart city proposals do not require internal subjugation as such, since governance is distributed within environments that default to automatic modes of regulation. Here is a version of biopolitics 2.0, where monitoring behavior is less about governing individuals or populations and more about establishing environmental conditions in which responsive (and correct) modes of behavior can emerge. Environmentality does not require the creation of normative subjects, as Foucault suggests, since the environmental citizen is not governed as a distinct figure; rather, environmentality is an extension of the actions and forces—automaticity and responsiveness—embedded and performed within environments. Such a situation could be characterized as what Deleuze calls the making of “dividuals,” a term he uses to describe the fluid entity that emerges within a “computer” age.⁶² For Deleuze, automation is coextensive with a deindividualizing set of processes characterized by patterns of responsiveness that rely less on individual engagement and more on the correct cybernetic connection.

Working transversally with this concept, however, I would suggest that smart city proposals signal less toward the elimination of individuals absolutely, since the “citizen” is an important operator within these spaces. Rather, the citizen works through processes that might generate *ambivdividuals*: ambient and malleable urban operators that are expressions of computer environments. While the ambivdividual is not an expression of a cognitive subject, it does articulate the distribution of nodes of action within the smart city. Ambivdividuals are not singularly demarcated or erased but variously contingent and responsive to fluctuating events, which are managed through informational practices. This resonates with Foucault’s suggestion that one characteristic of environmental technologies is the development of “a framework around the individual which is loose enough for him to be able to play.”⁶³ But I would suggest that who or what counts as an ambivdividual is not restricted to a human actor in the smart city, since the articulation of actions and responses occurs across human-to-machine and machine-to-machine fields of action.

CITIZEN SENSING AND SENSING CITIZENS

A final point of consideration that emerges within smart city and citizen-sensing frameworks is the extent to which environmental monitoring leads to actionable data. Smart city infrastructures are projected to operate as a self-regulating environment, but the monitoring technologies that are meant to enable efficiencies within these systems are less obviously able to generate efficiencies or action

within citizen practices. In a CSC scenario demonstrating the types of urban environmental citizenship made possible within the green and digital city, proposals are made for residents of Curitiba to experience enhanced and synchronized mass transit options while monitoring and reporting on air pollution at these nodes. Citizen reporting and community engagement are amplified by virtue of ICT connectivity. Through these monitoring and reporting capabilities, positive changes follow as a result of increased information and connectivity: gather the air pollution data, report to the relevant political body, and environmental justice will be realized. These activities and concerns are presented as universally applicable, in that anyone may have cause to monitor and collect pollution data and diligently forward this on to relevant governmental parties. The ambivital actions “coded” into these processes do not presuppose a particular subject, since a fully automated sensor may equally perform such a function. Rather, these programs of responsiveness allow for a fully interchangeable procession of human-to-machine or machine-to-machine data operations.

A similar trajectory is typically envisaged for self-regulating citizen activities: information on energy consumption will be made visible, a correcting action will be taken, and balance to the cybernetic-informational system will be restored. In these scenarios environmental technologies monitor environments and citizens, while citizens monitor environments and themselves. Citizens armed with environmental data are central democratic operators within these environments. But the “governing” contained within cybernetics may not neatly translate into the governing of environments.⁶⁴ It may be that the very responsiveness that enables citizens to gather data does not extend to enabling them to meaningfully act upon the data gathered, since this would require changing the urban “system” in which they have become effective operators. Similarly, dominant, if problematic, narratives within sustainability of continued growth through improved efficiency and ongoing monitoring typically do not mobilize an overall resource or waste reduction (what is well known within energy discourse as the “rebound effect”). Strategies of monitoring and efficiency might co-opt urbanites into modes of environmentality and biopolitics that leave modes of neoliberal power unexamined, since the aim of realizing sustainability objectives through citizen engagement is a worthy pursuit.

Foucault’s broader interest within the biopolitics lectures is in how neoliberal analyses are brought to bear on governance and subjects, such that economic logics of efficiency in-form what may have previously been understood through social or noneconomic modalities.⁶⁵ Environmentality describes the distribution of governance within environments as well as a qualification of governmentality through a market logic that would implement efficiency and productivity as the best guiding principles for urban ways of life. Individuals become governable to the extent that they operate as *homo economicus*,⁶⁶ where governance unfolds as an

environmental distribution of possible responses made according to the criteria of efficiency and maximum utility.

The transformation of citizens to data-gathering nodes potentially focuses the complexity of civic action toward a relatively reductive if legible set of actions. Participation in this smart and sustainable city is instrumentalized in terms of remedying environment issues through efficiency and devices that will harvest and connect up information to arrive at this outcome. Yet the informational- and efficiency-based approach to monitoring environments raises more questions about what constitutes effective environmental action than it answers. In order for such instrumentalization to occur, urban processes and participation directed toward sustainability, in many ways, must be programmed to be amenable to a version of (computational) politics that is able to operate on these issues. The modes of sensing as monitoring and responsiveness presented within many sensor-focused and smart-focused cities projects raise the question of whether a citizen might be more than an entity that emerges within the parameters of acceptable responsiveness.

FROM NETWORKS TO RELAYS, FROM PROGRAMS TO WAYS OF LIFE

The smart sustainable city vision discussed here is presented as a technical solution to political and environmental issues—an approach that is characteristic of many smart city projects. While the CSC and CUD project proposals are developed as conceptual-level design and planning documents, many of the questions raised here about how smart cities and citizen-monitoring projects organize political participation and the imagining of urban environmental citizenship are relevant for considering the proliferation of projects now taking place in these areas, both at the level of community engagement and through urban policy and development partnerships.⁶⁷

As I have argued, sustainable smart city proposals give rise to new modes of environmentality as well as biopolitical configurations of governance through distinctly digital *dispositifs*. Given Foucault's focus on the historical specificity of these concepts and the events to which they refer, it is timely to revisit and revise these concepts in the context of newly emerging smart city proposals. The environmentality, biopolitics 2.0, and digital political technologies that unfold through many smart city proposals are expressive of distributions of governance and operations of citizenship within programmed environments and technologies. A biopolitics 2.0 emerges within smart cities that involves the programming of environments and citizens for responsiveness and efficiency. Such programming is generative of political techniques for governing everyday ways of life, where urban processes, citizen engagements, and governance unfold through the spatial and temporal networks of sensors, algorithms, databases, and mobile platforms that constitute the environments of smart cities.

The environmentality that emerges through proposals for urban sustainability within the CSC project and many similar smart city projects involves monitoring, economizing, and producing a vision of digitalized economic growth. Such smart cities present ways of life that are orchestrated toward sustainability objectives characterized by productivity and efficiency. The data that develop through these practices are generative of practices of monitoring environments and activities, while activating environmental modes of governance that are found within the jurisdiction of public authorities as well as technology companies that own, manage, and use urban data. From Google Transit to Cisco TelePresence, HP Halo, and Toshiba Femininity, a range of environmental sensor and participatory technologies function in the CSC and other smart city scenarios that are tools of neo-liberal governance, and are operated across state and nonstate actors.

I have emphasized how Foucault's interest in environmentality can be advanced in the context of smart cities to consider how distributions of power within and through environments and environmental technologies are performative of the operations of citizenship—rather than of the individual *subjectness* of citizenship. The environmentalist aspects of the smart and sustainable city are not contingent on the production of an environmentalist or reflexively ecological subjectivity, and the performance of smart urban citizenship occurs not by expanding the possibilities of democratically engaged citizens but rather by delimiting the practices constitutive of citizenship. The “rules of the game” of the smart city do not articulate reversals, openings, or critiques of urban environmental ways of life. Rather, practices are made efficient, streamlined, and oriented toward enhancing existing economic processes. And yet, within this approach to environmentality through smart cities, what we might take as the rules or program of the smart city game might be understood less as a deterministic coding of cities and more as something that might unevenly materialize in practices and events. While design proposals put forward a persuasively singular case for the smart city program, inevitably multiple smart cities emerge through the circulation and implementation of this program.

Pushing Foucault's notion of environmentality even further, I suggest that his concept of the “rules of the game” might be recast in the context of smart cities less as rules and more as programs—here of responsiveness—that delimit and enable in particular ways but that also unfold, materialize, or fail in unexpected ways. If urban programs are not singular and are continually in process, then environmentality might also be updated to address the ways in which programs do not go according to plan, and work-arounds might also develop. Such an approach is not so much a simple recuperation of human resistance as a suggestion that programs are not fixed, and that in their unfolding and operating they inevitably give rise to new practices of urban environmental citizenship and ways of life that emerge across human and more-than-human urban entanglements.

This approach to ways of life is important in formulating not a simple denunciation of the smart city but rather a proposal for how to attend to the distinct environmental inhabitations and modalities of citizenship—and possibilities for urban collectives—that concretize in smart city proposals and developments. Subjectification, which Deleuze discusses as an important concept in Foucault's work, is ultimately concerned not with the production of fixed subjects but rather with the possibility of identifying, critiquing, and even creating ways of life.⁶⁸ Smart city projects require an attention to—and critique of—the ways of life that are generated and sustained in these proposals and developments. Critique, as articulated in a conversation between Deleuze and Foucault, can be an important way in which to experiment with political engagements and form “relays” between “theoretical action and practical action.”⁶⁹ From this perspective the ways of life proposed in the CSC scenarios might serve as provocation for thinking through how to experiment with urban imaginaries and practices in order not to be governed *like that*. If we read biopolitics 2.0 as a concept attentive to the ways of life that are generated and sustained within smart cities, and if this computational apparatus operates environmentally, then what new relays for theory and practice might emerge within our increasingly computational urbanisms?

[3]

Queerying Homophily

Wendy Hui Kyong Chun

To recap, in *Pattern Discrimination*:

1. YOU is always singular plural:
 - Recognition is never at the level of the individual
 - You = YOUS value
2. Machines engage in deep dreaming, creating patterns from noise.
 - Crab in = crap out
 - As with the gibbering muses, interpretation and hermeneutics enter through pattern discrimination, but now through the “back door”
 - We live in mythic times, but without knowing we do
3. The singularity of the market = the crapularity of the world:
 - the dumbing down of humans
 - the integration of subjectivity into information technologies
 - the reality of paranoia

4. To come out, we have to come in:

- we are inside when we think we are outside.
- Open societies need enemies to be “open”

This chapter continues these points by examining homophily—the axiom that similarity breeds connection—which grounds contemporary network science. If we are inside-out, it is because homophily, love as love of the same, closes the world it pretends to open; it makes cyberspace a series of echo chambers. This transformation ironically fulfills its purpose as a portal: a portal is an elaborate façade that frames the entrance to an enclosed space. Cyberspace was always a horizon trapped within in U.S. military-academic networks. Thus, to start with a more contemporary myth:

Once upon a time, a U.S. commerce-free, military, and academic inter-networking protocol, Transmission Control Protocol/Internet Protocol, became reborn as cyberspace. A consensual hallucination, it transformed TCP/IP into its opposite: a global, government-free, and anonymous space that was fundamentally discrimination-free (because if you can't see it, how can you hate it?). A decentralized network allegedly designed to survive a massive, catastrophic flattening (i.e., nuclear war), it would flatten all hierarchies through its boundless expansion. Unfortunately, things did not quite turn out as planned. Rather than an endless difference-free utopia, the internet became a series of poorly gated communities that spawned towering, hate- and terror-filled, racist—or to some even worse, banal, star-obsessed, cat-infested—echo chambers. This Internet made cyberpunk dystopian futures look banal in comparison. Rather than state-free, it became a breeding ground for state surveillance, in which governments spied on citizens, on foreign nationals, and on each other, and in which corporations perfected global tracking techniques. The future it augured looked even darker: the dusk of human spontaneity via the dawn of Big Data. Soon all human actions would be captured, calibrated, predicted,

and preempted. Networks, it would seem, were born free and yet everywhere were enchained.

*People bemoaned, accepted, or embraced this situation and offered various explanations for it. They revealed that the initial dreams of cyberspace were delusional (as if this was profound: the term “cyberspace,” after all, came from science fiction; William Gibson in *Neuromancer* described it as a “consensual hallucination”); they argued that the internet had to be purged of the anonymity (it never really had) because anonymity was the root of all evil (as if people were only obnoxious or nasty under cover); they pointed out that echo chambers were produced by “personalization”: corporate attempts to target individual consumers. What we were experiencing: the nightmare of buying “happily ever after.”*

This tale is both right and wrong. Yes, the internet changed dramatically after its opening/commercialization, but personalization alone is not the culprit—and purging the internet of anonymity will not make networks any less nasty. “Real Names” or unique identifiers lie at heart of Big Data analytics, for they are crucial to synching disparate databases and calibrating recycled data. Further, if Big Data predictive analytics work, it is not because everyone is treated like a special snowflake but because network analyses segregate users into “neighborhoods” based on their intense likes and dislikes. Further, it “trains” individuals to expect and recognize this segregation. Instead of ushering in a postracial, postidentitarian era, networks perpetuate identity via “default” variables and axioms. In network science, differences and similarities—differences as a way to shape similarities—are actively sought, shaped, and instrumentalized in order to apprehend network structures. Networks are neither unstructured masses nor endless rhizomes that cannot be cut or traced. Networks, because of their complexities, noisiness, and persistent inequalities, foster techniques to manage, prune, and predict. This new method—this pattern discrimination—makes older, deterministic, or classically analytic methods of control seem innocuous.

62 Homophily (love as love of the same) fuels pattern discrimination. The fact that networks perpetuate segregation should surprise no one because, again, segregation in the form of homophily lies at their conceptual core. Homophily launders hate into collective love, a transformation that, as Sara Ahmed has shown, grounds modern white supremacy (2004, 123). Homophily reveals and creates boundaries within theoretically flat and diffuse networks; it distinguishes and discriminates between allegedly equal nodes: it is a tool for discovering bias and inequality and for perpetuating it in the name of “comfort,” predictability, and common sense. Network and data analyses compound and reflect discrimination embedded within society. Like the trolls Whitney Phillips has diagnosed as the “grimacing poster children for the socially networked world,” they engage in “a grotesque pantomime of dominant cultural tropes” (2015, 8). Most broadly, this pattern discrimination is linked to a larger subsumption of democratic politics to neoliberal market economics, with its naïve overvaluing of openness (as discussed by Cramer in the preceding chapter) and authenticity (diagnosed brilliantly by Elizabeth Bernstein [2007]).

To intervene, we need to realize that this pantomime is not simply dramatic, it is also performative—it puts in place the world it discovers. It also depends on constantly repeated actions to create and sustain nodes and connections. We must thus embrace network analyses and work with network scientists to create new algorithms, new hypotheses, new grounding axioms. We also need to reembrace critical theory: feminism, ethnic studies, deconstruction, and yes, even psychoanalysis, data analytics’ repressed parent. Most crucially, what everyone needs now: training in critical ethnic studies.

Machine Learning: Money Laundering for Bias?

On June 19, 2016, Pinboard—an account linked to a site advertised as “Social Bookmarking for Introverts”—posted the following comment to *Twitter*: “Machine learning is like money laundering

for bias” (Pinboard 2016). This post, which was retweeted over a thousand times by the end of that summer, encapsulated growing suspicions about the objectivity of artificial intelligence and data-driven algorithms, suspicions confirmed by Cathy O’Neil in her remarkable *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* (2016). During this time period, news reports about biases embedded in machine learning abounded. Just two of the stories reported in the mainstream media the week of August 28, 2016, include news that:

- *Facebook* unexpectedly fired its news curators, in a delayed response to allegations that its editors deliberately suppressed conservative news, charges it had previously denied (Thielman 2016). This resulted, as *the Guardian* reported, in the algorithms going “crazy.” Among the top stories: a fraudulent one that then Fox News moderator Megyn Kelly was fired after she revealed that she was backing Hillary Clinton and a real video of a man masturbating with a McDonald’s sandwich. According to some, this was because Facebook had not addressed the human problem embedded in machine algorithms: *Fortune* contended that “getting rid of human editors won’t solve Facebook’s bias problem” because, in the end, the algorithms are written by human programmers (Ingram 2016).
- A coalition of civil liberties and civil rights organizations issued a statement against predictive policing technologies. According to this group, the crime data embedded in these programs poisoned the results. This data is “notoriously suspect, incomplete, easily manipulated, and plagued by racial bias” (Lartey 2016). These allegations followed a report by *Upturn* that revealed that these systems are not only overhyped, they also “reinforce disproportionate and discriminatory policing practices” (Robinson and Koepke 2016).

These are two of many. There are, as my coauthors have pointed out, many more instances of discriminatory algorithms. Other stories that broke in 2015–16 include news that:

- Google's photo app tagged two black people as "gorillas." Vivienne Ming, an artificial intelligence expert argued, "some systems struggle to recognize non-white people because they were trained on Internet images which are overwhelmingly white . . . the bias of the Internet reflects the bias of society." (Revealingly, Babak Hodjat, chief scientist at Sentinet Technologies, hypothesized that this error might have stemmed from the fact that the algorithm had not seen enough pictures of gorillas; Blarr 2015). This misrecognition of nonwhite people by cameras was hardly new: as Cramer also notes in his chapter in this volume, in 2009 it was revealed that HP Face-Tracking Webcams could not recognize black people, and the Nikon S360 asked its users if smiling Asians were "blinking" (see Frucci 2015; Lee 2009).
- The COMPAS software used by several U.S. courts to predict recidivism—and thus by some to determine sentencing and parole—was biased against racial minorities (Angwin et al. 2016).

These cases "revealed" well-documented biases that should not have been news. Historically, standard film stock was optimized for white skin; for the longest time, interracial filming was difficult not only for social reasons but also for technological ones (see Dyer 1997). As well, racial bias in sentencing within the United States has been debated and analyzed for years.¹ Further, racism within machine learning algorithms had been highlighted and predicted by numerous scholars: from Dr. Latanya Sweeney's revelation that "a black-identifying name was 25% more likely to get an ad suggestive of an arrest record" to predictions of price discrimination based on "social sorting"; from "inadvertent" and illegal discriminatory choices embedded in hiring software to biased risk profiles within terrorism-deterrence systems. These all highlighted the racism latent within seemingly objective systems, which, like money laundering, cleaned "crooked" data. To many, the solution was thus better, cleaner data: crime data, scrubbed free of police bias; more

images of black folks in libraries; more diversity within the tech industry, so technologies not tested on minorities would not reach the consumer market (Harris 2016). The problem, in other words, was the still-lingering digital divide.

Other analysts, however, pointed out that it is not simply a question of inclusion or exclusion but also of how differences are “latently” encoded. For example, Chicago police did not use overtly racial categories in their predictive policing algorithm to generate a “heat list” of those most likely to murder or be murdered, because they did not need to: their “neighborhood”-based system effectively discriminated on the basis of race (Saunders, Hunt, and Hollywood 2016). This system created “persons of interest” based on social ties (as well as personal history). As Kate Crawford and Jason Schultz have argued, Big Data compromises privacy protections afforded by the U.S. legal system by making personally identifiable information about “protected categories” legible (Crawford and Schultz 2014). As Faiyaz Al Zamal et al. (2012) have shown in their analysis of Twitter, latent attributes such as age and political affiliation are easily inferred via a user’s “neighbors.” These algorithms, in other words, do not need to track racial and other differences, because these factors are already embedded in “less crude” categories designed to predict industriousness, reliability, homicidal tendencies, et cetera. These algorithms can more precisely target key intersectional identities. Tellingly, Christopher Wylie—the Cambridge Analytica whistle-blower—told the *Guardian*’s Carole Cadwalladr that Steven Bannon was the only straight man Wylie’s ever talked to about feminist intersectional theory. Feminist intersectional theory was first developed by Kimberlé Crenshaw (Crenshaw 1991) to explain the violence against women of color—through Cambridge Analytica, it became a measure to understand “the oppressions that conservative, young white men feel” (Cadwalladr 2018). As Susan Brown (personal communication, June 2015) has noted, imagine what could be revealed in terms of location, class, and race through the category: buys organic bird feed.

66 Crucially, these algorithms perpetuate the discrimination they “find.” They are not simply descriptive but also prescriptive and performative in all senses of that word. Capture systems, as Phil Agre theorized in 1994, reshape the activities they model or “discover.” Through a metaphor of human activity as language, they impose a normative “grammar of action” as they move from analyzing captured data to building an epistemological model of the captured activity (364). The Chicago Police’s “heat list,” for instance, did not result in a reduction of homicides; it did, however, lead to subjects on the list being “2.88 times more likely than their matched counterparts to be arrested for a shooting” (Saunders, Hunt, and Hollywood 2016). It also possibly led to more homicides: those contacted by the police were afraid of being perceived as “snitches” by their neighbors (Gorner 2013). Networks create and spawn the reality they imagine; they become self-fulfilling prophecies (see Chun 2016; Healy 2015). Based on efficiency, they, like all performative systems, bypass questions of justice (see Lyotard 1984).

Performativity, however, does not simply mean the reformatting and reorganizing of the world “into line with theory” (Healy 2015, 175). Performative utterances, as Judith Butler and Jacques Derrida have argued, depend on iterability and community (Derrida 1988; Butler 1997). Butler in particular has revealed the inherent mutability of seemingly immutable and stable categories. Gender, she has argued, is performative: “it is real only to the extent that it is performed” (Butler 1988, 527). What we understand to be “natural” or “essential” is actually “manufactured through a sustained set of acts, positioned through the gendered stylization of the body . . . what we take to be an ‘internal’ feature of ourselves is one that we anticipate and produce through certain bodily acts, at an extreme, an hallucinatory effect of naturalized gestures” (Butler 1990, xv). These gestures and constant actions are erased/forgotten as they congeal into a “comfortable” fixed identity. As Sara Ahmed provocatively puts it: “regulative norms function in a way as repetitive strain injuries” (Ahmed 2004, 145). This understanding of performativity adds a further dimension to analyses of network

performativity, for this performativity courses through networks. As I've argued more fully in *Updating to Remain the Same* (Chun 2016), networks do not simply enact what they describe, their most basic units—nodes and ties—are also themselves the consequence of performative, habitual actions.

So: what would happen if we engaged, rather than decried, network performativity? How different could this pantomime called networks be? Crucially, to take up this challenge we must realize the expressive impact of our mute actions. If Big Data, as Antoinette Rouvroy among others have argued, devalues human language by privileging bodily actions over narratives, it does so via capture systems that, as Agre points out, translate our actions into “grammars of actions” (Rouvroy 2011). Our silent—and not so silent—actions register.

To take up this challenge, we also need to move beyond dismissing Big Data as hype and celebrating “missed” predictions as evidence of our unpredictability. The gap between prediction and actuality should not foster snide comfort, especially since random recommendations are increasingly deliberately seeded to provoke spontaneous behavior. The era of Big Data is arguably a future that we reach, if we do, asymptotically, and the fact that Big Data is hype is hardly profound: most of technology is. Further, Big Data poses fascinating computational problems (how does one analyze data that one can read in once, if at all?). The plethora of correlations it documents also raises fundamental questions about causality: If almost anything can be shown to be real (if almost any correlation can be discovered), how do we know what matters, what is true? The “pre-Big Data” example of the “Super Bowl predictor” nicely encapsulates this dilemma, for one of the best predictors of the U.S. stock market is the result of the Super Bowl: if an NFC team wins, it will likely be a bull market; if an AFC team wins, it will be a bear market (Silver 2012, 185). This example also poses the question: what does knowledge do? What is the relationship between knowledge and action? The best analogy for Big Data is the mapping of the human genome: before this mapping was actualized, it

68 was envisioned as the Holy Grail, or the Rosetta Stone for human illness. Rather than simply resulting in the cure for cancer and so forth, it raised new awareness about the importance of epigenesis, gene interactions, disease pathways, et cetera.

It is critical that we realize that the gap between prediction and reality is the space for political action and agency. Predictions can be “self-canceling” as well as self-fulfilling (Silver 2012, 219). Like global climate change and human population models, they can point to realities and futures to be rejected. They can, through their diagnosis, render impotent the predictive power of a symptom or enable new, unforeseen, grammars. To create new expressions, however, we need to read the scripts and analyze the set we find ourselves in the midst of, that is, the laboratory of network science.

Networks: The Science of Neoliberal Connections

At the most basic level, network science captures—that is, analyzes, articulates, imposes, instrumentalizes, and elaborates—connection (see the five stages of capture, Agre 1994). It is “*the study of the collection, management, analysis, interpretation, and presentation of relational data*”² (Brandes et al. 2013, 3). Described as fundamentally interdisciplinary, it brings together physics, biology, economics, social psychology, sociology, and anthropology. Put more extremely, it merges the quantitative social sciences with the physical and computer sciences in order to bypass or eliminate the humanities and media studies, two fields also steeped in theories of representation and networks. According to the acclaimed network scientist and author Albert-László Barabási, network science obviates the need for human psychology: “In the past, if you wanted to understand what humans do and why they do it, you became a card-carrying psychologist. Today you may want to obtain a degree in computer science” This is because network science, combined with “increasingly penetrating digital technologies,” places us in “an immense research laboratory that, in size,

complexity, and detail, surpasses everything that science has encountered before.” This lab reveals “the rhythms of life as evidence of a deeper order in human behavior, one that can be explored, predicted, and no doubt exploited” (Barabási 2010, 11). Network science unravels a vast collective unconscious, encased within the fishbowl of digital media.³ It is the bastard child of psychoanalysis: there are no accidents, no innocent slips of the tongue. Each action is part of a larger pattern/symptom. The goal: to answer that unanswerable question, what do (wo)men want?

Network science responds to increased global connectivity and capitalism, to “a growing public fascination with the complex ‘connectedness’ of modern society” (Easley and Kleinberg 2010, 11). As Duncan Watts, a pioneer in this field, explains, “if this particular period in the world’s history had to be characterized in any simple way, it might be as one that is more highly, more globally, and more unexpectedly connected than at any time before it.” Network science is crucial to mapping and navigating “the connected age” (Watts 2004).

Network science is a version of what Fredric Jameson once called “cognitive mapping” (Jameson 1990). It is the neoliberal cure for postmodern ills (see Chun 2016). Postmodernism, according to Jameson, submerged subjects “into a multidimensional set of radically discontinuous realities, whose frames range from the still surviving spaces of bourgeois private life all the way to the unimaginable decentering of global capital itself” (Jameson 1991, 413). Because of this, they were profoundly disoriented, unable to connect their local experience (authenticity) to global systems (truth). To resolve this situation, Jameson called for cognitive mapping, a yet imaginable form of political socialist art, which corresponded to “an imperative to grow new organs, to expand our sensorium and our body to some new, yet unimaginable, perhaps ultimately impossible, dimensions” (39). Like the cognitive mapping Jameson envisioned, network science lifts the fog of postmodernism by revealing the links between the individual to the totality in which she lives. Unlike Jameson’s vision, it is hardly socialist or empowering.

70 Rather than enabling humans to grow new organs, it contracts the world into a map: it forces a mode of authenticity shaped to an artificially intelligent truth.

Network science reduces real-world phenomena to a series of nodes and edges, which are in turn modeled to expose the patterns governing seemingly disparate behaviors, from friendship to financial crises. This mapping depends on dramatic simplifications of real world phenomena.⁴ In fact, these “discovered” relations are vast simplifications of vast simplifications, with each phase of network theory—initial abstraction/representation followed by mathematical modeling—producing its own type of abstraction. The first is “applied” and “epistemological”: It suggests and explicates “for given research domains, how to abstract phenomena into networks. This includes, for example, what constitutes an individual entity or a relationship, how to conceptualize the strength of a tie, etc.” (Easley and Kleinberg 2010, 2). Most simply, in this stage, one decides what is a node, what is an edge, and how they should be connected. The second is “pure” network theory, for it deals “with formalized aspects of network representations such as degree distributions, closure, communities, etc., and how they relate to each other. In such pure network science, the corresponding theories are mathematical—theories of networks” (5). In this second phase, the goal is to build a model that reproduces the abstraction produced in stage one. Whatever does so is then considered true or causal. This two-step process highlights the tightrope between empiricism and modeling that network science walks: network science models not the real world but rather the initial representation and truth is what reproduces this abstraction.

These abstract relations reveal and construct a complex relationship between the local and the global. Fundamentally, network science is nonnormative: it does not assume that aggregate behaviors stem from identical agents acting identically. It connects previously discontinuous scales—the local and global, the micro and the macro—by engaging dependencies that were previously “filtered” or controlled for. It, as the authors of the inaugural

volume of *Network Science* explain, differs from other sciences in its evaluation of dependency and structure. Rather than defining the domain of variables as a simple set without a structure, it assumes “at least some variables . . . to have structure. The potentially resulting dependencies are not a nuisance but more often than not they constitute the actual research interest” (Brandes et al. 2013, 8).⁵ These dependencies go beyond correlations within actor attribute variables (such as the relation between income and age) to encompass the entire set of network variables. Network variables are themselves defined in terms of pairs, which are valued according to their degree (or not) of connection (for instance, 1 for connected; 0 for not). These variables in turn affect one another: “the crucial point is that the presence of one tie may influence the presence of another. . . . While this will appear an unfamiliar point of view to some, it is merely a statement that networks may be systematically patterned. Without dependence among ties, there is no emergent network structure (Brandes et al. 2013, 10).⁶ At all levels, networks are dynamic and interdependent. What matters then is understanding and creating interdependencies.

Currently, modeling these interdependencies—tying global events to individual interactions—entails the marriage of graph theory with game theory, or other agent-based modeling. Computer scientist Jon Kleinberg’s collaboration with economist David Easley exemplifies this fruitful combination. In their canonical and excellent textbook, *Networks, Markets, and Crowds*, based on their class at Cornell (now a popular EdX MOOC with Eva Tardos), they explain that understanding networks requires apprehending two levels of connectedness: “connectedness at the level of structure—who is connected to whom—and . . . connectedness at the level of *behavior*—the fact that each individual’s actions have implicit consequences for the outcomes of everyone in the system” (Easley and Kleinberg 2010, 4). Global concerns impact local decisions, and local effects often only manifest themselves at global scales.⁷ Network science thus spans the two extremes—macro-level structure and micro-level behavior—by mapping the

72 ways that “macroscopic effects . . . arise from an intricate pattern of localized interactions” (6). *Networks, Markets, and Crowds* explicitly draws from graph theory and game theory, showing how this combination can explain seemingly “irrational” phenomena such as information cascades.

As the turn to game theory reveals, a market-based logic permeates network science models (a theme pursued later in this series by the *Markets* book by Armin Beverungen, Philip Mirowski, Edward Nik-Khah, and Jens Schroeter). Most generally, capture systems are justified and praised as inherently more efficient and empowering (and thus more democratic) than older disciplinary or firm-based ones. Agre hypothesizes that

the computer practitioner’s practice of capture is instrumental to a process by which economic actors reduce their transaction costs and thereby help transform productive activities along a trajectory towards an increasingly detailed reliance upon (or subjection to) market relations. The result is a generalized acceleration of economic activity whose social benefits in terms of productive efficiency are clear enough but whose social costs ought to be a matter of concern. (Agre 1994, 121–22)

Most succinctly: capture systems transform all transactions into market-based ones so that computerization = liberalization. Although Agre stresses that this relation is historically contingent and itself the product of a “kind of representational crusade” (120), he nonetheless hypothesizes that this relation, which “presupposes that the entire world of productive activities can be conceptualized, *a priori*, in terms of extremely numerous episodes of exchanges among economic actors,” constitutes the political economy of capture (121). The language of “costs” not only underlies Agre’s own critical language, it also litters the literature on networks: from attempts to model (and thus understand) collective action and critical mass (Centola 2013) to those that map differential networking techniques of women and minorities (Ibarra 1993) to those that

model social learning (DiMaggio and Garip 2012); from those that seek to identify the impact of influential or susceptible members of social networks (Aral and Walker 2012) to those that analyze the “payoffs” of social capital within immigrant networks (Ooka and Wellman 2006). As this last example reveals, this market-based logic also presumes the existence of “social capital,” a concept Pierre Bourdieu tied to group membership and accreditation.⁸

In the current literature, social capital explains lingering inequality among individuals. It explains disparities in success that cannot be explained in terms of individual differences in “human capital,” that is, differences in intelligence, physical appearances, and skill (Burt 2002). According to sociologist Ronald S. Burt, social capital is a “metaphor or advantage” within a society “viewed as a market in which people exchange all variety of goods and ideas in pursuit of their interests.” It reveals that

the people who do better are somehow better connected. Certain people or certain groups are connected to certain others, trusting certain others, obligated to support certain others, dependent on exchange with certain others. Holding a certain position in the structure of these exchanges can be an asset in its own right. That asset is social capital, in essence, a concept of location effects in differentiated markets. (Burt 1992, 150)

A relational form of capital, it grants advantage to those who invest in social relations. It thrives off “trust” and obligation.

Marion Fourcade and Kieran Healy have refined this notion of relational capital, arguing that this form of capital is really “über-capital,” which is tied to “one’s position and trajectory according to various scoring, grading, and ranking methods. . . . An example would be the use of credit scores by employers or apartment owners as an indicator of an applicant’s ‘trustworthiness’” (Fourcade and Healy 2016, 10).⁹ Fourcade and Healy’s analysis thus reveals the actuarial mechanisms that construct the “trust” that Burt assumes. The term “über” denotes “the meta-, generalized,

74 or transcendent, nature of this capital, largely stored in the “cloud”. . . . the term *über* also connotes something or someone who is extra-ordinary, who stands above the world and others . . .” (23). This form of capital categorizes consumers based on their “habitus” in order to make “good matches” between products and consumers. Crucially, the categories employed by corporations do not explicitly reference race/gender/class, for they are based on actions rather than inherent traits. Thus,

everyone seems to get what they deserve. Eschewing stereotypes, the individualized treatment of financial responsibility, work performance, or personal fitness by various forms of predictive analytics becomes harder to contest politically, even though it continues to work as a powerful agent of symbolic and material stratification. In other words, *Übercapital* subsumes circumstance and social structure into behavior. (33, 38)

The emphasis—in all capture systems—is on translating and figuring actions.

As the above discussions of social capital and capture imply, network science, as currently formulated, is the science of neoliberalism. To be clear, this is not to blame network science for neoliberalism—or to claim that network scientists are inherently neoliberal—but to highlight the fact that the many insights network science currently produce are deeply intertwined with the neoliberal system they presuppose. Neoliberalism, as Wendy Brown has argued, is based on inequality and “financialized human capital”: “When we are figured as human capital in all that we do and in very venue,” she reveals, “equality ceases to be our presumed natural relation with one another” (Brown 2015, 179). Brown elucidates the social impact of capture systems, with their relentless rendering of all human actions in terms of “transactions costs,” namely the destruction of democracy through the reduction of “freedom and autonomy to unimpeded market behavior and the meaning of citizenship to mere enfranchisement.” Crucially,

this evisceration of robust norms of democracy is accompanied by unprecedented challenges to democratization, including complex forms and novel concentrations of economic and political power, sophisticated marketing and theatricality in politics, corporately owned media, and a historically unparalleled glut of information and opinion that, again, produced an illusion of knowledge, freedom, and even participation in the face of their opposites. (179)

These unprecedented challenges enumerated by Brown are exactly the challenges that network science manages by reducing public life to “problem solving and program implementation, a casting that brackets or eliminates politics, conflict, and deliberation about common values or ends” (127). Network science, as the rest of this chapter will explain, valorizes consensus, balance, and “comfort”: it validates and assumes segregation by focusing on individual “preference,” rather than institutional constraints and racism.

That is, to complement Fourcade and Healy’s analysis and to draw from my *Updating to Remain the Same: Habitual New Media*, we need to understand how seemingly individualized scores coincide with “older” racial and class categories. Network categorizations do not only depend on your actions but on actions of your so-called neighbors—you are constantly compared to and lumped in with others. Advertisers divide the population into types such as “rising prosperity” and then subdivide that category into others such as “city sophisticates,” which in turn produces categories such as “townhouse cosmopolitans” (see ACORN, developed by CACI). Neoliberalism destroys society by proliferating neighborhoods. Networks preempt and predict by reading all singular actions as indications of larger collective habitual patterns, based not on our individual actions but rather the actions of others. Correlations, that is, are not made based solely on an individual’s actions and history but rather the history and actions of others “like” him or her. Through the analytic of habits, individual actions coalesce bodies into monstrously connected chimeras. That is, if as Barabási argues, “in order to predict the future, you first need

76 to know the past” and if information technologies have made uncovering the past far easier than before, they have done so not simply through individual surveillance but through homophily (McPherson, Smith-Lovin, and Cook 2001). Homophily is the mechanism by which individuals “stick” together, and “wes” emerge. It is crucial to what Sara Ahmed has diagnosed as “the cultural politics of emotion”: a circulation of emotions as a form of capital.

Homophily: Laundering “Our” Past

At the heart of network science is the principle of homophily: the axiom that “similarity breeds connection” (McPherson, Smith-Lovin, and Cook 2001). Homophily structures networks by creating clusters; by doing so, it also makes networks searchable (Marsden 1988; Jackson 2008). Homophily grounds network growth and dynamics, by fostering and predicting the likelihood of ties. Homophily—now a “commonsense” concept that slips between effect and cause—assumes and creates segregation; it presumes consensus and similarity within local clusters, making segregation a default characteristic of network neighborhoods. In valorizing “voluntary” actions, even as it troubles simple notions of “peer influence” and contagion, it erases historical contingencies, institutional discrimination, and economic realities (Kandel 1978; Aral, Muchnik, and Sundaraajan 2013). It serves as an alibi for the inequality it maps, while also obviating politics: homophily (often allegedly of those discriminated against)—not racism, sexism, and inequality—becomes the source of inequality, making injustice “natural” and “ecological.” It turns hate into love and transforms individuals into “neighbors” who naturally want to live together, which assumes that neighborhoods should be filled with people who are alike. If we thus manage to “love our neighbor”—once considered a difficult ethical task—it is because our neighbors are virtually ourselves. Homophily makes anomalous conflicting opinions, cross-racial relationships, and heterosexuality, among many other things.

According to Miller McPherson, Lynn Smith-Lovin, and James Cook, in their definitive review article on homophily, “the homophily principle . . . structures network ties of every type, including marriage, friendship, work, advice, support, information transfer, exchange, co-membership, and other types of relationship” (2001, 415). As a result, “people’s personal networks are homogeneous with regard to many sociodemographic, behavioral, and intrapersonal characteristics.” Rather than framing homophily as historically contingent, they understand it as fundamental and timeless: indeed, they start their review with quotations from Aristotle and Plato about similarity determining friendship and love (which they admit in a footnote may be misleading, since Aristotle and Plato also claimed that opposites attract—indeed, homophily renders heterosexuality anomalous—a mysterious fact to be explained). Homophily, according to McPherson et al., is the result of and factor in “human ecology” (415).

Homophily sits at the fold between network structure and individual agency. As McPherson et al. summarize the “remarkably robust” patterns of homophily across numerous and diverse studies, they also break down homophily into two types: baseline homophily (“homophily effects that are created by the demography of the potential tie pool”) and inbreeding homophily (“homophily measured as explicitly over and above the opportunity set”) (419). McPherson et al. also reiterate Paul F. Lazarsfeld and Robert K. Merton’s influential division of homophily into “status homophily,” and “value homophily”:

Status homophily includes the major sociodemographic dimensions that stratify society—ascribed characteristics like race, ethnicity, sex, or age, and acquired characteristics like religion, education, occupation, or behavior patterns. Value homophily includes the wide variety of internal states presumed to shape our orientation toward future behavior. (McPherson, Smith-Lovin, and Cook, 419)

In their review, the authors note that race and ethnicity are clearly the “biggest divide in social networks today in the United States,”

78 due both to baseline and inbreeding homophily" (420). They list the following causes of homophily: geography ("the most basic source of homophily is space," (429); family ties (431); organizational foci, occupational, family, and informal roles (80); cognitive processes (434); and selective tie dissolution (435). Remarkably missing are: racism and discrimination, at personal or institutional levels, and history. In the world of networks, love, not hate, drives segregation.

Given that the very notion of homophily emerges from studies of segregation, the "discovery" of race as a divisive factor is hardly surprising. Lazarsfeld and Merton's 1954 text, in which they coined the terms "homophily" and "heterophily" (inspired by friendship categorizations of the "savage Trobrianders whose native idiom at least distinguishes friendships within one's in-group from friendships outside this social circle") analyzes friendship patterns within two towns: "Crafttown, a project of some seven hundred families in New Jersey, and Hilltown, a bi-racial, low-rent project of about eight hundred families in western Pennsylvania" (Lazarfeld and Merton 1954, 18–66, 23, 21). Crucially, they do not assume homophily as a grounding principle, nor do they find homophily to be "naturally" present. Rather, documenting both homophily and heterophily, they ask: "what are the dynamic processes through which the similarity or opposition of values shape the formation, maintenance, and disruption of close friendships?" (28). Homophily in their much-cited chapter is one instance of friendship formation—and one that emerges by studying the interactions between "liberal" and "illiberal" white residents of Hilltown (27). The responses of the black residents were ignored, since all these residents were classified as "liberal." As Samantha Rosenthal has noted, the very concept of value homophily is thus enfolded within status homophily (personal correspondance). Value and status are not separate—and value increasingly is used as a "code word" for race- and class-based distinctions. The implications of this segregation have been profound for the further development of network principles, as well as U.S. housing policy.

This history has been erased in the current form of network science, in which homophily has moved problem to solution. In the move from “representation” to “model,” homophily is no longer something to be accounted for, but rather something that “naturally” accounts for and justifies persistence of inequality within facially equal systems. It has become axiomatic, that is, common sense, thus limiting the scope and possibility of network science.¹⁰ As Easley and Kleinberg—again two of the most insightful and important scholars working in the field—explain: “one of the most basic notions governing the structure of social networks is *homophily*—the principle that we tend to be similar to our friends.” To make this point, they point to the distribution of “our” friends. “Typically,” they write,

your friends don’t look like a random sample of the underlying population. Viewed collectively, your friends are generally similar to you along racial and ethnic dimensions: they are similar in age; and they are also similar in characteristics that are more or less mutable, including the places they live, their occupations, their interests, beliefs, and opinions. Clearly most of us have specific friendships that cross all these boundaries; but in aggregate, the pervasive fact is that links in a social network tend to connect people who are similar to one another. (Easley and Kleinberg, 78)

Homophily is a “pervasive fact” that governs the structure of networks. As a form of natural governance—based on presumptions about “comfort”—it grounds network models, which not surprisingly also “discover” segregation.¹¹ Like many other texts, Damon Centola et al.’s analysis in “Homophily, Cultural Drift, and the Co-Evolution of Cultural groups,” lists “comfort” as one of the reasons “why homophily is such a powerful force in cultural dynamics.” Referencing the work of Lazarsfeld and Merton, Centola states: “Psychologically, we often feel justified in our feel more comfortable opinions when we are surrounded by others who share the same beliefs—what Lazarsfeld and Merton (1954) call

80 “value homophily” . . . we also feel more comfortable when we interact with others who share a similar background (i.e., status homophily)” (Centola et al. 2007, 906). To model the effects of cultural drift—and thus to show why globalization does not/will not impose a monoculture—the authors make the following assumption:

in our approach to studying cultural dynamics, if cultural influence processes create differentiation between two neighbors such that they have no cultural traits in common, we allow these individuals to alter the structure of the social network by dropping their tie and forming new ties to other individuals. Thus, in our specification of homophily, the network of social interactions is not fixed . . . but rather evolves in tandem with the actions of the individuals. (908)

Embedded, then, in the very dynamics of network science is the presumption that there can be no neighbors without common cultural traits. Remarkably, this assumption uses Lazarsfeld and Merton’s work—which, as noted earlier, did not find homophily to be “natural”—to ground their model’s dynamics. Not surprisingly, Centola et al. “discover” that homophily creates “cultural niches” (926). Homophily, in so many ways, “governs” networks structure.

The point is this: although many authors such as Easley and Kleinberg insist that homophily “is often not an end point in itself but rather the starting point for deeper questions—questions that address why the homophily is present, how its underlying mechanisms will affect the further evolution of the network, and how these mechanisms interact with possible outside attempts to influence the behavior of people in the network” (83), homophily as a starting point cooks the ending point it discovers. Not only does it limit the databases used for models—these studies often draw from the same database, such as the National Longitudinal Study of Adolescent Health (ADD Health) or Facebook or Myspace, since these studies already include “friend” as a category—homophily also accentuates the clusters network science “discovers.” In

particular, homophily both accounts for and accentuates “triadic closure,” another fundamental and “intuitive” principle of networks, which posits that “if two people in a social network have a friend in common, then there is an increased likelihood they will become friends themselves at some point in the future” (44). Although sometimes considered as a “structural” cause outside of homophily, it also presumes homophilous harmony and consensus. The reasons often given for this “very natural” phenomena are: opportunity (if A spends time with both B and C, then there is an increased chance that they will become friends), trust, and incentive (“if A is friends with B and C, then it becomes a source of latent stress in these relationship if B and C are not friends with each other” [45]). Network science posits nonconnection as unsustainable—a cause of stress. Conflict as a tie is difficult to conceive. Crucially, social networks such as Facebook (again the model organism for network science) amplify the effects of “triadic closure” and “social balance.” By revealing the friends of friends—and by insisting that friendship be reciprocal—it makes triadic closure part of its algorithm: it is not simply predicted, it is predicative. As Andreas Wimmer and Kevin Lewis point out in “Beyond and Below Racial Homophily: ERG Models of a Friendship Network Documented on Facebook,” Facebook’s demands for reciprocity produces homophilous effects (Wimmer and Lewis 2010).

Again, homophily not only erases conflict, it also naturalizes discrimination. Segregation is what’s “recovered” and justified if homophily is assumed. Easley and Kleinberg state quite simply that “one of the most readily perceived effects of homophily is the formation of ethnically and racially homogeneous neighborhoods in cities” (96). To explain this, they turn to the “Schelling model” of segregation, a simulation that maps the movement of “two distinct types of agents” in a grid. The grounding constraint is the desire of each agent “to have at least some other agents of its own as type of neighbors” (97). Showing results for this simulation, they note that spatial segregation happens even when no individual agent seeks it: the example for $t = 4$ (therefore, each agent would be happy as

82 a minority) yields overwhelmingly segregated results. In response, they write:

Segregation does not happen because it has been subtly built into the model: agents are willing to be in the minority, and they could all be satisfied if only we were able to carefully arrange them in an integrated pattern. The problem is that, from a random start, it is very hard for the collection of agents to find such integrated patterns. . . . In the long run, the process tends to cause segregated regions to grow at the expense of more integrated ones. The overall effect is one in which the local preferences of individual agents have produced a global pattern that none of them necessarily intended.

This point is ultimate at the heart of the model: although segregation in real life is amplified by a genuine desire within some fraction of the population to belong to large clusters of similar people—either to avoid people who belong to other groups, or to acquire a critical mass of members from one's own group—such factors are not necessary for segregation to occur. The underpinnings of segregation are already present in a system where individuals simply want to avoid being in too extreme a minority in their own local area. (101)

I cite this at length because this interpretation reveals the dangers of homophily. The long history and legacy of race-based slavery within the United States is completely erased, as well as the importance of desegregation to the civil rights movement. There are no random initial conditions. The “initial conditions” found within the United States and the very grounding presumption that agents have a preference regarding the number of “alike” neighbors are problematic. This desire not to be in a minority—and to move if one is—maps most accurately the situations of white flight, a response to desegregation. Further, if taken as an explanation for gentrification, it portrays the movement of minorities to more affordable and less desirable areas as voluntary, rather than as the

result of rising rents and taxes. Most importantly, if it finds that institutions are not to blame for segregation, it is because institutional actions are rendered invisible in these models.

Thomas C. Schelling's original publication makes this deliberate erasure of institutions and economics, as well as its engagement with white flight (or "neighborhood tipping"), clear. His now classic "Dynamic Models of Segregation" was published in 1971, during the heart of the civil rights movement and at the beginning of forced school desegregation.¹² Schelling, in his paper, acknowledges that he is deliberately excluding two main processes of segregation: organized action (it thus does not even mention the history of slavery and legally enforced segregation) and economic segregation, even though "economic segregation might statistically explain some initial degree of segregation" (145). Economic assumptions, however, are embedded at all levels in his model. Deliberate analogies to both economics and evolution ground his analysis of the "surprising results" of unorganized individual behavior.¹³ He uses economic language to explain what he openly terms "discriminatory behavior."¹⁴ At the heart of his model lies immutable difference: "I assume," he asserts,

a population exhaustively divided into two groups; everyone's membership is permanent and recognizable. Everybody is assumed to care about the color of the people he lives among and able to observe the number of blacks and whites that occupy a piece of territory. Everybody has a particular location at any moment; and everybody is capable of moving if he is dissatisfied with the color mixture where he is. The numbers of blacks and whites, their color preferences, and the sizes of 'neighborhoods' will be manipulated. (149)

These assumptions are troubling and loaded. They erase the history of redlining and other government sanctioned programs that made it almost impossible for black citizens to buy homes in certain neighborhoods, while helping white citizens buy homes

84 in new developments (Rothstein 2017). They also cover over the oftentimes troubling fluidity of racial identity within the United States, in particular the “one drop rule,” which grounded segregation and effectively made black and white identity *not* about visible differences. As well, homophily maps hate as love. How do you show you love the same? By running away when others show up.

The erasure of history and qualitative theories about race, gender, and sexuality within social network models represents and reproduces troubling assumptions that many, within the humanities especially (but not only: think here of the overwhelming notion of the United States as “postracial” during the beginning of the Obama presidency) had thought were history. Judith Butler’s definitive analysis of gender performativity at the end of the last century, combined with work in queer theory and trans studies, has made gender mutability a default assumption. The critique of race as socially constructed, which gained widespread acceptance after the horrors of the Holocaust, have been buttressed by careful historical, empirical, and theoretical studies: from Michael Omi and Howard Winant’s canonical *Racial Formation in the United States* (1994) to Alondra Nelson’s analysis of the genetics and race in the *Social Life of DNA: Race, Reparations, and Reconciliation after the Genome* (2016), from Paul Gilroy’s controversial and provocative *Against Race: Imagining Political Culture beyond the Color Line* (2000) to Grace Elizabeth Hale’s thorough examination of the Southern myth of absolute racial difference in *Making Whiteness: The Culture of Segregation in the South, 1890–1940* (1998).

Combined with so many more works, these texts document the rise of the modern concept of race during the era of Enlightenment; its centrality to colonization and slavery; its seeming zenith during the era of eugenics; its transformations after World War II; and its resurgence as an “invisible” marker in genetics. All of this is ignored within network science, when “race,” “gender,” and other differences are solidified as node characteristics. All of this drives twenty-first century echo chambers and politics. So what to do?

Crucially, simply insisting on the fluidity of racial categories or “deconstructing” assumptions is not enough. Some work in network science does question assumptions behind racial homophily. As mentioned previously, Andreas Wimmer and Kevin Lewis have revealed that effects, understood as caused by “racial homophily,” are usually caused by other factors: from homophily among coethnic groups rather than racial groups (so, underlying “Asian” homophily are tendencies of South Asians to befriend South Asians; Chinese other Chinese, et cetera) to homophily based on “socioeconomic status, regional background, and shared cultural taste” (143), to the “balancing mechanisms” employed by social media sites. (Importantly, this study was based on an extensive analysis of Facebook pages of an entire college cohort of 1,640 students.) Although this work in intersectionality is important, it is not enough, especially since intersectionality, as mentioned earlier, is exactly what “proxy factors” target, and also because this work still assumes homophily, but at different “ethnic” levels.

To create a different world, we need to question default assumptions about homophily. As Sara Ahmed has argued in *The Cultural Politics of Emotion*, “love of the same” is never innocent: white supremacist love, for instance, is based on a hatred of others (Ahmed 2004). The movement away from others, which grounds models of homophily, reveals the extent to which hatred precedes homophily. The hatred that networks foster, then, should surprise no one. Hatred, Ahmed stresses, organizes bodies. It is an emotional “investment” that makes certain bodies responsible for pain or injury. It organizes by bringing things and bodies together—by linking certain figures together so they become a common threat, an X to “our” O. Hate transforms the particular into the general: it transforms individuals into types so they become a common threat (I hate you because you are Y). It also transforms *Is* into *wes* who are threatened by this other. Homophily is never innocent: the very construction of Xs and Os, who define their discomfort in relation

86 to the presence of others, reveals hatred, not love. Hatred is what makes possible strong bonds that define a core against a periphery. Thus, it is not only that network science seemingly makes the modeling of conflict impossible, it does so while also hiding conflict as friendship.

What this makes clear is the following: rather than mutual ignorance, apathy, or revulsion, what is needed is engagement, discussion, and yes, even conflict, in order to imagine and perform a different future. The proliferation of echo chambers and the erasure of politics is not inevitable—we can make them self-canceling prophecies. Although this will entail more than different network algorithms, these algorithms are a good place to start. What if we heeded Safiya Noble's analysis of how Google searches spread sexism and racism, and her call for better, public search engines (2018)? What if we took up Joanne Sison and Warren Sack's challenge to build democratic search engines, that is, search engines that gave users the most diverse rather than the most popular results)? How would this challenge assumptions about the "power law" (rich get richer; poor get poorer), which these algorithms foster, as well as discover? What would happen if ties did not represent friendship but rather conflict? What other world would emerge if clusters represented difference rather than similarities? What other ways would be revealed of navigating the world and of making recommendations?

Vi Hart, in her remarkable remodeling of Schelling—*The Parable of the Polygons* (2017)—makes explicit the relationship between initial conditions and history. Further, her model takes the desire for desegregation, rather than segregation, as the default. The lessons learned are thus:

1. Small individual bias → Large collective bias.
When someone says a culture is shapist, they're not saying the individuals in it are shapist. They're not attacking you personally.

2. The past haunts the present.

Your bedroom floor doesn't stop being dirty just coz you stopped dropping food all over the carpet. Creating equality is like staying clean: it takes work. And it's always a work in progress.

3. Demand diversity near you.

If small biases created the mess we're in, small anti-biases might fix it. Look around you. Your friends, your colleagues, that conference you're attending. If you're all triangles, you're missing out on some amazing squares in your life—that's unfair to everyone. Reach out, beyond your immediate neighbors. (Hart and Case 2017)

Fox Harrell, a pioneer in computational media studies, also offers a different way to engage computational modeling. Fox Harrell's work asks: how can A.I. generate new and more humane interactions? In contrast to most computational identity systems that incorrectly *reify* identity categories by implementing them as simple data fields (e.g., selecting gender from a brief drop-down menu) or a collection of attributes (e.g., races represented as modifiers to numerical statistics and constrained graphical characteristics in computer games), he has developed the AIR (Advanced Identity Representation) project to produce "computational models of *subjective* identity phenomena related to categorization such as specific forms of marginalization that are overlooked in engineering" (Harrell 2013, 1). Crucially, systems he has built, such as *Chimeria: Gatekeeper*, confront users with the fluidity of racial identifications and the difficulties of managing discrimination based on stereotypes and the limitations of passing. Further, his analyses of existing systems and user interactions with his systems based on "archetypal analyses," exposes and analyzes the "ideal players" embedded within popular games and how they can perpetuate stereotypes through the actions they enable and prohibit. For instance, he reveals how certain "species" within games line up

88 with certain stereotypical assumptions about races, as well as how user actions with differently gendered avatars reveal assumptions about gender.

Harrell's work most critically engages the creativity embedded within artificial intelligence. *Phantasmal Media: An Approach to Imagination, Computation, and Expression* (2013), drawn from his work with Define Me and GRIOT, groundbreaking social networking and expressive A.I. projects, asks: can A.I. have the same impact as great literature, such as Ralph Ellison's *Invisible Man*? That is, through its powerful imagery and literary innovations, can A.I. enable its readers to experience the world of social invisibility? Can A.I. imagine different, more just worlds, while also exposing the extent to which society and ideology are linked to the imagination? To produce computational and interactive narratives that do this, Harrell in his first book developed a theory of phantasmal media, in which a phantasm is a combination of imagery and ideas. By focusing on the role of phantasms, Harrell addresses not simply the centrality of the imagination to individual experience but also the relationship between individuals and larger cultural and political issues. Significantly, Harrell does not simply condemn phantasms as unreal and unjust but rather reveals how they can be both empowering and oppressive. They are forms of agency play. Through a comparative analysis that reveals the experiences of those normally excluded from mainstream society, his work thus both exposes the negative impact of phantasms and produces new phantasms that allow his users to imagine new worlds. That is, his work in cultural computing makes visible cultural phantasms in order to diversify the range and impact of computing systems. For instance, by revealing the cultural phantasms behind notions of grey/black sheep (persons who do not fit nicely into preconceived identity and behavioral categorizations), Harrell transforms them from errors into rich sources of knowledge. As well (and as noted earlier), critical computing enables empowerment and agency, where agency is not the freedom to do anything one wants but rather the situated mechanisms for user action within the context

of cultural phantasms. By thinking expressive, cultural, and critical computing together, Harrell shows how embodied individual experiences are created and how the social and the computational are linked together through the phantasmal.

As well as this new type of artificial intelligence, new theories of connection—which do not presume a dangerously banal and reciprocal notion of friendship—are needed. Rather than similarity as breeding connection, we need to think, with Ahmed, through the generative power of discomfort. We need to queer homophily, a concept that should in its very nature be queer. Ahmed views queerness as an inability to be comfortable in certain norms:

To feel uncomfortable is precisely to be affected by that which persists in the shaping of bodies and lives. Discomfort is hence not about assimilation or resistance, *but about inhabiting norms differently*. The inhabitation is generative or productive insofar as it does not end with the failure of norms to be secured, but with the possibilities of living that do not “follow” those norms through. (emphasis in original, 155).

To be uncomfortable, then, is to inhabit norms differently, to create new ways of living with others—different ways of impressing upon others. Working with Ahmed and others, we can imagine new defaults, new forms of engagement. Different, more inhabitable, patterns.

We also need to examine theoretical moves and assumptions within the humanities. That the humanities and cultural theory more generally have moved away from questions of cultural difference and identity at a time when such an engagement could not be more crucial is mind-boggling. The various turns toward “less coarse” and “static” concepts such as nonhuman allure (themselves inspired by networks and new media), not to mention the embrace of an instrumentalist technological logic that demeans critical analysis and celebrates digital tinkering, are oddly contradictory and self-defeating. The early twenty-first century has witnessed a

90 move away from theories of performativity, mutability, and deep interpretation, just when such theories are crucial to unpacking, re-imagining and remaking the retrograde identity politics embedded within the world of networks. By refusing to analyze and engage these patterns—by refusing to use the “old” keys in our pocket—we lock ourselves into a future we allegedly oppose.

The future lies in the new patterns we can create together, new forms of relation that include liveable forms of indifference. The future lies in unusual collaborations that both respect and challenge methods and insights, across disciplines and institutions.

Notes

- 1 For an overview, see Sweeney and Haney 1992. During this same period, this was made clear in the disparity between jail sentences given to two U.S. male college athletes for sexually assaulting unconscious women. Corey Batey, a nineteen-year-old African American football player at Vanderbilt was sentenced to a mandatory minimum sentence of fifteen to twenty-five years; Brock Turner, a nineteen-year-old swimmer at Stanford was sentenced to six months, which could be shortened for good behavior (see King 2016).
- 2 These editors of *Network Science* made the following claims in their introduction to the inaugural issue:

Claim 1: Network science is the study of network models.

Claim 2: There are theories about network representations and network theories about phenomena: both constitute network theory.

Claim 3: Network science should be empirical—not exclusively so, but consistently—and its value assessed against alternative representations.

Claim 4: What sets network data apart is the incidence structure of its domain.

Claim 5: At the heart of network science is dependence, both between and within variables.

Claim 6: Network science is evolving into a mathematical science in its own right.

Claim 7: Network science is itself more of an evolving network than a paradigm expanding from a big bang. (Brandes et al. 2013, 1–15)

- 3 Barabási’s description resonates with cyberpunk fiction, which posits artificial intelligence and supreme cowboy hackers as capable of detecting “patterns . . . in the dance of the street” and thus foresee events that elude mere humans (see Gibson 1984, 250).
- 4 As Duncan Watts notes: “The truth is that most of the actual science here com-

- prises extremely simple representations of extremely complicated phenomena. Starting off simple is an essential stage of understanding anything complex, and the results derived from simple models are often not only powerful but also deeply fascinating. By stripping away the confounding details of a complicated world, by searching for the core of a problem, we can often learn things about connected systems that we would never guess from studying them directly. The cost is that the methods we use are often abstract, and the results are hard to apply directly to real applications. It is a necessary cost, unavoidable in fact, if we truly desire to make progress" (Watts 2004).
- 5 The example they give of the difference between network science and statistic is quite illuminating: "While the range of attributes is structured, in much of science, the domain on which variables are defined is assumed to have no structure, i.e., simply a set. This may be for good reason. If we are interested in associations between, say, education and income controlled for age, we actually do not want there to be relations between individuals that also moderate the association. Much of statistics is in fact concerned with detecting and eliminating such relations. Network science, on the other hand, seeks to understand the correspondence and impact of these relations, rather than control for any variable" (Brandes et al. 2013, 8).
 - 6 As Easley and Kleinberg explain, "the pattern of connections in a given system can be represented as a network, the components of the system being the network vertices and the connections the edges. Upon reflection it should come as no surprise (although in some fields it is a relatively recent realization) that the structure of such networks, the particular pattern of interactions, can have a big effect on the behavior of a system. . . . A network is a simplified representation that reduces a system to an abstract structure capturing only the basics of connection patterns and little else (Easley and Kleinberg 2010, 2).
 - 7 They write: "in a network setting, you should evaluate your actions not in isolation but with the expectation that the world will react to what you do." This makes "cause-and-effect relationships . . . quite subtle" and may only become evident at the population level" (Easley and Kleinberg 2010, 5).
 - 8 Pierre Bourdieu defined social capital as: "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group" (Bourdieu 1986). Social capital is a form of credit or credentialing that relies on reciprocal and networked acknowledgement and exchange. This form of capital, he stresses, exists "only in the practical state, in material and/or symbolic exchanges which help to maintain them." The ties, that is, are dynamic and constantly enacted.
 - 9 As Cramer writes: "The reduction of audience members to countable numbers—data sets, indices—is thus a self-fulfilling prophecy of stability" (Cramer in this volume).
 - 10 By 1977, homophily was already accepted as an axiomatic if problematic aspect of society. In an equally key early text, *Inequality and Heterogeneity: A Primitive Theory of Social Structure*, Peter Blau outlined what would become "contact

theory": the theory that contact creates integration. An ambitious attempt to create a roadmap of "macrosociological theory" (written in the spirit of Karl Marx and Georg Simmel), it argued for the importance of "weak ties" and heterogeneity to combat inequality within society. As he put it, heterogeneity and inequality were "complementary opposites" and "there can be too much inequality, but cannot be too much heterogeneity" (Blau 1977, 11). Blau argued strongly for the replacement of "strong ingroup bonds," which "restrain individual freedom and mobility . . . and sustain rigidity and bigotry" with "diverse intergroup relations" (85). These heterogeneous relations, "though not intimate, foster tolerance, improve opportunities, and are essential for the integration of a large society" (85). In terms that resonated with Jameson's description of postmodernism and the possibilities of "cognitive mapping," he states, "the loss of extensive strong bonds in a community of kin and neighbors undoubtedly has robbed individuals of a deep sense of belonging and having roots, of profound feelings of security and lack of anxiety. This is the price we pay for the greater tolerance and opportunities that distinguish modern societies, with all their grievous faults, from primitive tribes and feudal orders. The social integration of individuals in modern society rests no longer exclusively on strong bonds with particular ingroups but in good part on multiple supports from wider networks of weaker social ties, supplemented by a few intimate bonds" (85). This insight itself draws from the work of another early progenitor of network science, Mark Granovetter's 1973 theorization of "weak ties" as essential to information dissemination and success. For more on this in relation to networks as dissolving postmodern confusion, see Chun (2016). Tellingly, Blau's argument assumes—and indeed takes as axiomatic—the fact that ingroup interactions are greater than intergroup ones (Axiom A1.1). It also divides and identifies individuals based on structural parameters, such as "age, race, education, and socioeconomic status," some of which Blau considers "inborn" (1977, 6).

- 11 For instance, Lenore Newman and Ann Dalez state: "We feel more comfortable with those like ourselves, even in virtual communities." (2007, 79–90).
- 12 In 1972, the NAACP filed a class action lawsuit against the Boston School Committee—Boston is contiguous with Cambridge, Massachusetts, which is where Harvard is located.
- 13 Schelling writes: "economists are familiar with systems that lead to aggregate results that the individual neither intends nor needs to be aware of, results that sometimes have no recognizable counterpart at the level of the individual. The creation of money by a commercial banking system is one; the way savings decisions cause depressions or inflations is another. Similarly, biological evolution is responsible for a lot of sorting and separating, but the little creatures that mate and reproduce and forage for food would be amazed to know that they were bringing about separation of species, territorial sorting, or the extinction of species" (Schelling 1971, 145). Schelling also uses the term "incentives" to explain segregation: from preferences to avoidance to economic constraints (148).

- 14 At the start of this article, Schelling explains: "This article is about the kinds of segregation—or separation, or sorting—that can result from discriminatory individual behavior. By 'discriminatory,' I mean reflecting an awareness, conscious or unconscious, of sex or age or religion or color or whatever the basis of segregation is, an awareness that influences decisions on where to live, whom to sit by, what occupation to join or avoid, whom to play with or whom to talk to" (144).

References

- ACORN. 2013. "What Is ACORN?" *Caci*. Accessed March 1, 2016. <http://acorn.caci.co.uk>.
- Agre, Phil. 1994. "Surveillance and Capture: Two Models of Privacy." *The Information Society* 100: 101–27.
- Ahmed, Sara. 2004. *The Cultural Politics of Emotion*. London: Routledge.
- Al Zamil, Faiyaz, Wendy Liu, and Derek Ruths. 2012. "Homophily and Latent Attribute Inference: Inferring Latent Attributes of Twitter Users from Neighbors." *Proceedings of the Sixth International AAAI Conference on Weblogs and Social Media*. <https://www.aaai.org/ocs/index.php/ICWSM/ICWSM12/paper/viewFile/4713/5013>.
- Angwin, Julio, Jeff Larson, Surya Mattu, and Lauren Kirchner. 2016. "Machine Bias: There's Software Used Across the Country to Predict Future Criminals. And It's Biased against Blacks." *ProPublica*. Accessed May 23, 2016. <https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing>.
- Aral, Sinan, and Dylan Walker. 2012. "Identifying Influential and Susceptible Members of Social Networks." *Science* 337: 337–41.
- Aral, Sinan, Lev Muchnik, and Arun Sundaraajan. 2013. "Engineering Social Contagions: Optimal Network Seeding and Incentive Strategies." *Network Science* 1, no. 2: 125–53.
- Barabási, Albert-László. 2010. *Bursts: The Hidden Patterns behind Everything We Do, from Your E-mail to Bloody Crusades*. New York: Plume.
- Bernstein, Elizabeth. 2007. *Temporarily Yours: Intimacy, Authenticity, and the Commerce of Sex*. Chicago: University of Chicago.
- Blarr, Alistair. 2015. "Google Mistakenly Tags Black People as 'Gorillas,' Showing Limits of Algorithms." *The Wall Street Journal*. Accessed July 1, 2015. <http://blogs.wsj.com/digits/2015/07/01/google-mistakenly-tags-black-people-as-gorillas-showing-limits-of-algorithms/>.
- Blau, Peter M. 1977. *Inequality and Heterogeneity: A Primitive Theory of Social Structure*. New York: The Free Press.
- Bourdieu, Pierre. 1986. "The Forms of Capital." In *Handbook of Theory and Research for the Sociology of Education*, edited by John G. Richardson, 241–58. New York: Greenwood.
- Brandes, Ulrik, et al. 2013. "What Is Network Science?" *Network Science* 1, no. 1: 1–15.
- Brown, Wendy. 2015. *Undoing the Demos: Neoliberalism's Stealth Revolution*. Cambridge, Mass.: MIT Press.
- Burt, Ronald S. 2002. "Chapter 7: The Social Capital of Structural Holes." In *The New*

- Economic Sociology: Developments in an Emerging Field*, edited by Marshall Meyer, Maruo F. Guillen, Randall Collins, and Paula England, 148–92. New York: Russell Sage.
- Burt, Ronald S. 1992. *Structural Holes: The Social Structure of Competition*. Cambridge, Mass.: Harvard University Press.
- Butler, Judith. 1988. "Performative Acts and Gender Constitution: An Essay in Phenomenology and Feminist Theory." *Theater Journal* 40, no. 4: 519–31.
- Butler, Judith. 1990. *Gender Trouble: Feminism and the Subversion of Identity*. London: Routledge.
- Butler, Judith. 1997. *Excitable Speech: A Politics of the Performative*. London: Routledge.
- Cadwalladr, Carole. 2018. "I Made Steve Bannon's Psychological Warfare Tool: Meet the Data War Whistleblower," *The Guardian*. Accessed July 5, 2018. <https://www.theguardian.com/news/2018/mar/17/data-war-whistleblower-christopher-wylie-faceook-nix-bannon-trump>.
- Centola, Damon M. 2013. "Homophily, Networks, and Critical Mass: Solving the Start-up Problem in Large Group Collective Action." *Rationality and Society* 15 (1): 3–40.
- Centola, Damon, Juan Carlos González-Avella, Victor M. Eguíluz, and Maxi San Miguel. 2007. "Homophily, Cultural Drift, and the CO-Evolution of Cultural Groups." *The Journal of Conflict Resolution* 51, no. 6: 905–29.
- Chun, Wendy Hui Kyong. 2016. *Updating to Remain the Same: Habitual New Media*. Cambridge, Mass.: MIT Press.
- Crawford, Kim, and Jason Schultz. 2014. "Big Data and Due Process: Toward a Framework to Redress Predictive Privacy Harms." *Boston College Law Review* 55, no. 1: 93–128. <http://lawdigitalcommons.bc.edu/cgi/viewcontent.cgi?article=3351&context=bclr>.
- Crenshaw, Kimberlé. 1991. "Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color." *Stanford Law Review* 43, no. 6: 1241–99.
- Derrida, Jacques. 1988. "Signature, Event, Context." In *Limited Inc.*, translated by Samuel Weber, 1–23. Evanston, Ill.: Northwestern University Press.
- DiMaggio, Paul, and Filiz Garip. 2012. "Network Effects and Social Inequality." *Annual Review of Sociology* 38:93–118.
- Dyer, Richard. 1997. *White: Essays on Race and Culture*. London: Routledge.
- Easley, David, and Jon Kleinberg. 2010. *Networks, Crowds, and Markets: Reasoning about a Highly Connected World*. Cambridge: Cambridge University Press.
- Fourcade, Marion, and Kieran Healy. 2016. "Seeing Like a Market." *Socio-Economic Review* 15, no. 1: 1–21.
- Frucci, Adam. 2009. "HP Face-Tracking Webcams Don't Recognize Black People." *Gizmodo*. Accessed December 21, 2009. <http://gizmodo.com/5431190/hp-face-tracking-webcams-dont-recognize-black-people>.
- Gibson, William. 1984. *Neuromancer*. New York: ACE.
- Gilroy, Paul. 2000. *Against Race: Imagining Political Culture beyond the Color Line*. Cambridge, Mass.: Harvard University Press.
- Gorner, Jeremy. 2013. "Chicago Police Use 'Heat List' as Strategy to Prevent Violence." *The Chicago Tribune*. Accessed August 21, 2013. <http://articles.chicagotribune>

- .com/2013-08-21/news/ct-met-heat-list-20130821_1_chicago-police-commander-andrew-papachristos-heat-list.
- Granovetter, Mark. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78, no. 6: 1360–80.
- Hale, Grace Elizabeth. 1998. *Making Whiteness: The Culture of Segregation in the South, 1890–1940*. New York: Pantheon Books.
- Harrell, D. Fox. 2013. *Phantasmal Media: An Approach to Imagination, Computation, and Expression*. Cambridge, Mass.: MIT Press.
- Harris, Meena. 2016. "Talking with Black Women Engineers about Diversity in Silicon Valley." *Lenny*. Accessed March 1, 2016. <http://www.lennyletter.com/work/a283/talking-with-black-women-engineers-about-diversity-in-silicon-valley/>.
- Hart, Vi, and Nick Case. 2017. "Parable of the Polygons." Accessed June 29, 2017. <http://ncase.me/polygons/>
- Healy, Kieran. 2015. "The Performativity of Networks." *European Journal of Sociology* 52, no. 2: 175–205.
- Ibarra, Herminia. 1993. "Personal Networks of Women and Minorities in Management: A Conceptual Framework." *The Academy of Management Review* 18, no. 1: 56–87.
- Ingram, Matthew. 2016. "Why Getting Rid of Human Editors Won't Solve Facebook's Bias Problem." *Fortune*. Accessed August 29, 2016. <http://fortune.com/2016/08/29/facebook-trending-human-bias/>.
- Jackson, Matthew O. 2008. "Average Distance, Diameter, and Clustering in Social Networks with Homophily." In *Internet and Network Economics: Proceedings of the 4th International Workshop WINE 2008*, edited by Christos Papadimitriou and Shuzhong Zhang, 4–11. Berlin: Springer-Verlag.
- Jameson, Frederic. 1990. "Cognitive Mapping." In *Marxism and the Interpretation of Culture*, edited by Cary Nelson and Lawrence Grossberg, 347–60. Urbana and Chicago: University of Illinois Press.
- Jameson, Frederic. 1991. *Postmodernism, or the Cultural Logic of Late Capitalism*. London: Verso.
- Kandel, Denise B. 1978. "Homophily, Selection, and Socialization in Adolescent Friendships." *American Journal of Sociology* 84, no. 2: 427–36.
- King, Shawn. 2016. "Brock Turner and Cory Batey, Two College Athletes Who Raped Unconscious Women, Show How Race and Privilege Affect Sentences." *New York Daily News*. Accessed June 7, 2016. <http://www.nydailynews.com/news/national/king-brock-turner-cory-batey-show-race-affects-sentencing-article-1.2664945>.
- Lartey, Jamiles. 2016. "Predictive Policing Practices Labeled as 'Flawed' by Civil Rights Coalition." *The Guardian*. Accessed August 31, 2016. <https://www.theguardian.com/us-news/2016/aug/31/predictive-policing-civil-rights-coalition-aclu>.
- Lazarsfeld, Paul F., and Robert K. Merton. 1954. "Friendship as Social Process: A Substantive and Methodological Analysis." In *Freedom and Control in Modern Society*, edited by Morroe Berger, Theodore Abel, and Charles H. Page, 18–66. Toronto: D. Van Nostrand Company, Inc.
- Lee, Odellia. 2009. "Camera Misses the Mark on Racial Sensitivity." *Gizmodo*. Accessed

- May 15, 2009. <http://gizmodo.com/5256650/camera-misses-the-mark-on-racial-sensitivity>.
- Lyotard, Jean-François. 1984. *The Postmodern Condition: A Report on Knowledge*. Minneapolis: University of Minnesota Press.
- Marsden, Peter V. 1988. "Homogeneity in Confiding Relations." *Social Networks* 10, no. 1: 57–76.
- McPherson, Miller, Lynn Smith-Lovin, and James Cook. 2001. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27:415–44.
- Nelson, Alondra. 2016. *Social Life of DNA: Race, Reparations, and Reconciliation after the Genome*. Boston: Beacon Press.
- Newman, Lenore, and Ann Dalez. 2007. "Homophily and Agency: Creating Effective Sustainable Development Networks." *Environment, Development, and Sustainability* 9:79–90.
- Noble, Safiya Umoja. 2018. *Algorithms of Oppression: How Search Engines Reinforce Racism*. New York: New York University Press.
- Omi, Michael, and Howard Winant. 1994. *Racial Formation in the United States: From the 1960s to the 1990s*, 2nd edition. New York: Routledge.
- O'Neil, Cathy. 2016. *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*. London: Penguin.
- Ooka, Emi, and Barry Wellman. 2006. "Does Social Capital Pay Off More within or between Ethnic Groups? Analyzing Job Searches in Five Toronto Ethnic Groups." In *Inside the Mosaic*, edited by Erik Fong, 199–226. Toronto: University of Toronto Press.
- Phillips, Whitney. 2015. *This Is Why We Can't Have Nice Things: Mapping the Relationship between Online Trolling and Mainstream Culture*. Cambridge, MA: MIT Press.
- Pinboard. 2016. "Machine Learning Is Money Laundering for Bias." Accessed August 29, 2016. <https://twitter.com/pinboard/status/744595961217835008>.
- Robinson, David, and Logan Koepke. 2016. "Stuck in a Patter: Early Evidence on 'Predictive Policing' and Civil Rights." *Upturn*. Accessed August 30, 2016. <https://www.teamupturn.com/reports/2016/stuck-in-a-pattern>.
- Rothstein, Richard. 2017. *The Color of Law: A Forgotten History of How Our Government Segregated America*. New York and London: Liveright Publishing Corporation, a Division of W.W. Norton & Company.
- Rouvroy, Antoinette. 2011. "Technology, Virtuality, and Utopia: Governmentality in an Age of Autonomic Computing." In *The Philosophy of Law Meets the Philosophy of Technology: Autonomic Computing and Transformations of Human Agency*, edited by Mireille Hildebrandt and Antoinette Rouvroy, 136–57. Milton Park, UK: Routledge.
- Saunders, Jessica, Priscilla Hunt, and John S. Hollywood. 2016. "Predictions Put into Practice: A Quasi-Experimental Evaluation of Chicago's Predictive Policing Pilot." *Journal of Experimental Criminology* 22, no. 3: 347–71. <http://link.springer.com/article/10.1007/s11292-016-9272-0>.
- Schelling, Thomas C. 1971. "Dynamic Models of Segregation." *Journal of Mathematical Sociology* 1:143–86.
- Silver, Nate. 2012. *The Signal and the Noise: Why So Many Predictions Fail—but Some Don't*. New York: Penguin Books.
- Sweeney, Laura T., and Craig Haney. 1992. "The Influence of Race on Sentencing: A

- Thielman, Sam. 2016. "Facebook Fires Trending Team, and Algorithm without Humans Goes Crazy." *The Guardian*. Accessed August 29, 2016. <https://www.theguardian.com/technology/2016/aug/29/facebook-fires-trending-topics-team-algorithm>.
- Watts, Duncan J. 2004. *Six Degrees: The Science of a Connected Age* (Kindle Locations 191–94). W. W. Norton. Kindle Edition.
- Wimmer, Andreas, and Kevin Lewis. 2010. "Beyond and Below Racial Homophily: ERG Models of a Friendship Network Documented on Facebook." *American Journal of Sociology* 116, no. 2: 642–83.

Technoconstruction

Moving now from the implicit hermeneutics within science praxis to the more complex practices—increasingly technologically embodied and instrumentally constructed—we are ready to take note of a stronger program.

1. The "Strong Program": Hermeneutic Sophistication

In the "weak program" I chose to outline what could easily be recognized as hermeneutic features operative within science. As I now turn to a stronger program, I shall continue to examine certain extant features within science practice which relate to hermeneutic activity, but I shall increasingly turn here to forefront modes of investigation which drive the sciences closer to a postmodern variant upon hermeneutics.

A. Whole body perception

It is, however, also time to introduce more fully, albeit sketchily, a phenomenological understanding of perception in action. This approach will be recognizably close to the theory of perception developed by Merleau-Ponty, although taken in directions which include stronger aspects of multistability and polymorphy, which earlier investigations of my own developed.

1. I have already noted some perceptual *Gestalt features*, including the presentation of a perceptual field, within which figure/ground phenomena may be elicited. Following a largely Merleau-Pontean approach, one notes that fields are always complexly structured, open to a wide variety of intentional interests, and bounded by a horizontal limit. Science, I have claimed, in its particular style of knowledge construction, has developed a visualist hermeneutic which in the contemporary sense has

fulfilled its interests through *imagery* constituted instrumentally or technologically. The role of repeatable, Gestalt patterns, in both isomorphic and graphic directions, is the epistemological product of this part of the quest for knowledge.

2. In a strong sense, all sensory fields, whether focused upon in reduced "monosensory" fashion, or as ordinarily presented in synthesized and multidimensional fashion, are *perspectival* and concretely *spatial-temporal*. Reflexively, the embodied "here" of the observer not only may be noted but is a constant in all sensory perspectivalism. This constant may be enhanced only by producing a string of interrelated perspectives, or by shifting into multiperspectival modes of observation. The "ideal observer," a "god's eye view," and nonperspectivalism do not enter a phenomenology of perception.

3. However, while a body perspective relative to the perceptual field or "world" is a constant, both the field and the body are *polymorphic* and *multistable*. In my work in this area, I have shown that multistability is a feature of virtually every perceptual configuration (and the same applies to the extensions and transformations of perception through instrumentation), and that the interrelation of bodily (microperceptual features) and cultural significations (macroperceptual features) makes the polymorphy even more complex. *There is no perception without embodiment; but all embodiment is culturally and praxically situated and saturated.*

4. While I have sometimes emphasized spatial transformations (Galileo's telescope) in contrast to temporal transformations (still photography), all perceptual spatiality is *spatial-temporal*. This space-time configuration may be shown with different effects, as in contrasts between visual repeatability and auditory patterning, but is a constant of all perceptions.

5. All perceptual phenomena are synesthetic and multidimensioned. The "monosensory" is an abstraction—although useful and possible to forefront—and simply does not occur in the experience of the "lived body" (*corps vécu*). The same applies, although not always noted, in our science examples. I will say more below on this feature of perception. The issue of the "monosensory" is particularly acute with respect to the technological embodiments of science, since instruments (not bodies) may be "monosensory." Again, we reach a contemporary impasse which has been overcome only in part. Either we turn ingenious in the ways of "translating" the spectrum of perceptual phenomena into a visual hermeneutic—perhaps the dominant current form of knowledge construction in science—or we find ways of enhancing our instrumental reductions through variant instruments or new modes of perceptual transformation (I am pointing to "virtual reality" developments here).

A "strong program," I am hinting, may entail the need for breakthroughs whereby a fuller sense of human embodiment may be brought into play in scientific investigations. Whereas the current, largely visualist hermeneutic within science may be the most sophisticated such mode of knowledge construction to date, it remains short of its full potential were "whole body" knowledge made equally possible. This would be a second step toward the incorporation of lifeworld structures within science praxis.

B. Instrumental phenomenological variations

In the voice metaphor I used to describe the investigation of things, I noted that the "giving of a voice" entails, actually, the production of a "duet" at the least. But this also means that different soundings may be produced, either in sequence or in array, by the applications of different instruments. This is a material process which incorporates the practice of "phenomenological variations" along with the intervention within which a thing is given a voice. This practice is an increasing part of science practice and is apparent in the emergence of a suite of new disciplines which today produce an ever more rapid set of revolutions in understanding or of more frequent "paradigm shifts."

I use this terminology because it is a theme which regularly occurs in science reporting. A Kuhnian frame is often cast over the virtually weekly breakthroughs which are reported in *Science*, *Scientific American*, *Nature*, and other magazines. Challenges to the "standard view" are common. I shall look at a small sample of these while relating the challenges to the instrumental embodiments which bring about the "facts" of the challenges. Here the focus is upon *multiple instrumental arrays* which have different parameters in current science investigation.

1. *Multiple new instruments/more new things.* The development of multivariant instruments has often led to increased peopling of the discipline's objects. And much of this explosion of scientific ontology has occurred since the mid-twentieth century. This is so dramatically the case that one could draw a timeline just after World War II, around 1950 for most instrumentation, and determine new forms for many science disciplines. For example, in astronomy, until this century, the dominant investigative instrumentation was limited to *optical* technologies and thus restricted to the things which produce *light*. With the development of *radio-telescopy*, based upon technologies developed in World War II—as so many fields besides astronomy also experienced—the field expanded to the forms of microradiation which occur along spectra beyond the

bounds of visible light. *The New Astronomy* makes this "revolution" obvious. The editors note that

The range of light is surprisingly limited. It includes only radiation with wavelengths 30 per cent shorter to 30 per cent longer than the wavelength to which our eyes are most sensitive. The new astronomy covers radiation from extremes which have wavelengths less and one thousand-millionth as long, in the case of the shortest gamma rays, to over a hundred million times longer for the longest radio waves. To make an analogy with sound, traditional astronomy was an effort to understand the symphony of the Universe with ears which could hear only middle C and the two notes immediately adjacent.¹

Without noting which instruments came first, second, and so on, expanding out from visible light, first to ultraviolet on one side, and infrared on the other, now reaching into the previously invisible-to-eyeball perceptions, but still within the spectrum of optical light waves, the first expansion into invisible light range occurs through types of "translation" technologies as I have called them. The usual tactic here is to "constitute" into a *visible depiction* the invisible light by using some convention of *false color depiction*.

The same tactic, of course, is used once the light spectrum itself is exceeded. While some discoveries in radio astronomy were made by *listening* to the radio "hiss" of background radiation, it was not long before the gamma-to-radio wavelengths beyond optical capacities were also "translated" into visible displays.

With this new instrumentation, the heavens begin to show phenomena previously unknown but which are familiar today: highly active magnetic gas clouds, radio sources still invisible, star births, supernovas, newly discovered superplanets, evidence of black holes, and the like. The new astronomy takes us closer and closer to the "birth" of the universe. More instruments produce more phenomena, more "things" within the universe.

The same trajectory can be found in many other science disciplines, but for brevity's sake I shall leave this particular example as sufficient here.

2. *Many instruments/the same thing.* Another variant, now virtually standard in usage, is to apply a range of instruments which measure different processes by different means to the same object. Medical imaging is a good example here. If some feature of the brain is to be investigated, perhaps to try to determine without surgical intrusion whether a

formation is malignant or not, multiple instrumentation is now available to enhance the interpretation of the phenomenon. A recent history of medical imaging, *Naked to the Bone*, traces the imaging technologies from the inception of X-rays (1896) to the present.

As noted above, X-rays allowed the first technologized making of the body into a "transparent" object. It followed the pattern noted of preparing the phenomenon for a scientific "reading" or perception. Early development entailed—to today's retrospective horror—long exposures, sometimes over an hour, to get barely "readable" images sometimes called "shadowgraphs." This is because X-ray imaging relies upon radiation sent through the object to a plate, and thus the degrees of material resistance cast "shadows" which form the "picture." The earliest problems focused upon getting clearer and clearer images.²

I have noted that the microscope became useful only when the specimen could be prepared for "reading" through a dye process which enhanced contrasting or differentiated structures (in the micro-organism). This image enhancement began to occur in conjunction with X-rays as early as 1911 with the use of *radioactive tracers* which were ingested or injected into the patient. This was the beginning of nuclear medicine (304).³

Paralleling X-ray technologies, *ultrasound* began to be explored with the first brain images produced in 1937 (310). The quality of this imaging, however, remained poor since bone tended to reduce what could be "seen" through this sounding probe. (As with all technologies, it takes some time before the range of usefulness is discovered appropriate to the medium. In the case of ultrasound, soft tissue is a better and easier-to-define target.)

But, even later than the new astronomy, the new medical imaging does not actually proliferate into its present mode until the 1970s. Then, in 1971 and 1972, several patents and patent attempts are made for magnetic resonance processes (MRIs) (314). These processes produce imagery by measuring molecular resonances within the body itself. At the same moment, the first use of the computer—as a *hermeneutic instrument*—comes into play with the refinement of *computer-assisted tomography* (CT scanning). Here highly focused X-ray beams are sent through the object (brains, at first), and the data are stored and reconstructed through computer calculations and processes. Computer-"constructed" imaging, of course, began in the space program with the need to turn data into depictions. Kevles notes that

After the Apollo missions sent back computer-reconstructed pictures of the moon, it did not stretch the imagination to propose that computers

could reconstruct the images of the interior of the body, which, like pictures from space, could be manipulated in terms of color and displayed on a personal video monitor. (143-44)

Here mathematics and imagery or constructed perceivable depictions meet. I claim this is important to a strong hermeneutic program in understanding science.

By 1975 the practical use of positron emissions is captured in the PET scan process. These emissions (from positrons within the object) are made visible (314). This imagery has never attained the detail and clarity of the above technologies but has some advantage in a dynamic situation when compared to the "stills" which are produced by all but ultrasound processes (and which also are limited in clarity). Thus living brain *functions* can be seen through PET instrumentation. Then, in the 1990s, functional MRI and more sophisticated computer tomographic processes place us into the rotatable, three-dimensional depictions which can be "built up" or "deconstructed" at command, and the era of the *whole body image* is attained (314).

While each of these processes can show different phenomena, the multiple use is such that ever more complete analysis can also be made of single objects, such as tumors, which can be "seen" with differences indicating malignancy or benignity. This, again, illustrates the ever more complex ways in which science instrumentation produces a visible result, a visual hermeneutics which is the "script" of its interpretive activity.

3. *Many instruments/convergent confirmations.* Another variant upon the multiple instrument technique is to use a multiplicity of processes to check—for example, dating—for greater agreement. In a recent dating of Java *homo erectus* skulls, uranium series dating of teeth, carbon 14, and electron spin resonance techniques were all used to establish dates much more recent (27,000 B.P. +/- 53,000 B.P. for different skulls) than previously determined and thus found *homo erectus* to be co-extant with *homo sapiens sapiens*.⁴ And, with the recent discovery of 400,000 B.P. javelin-like spears in Germany, one adds thermo-luminescence techniques to establish this new date for human habitation in Europe, at least double or triple the previously suspected earliest date for humans there. (Similar finds, now dated 350,000 B.P. in Siberia, and 300,000+ B.P. finds in Spain, all within 1996-97 discovery parameters, evidence this antiquity.)⁵

4. *Single instrument (or instrumental technique)/widespread multiple results.* Here perhaps one of the most widely used new techniques involves DNA "fingerprinting," which is now used in everything from forensics (rapists and murderers both convicted and found innocent and released), to pushing dates back for human migrations or origins. (The

"reading" process which goes with DNA identification entails matching pairs and includes visualizations once again.) *Scientific American* has recently reported that DNA tracing now shows that human migrations to the Americas may go back to 34,000 years (not far from the dates claimed for one South American site, claimed to be 38,000 B.P., which with respect to physical data remain doubtful), with other waves at 15,000 B.P., to more recent waves, included a set of Pacific originated populace around 6,500 B.P.)⁶ The now widely cited DNA claims for the origins of *homo sapiens* between 200,000 and 100,000 B.P. is virtually a commonplace.

DNA fingerprinting has also been used in the various biological sciences to establish parentage compared to behavioral mating practices. One result is to have discovered that many previously believed-to-be "monogamous" species are, in fact, not. Similarly, the "Alpha Male" presumed successful at conveying his genes within territorial species has been shown to be less dominantly the case than previously believed.⁷

5. *Multiple instruments/new disciplines.* Beginning with DNA (mitochondrial DNA matching) again, the application of this technique has given rise to what is today called "ancient DNA" studies, with one recent result developed in Germany this year, which purports to show that Neanderthals could not have interbred with modern humans, due to the different genetic makeup of these hominids who coexisted (for a time) with modern humans.⁸

Then, returning to variants upon imaging, the new resources for such disciplines as archeology produce much more thorough "picturing" of ancient sites, activities, and relations to changes in environmental factors. Again, drawing from *Scientific American*—one can draw similar examples from virtually every issue of this and similar science-oriented magazines—the array of instruments now available produces, literally, an "in-depth" depiction of the human past. In part, now drawing from uses originally developed for military purposes, imaging from (1) *Landsat*, which used digital imaging and multispectral scanners from the 1970s, to (2) refinements for *Landsats 4* and *5* in the 1980s, which extended and refined the imaging and expanded to infrared and thermal scanning, (3) to *SPOT*, which added linear-array technologies to further refine imaging, to (4) imaging radar, which actually penetrates below surfaces to reveal details, to (5) *Corona*, which provides spectrographic imagery (recently declassified), the modern archeologist, particularly desert archeologists, can get full-array depictions of lost cities, ancient roads, walls, and the like from remote sensing used now.⁹

Once located, instrumentation on Earth includes (1) electromagnetic sounding equipment, which penetrates up to six meters into the earth, (2) ground-penetrating radar, which goes down to ten meters,

(3) magnetometers, which can detect such artifacts as hearths, (4) resistivity instruments, which detect different densities and thus may be used to locate artifacts, and (5) seismic instruments, which can penetrate deeper than any of the above instruments. At a recent meeting in Mexico, an anthropologist reported to me that a magnetometer survey of northern Mexico has shown there to be possibly as many as 86,000 buried pyramids (similar to the largest, Cholula, although the remainder are smaller).¹⁰

In short, the proliferation of instrumentation, particularly that which yields imagery, is radical and contemporary and can now yield degrees and spans of three-dimensional imagery which includes all three of the image breakthroughs previously noted: early optics magnified the micro- and macro-aspects of barely noted or totally unnoted phenomena through magnification (telescope and microscopy) but remained bound to the limits of the optically visible, by producing "up close" previously distant phenomena.

Photography increased the detail and isomorphy of imaging in a repeatable produced image, which could then be studied more intensely since "fixed" for observation. It could also be manipulated by "blowups" and other techniques, to show features which needed enhancement. Then, with X-rays, followed by other interior-producing imagery, the possibilities were outlined for the contemporary arrays by which image surfaces are made transparent so that one may see interiors. Then add the instruments which expand thoroughly beyond the previously visible and which now go into previously invisible phenomena through the various spectra which are "translated" into visible images for human observation.

Here we have the decisive difference between ancient science and Modern science: Democritus claimed that phenomena, such as atoms, not only were in fact imperceptible, but were *in principle* imperceptible. A modern, technologized science returns to Democritus to the "in fact" only—that is, the atomic is invisible only until we can come up with the technology which can make it visible. This, I claim, is an instrumental *visual hermeneutics*.

C. Technoconstitution

In the reconstrual of science which I have been following here, I have argued that late Modern science has developed a complex and sophisticated system of *visual hermeneutics*. Within that visualist system, its "proofs" are focused around the things seen. But, also, things are never just or merely seen—the things are *prepared* or made "readable." Scientifically, things are (typically, but not exclusively) *instrumentally mediated*, and the "proof" is often a *depiction* or image.

Interestingly, if in ordinary experience there is a level of *naïve realism* where things are taken simply to be what they are seen to be, similarly, within imaging there is at least the temptation to an imaging naïve realism. That naïveté revolves around the intuitive taking of the image to be "like" or to "represent" an original (which would be seen in unmediated and eyeball perceptions). In short, "truth" is taken to be some kind of *isomorphism* between the depiction and the object.

By putting the issue in precisely that way, there are many traps which are set which could lead us back into the issues of modern (that is, Cartesian or seventeenth- and eighteenth-century) epistemologies. But to tackle these would lead us into a detour of some length. It would entail deconstructing "copy theory" from Plato on, deconstructing "representationalism" as the modern version of copy theory, before finally arriving at a more "postmodern" theory which entails both a theory of relativistic intentionality, a notion of perspectivalism, and an understanding of instrumental mediations as they operate within a phenomenological context. (I have addressed these issues in some degree in essays which preceded my formulation here.)¹¹ I simply want to avoid these traps.

To do so, I shall continue to interpret science in terms of a visual hermeneutics, embodied within an instrumentally realistic—but *critical*—framework in which instruments mediate perceptions. The device I shall now develop will fall within an idealized "history" of imaging, which, while containing actual chronologically recognizable features, emphasizes patterns of *learning to see*.

1. Isomorphic visions

The first pattern is one which falls into one type of *initial isomorphism* within imaging. As a technical problem, it is the problem of getting to a "clear and distinct" image. Imaging technologies do not just happen, they develop. And in the development there is a dialectic between the instrument and the user in which both a learning-to-see meets an elimination-of-bugs in the technical development. This pattern is one which, in most abstract and general terms, moves from initial "fuzziness" and ambiguity to greater degrees of clarity and distinctness.

Histories of the telescope, the microscope, photography, and X-rays (and, by extension, all the other imaging processes as well) are well documented with respect to this learning-to-see. Galileo, our quasi-mythical founder of early Modern science, was well aware of the need to teach telescopic vision, and of the problems which existed—although he eventually proclaimed the *superiority* of instrumentally mediated vision over ordinary vision. The church fathers, however, did have a point about how to take what was seen through the telescope. Not all of Galileo's

observations were clear and easily seen by "any man." The same problem reemerged in the nineteenth century through the observations of Giovanni Schiaparelli, who gave the term the "canals of Mars." Schiaparelli was a well-known astronomer who had made a number of important discoveries, particularly with respect to asteroids and meteor swarms (because, in part, he had a much better telescope than Galileo). But in noting "canali"—which should have been translated into "channels"—which were taken to be "canals"—he helped stimulate the speculations about life on Mars. But neither channels nor canals existed—these, too, were instrumental artifacts.¹²

The dialectic between learning and technical refinement, in the successful cases, eventually leads to the production of clear and distinct images and to quick and easy learning. These twin attainments, however, cover over and often occlude the history and struggle which preceded the final plateaus of relative perfections. Thus, as in the previous illustrations concerning my guests and our Vermont observations of the Moon, once focused and set, it literally takes only instants before one can recognize nameable features of its surface. The "aha phenomenon," in short, is virtually immediate today because it is made possible by the advanced technologies. That instantaneity is an accreted result of the hidden history of learning-to-see and its accompanying technical debugging process.

This same pattern occurred with the microscope. Although microorganisms never before seen were detected early, the continued problems of attaining clear and distinct microscopic vision was so difficult that it did not allow the microscope to be accepted into ordinary scientific practice until the nineteenth century. Again, the dialectic of learning how and what to see meets the gradual technical improvement concerning lenses and focusing devices, and finally the application of dying procedures to the things themselves. (This is an overt example of preparing a thing to become a scientific or "readable" object!)

Photography stands in interesting contrast to microscopy—if it took a couple of centuries for microscopy to become accepted for scientifically acceptable depiction, photography was much faster to win the same position. From Niepce's first "fixed" image in 1826, to the more widely accepted date of 1839 for Daguerre's first images, it was less than a half century until, as Bettyann Kevles notes in her history of medical imaging, "By the 1890's photographs had become the standard recorders of objective scientific truth."¹³

The same pattern occurs, but with even greater speed, in the history of early X-rays. In publicizing his new invention, Wilhelm Röntgen made copies of the X-ray of his wife's hand, which showed the bones of her fingers and the large ring which she wore, and sent these to his

colleagues across Europe as evidence of his new process. That X-ray (with a long exposure time) was fuzzy, and while easily recognizable as a skeletal hand and ring, contrasts starkly with the radiograph made by Michael Pupin of Prescott Bulger's shot-filled (shotgun-injured) hand later the same year (21, 35). X-rays, duplicated across Europe and America almost immediately after Röntgen's invention, were used "scientifically" from the beginning.

The acceleration of acceptance time (of the learning-technical vision dialectic) similarly applies to the recent histories of imaging, which include, as above, sonograms (1937) and MRIs (1971) in medicine, of remote imaging since the *Tiros* satellite (1965), or of digitally transmitted and reconstructed images from *Mariner 4* (1965) in Earth and space science.

All of the above samples, however, remain within the range of the possible "naive image realism" of visual isomorphisms in which the objects are easily recognizable, even when new to the observer's vision. (Even if Röntgen had never before seen a "transparent hand" as in the case of his wife's ringed fingers, it was "obvious" from the first glimpse what was seen.) The pattern of making clear is an obvious trajectory. Yet we are not quite ready to leave the realm of the isomorphic.

How does one make "clearer" what is initially "fuzzy"? The answer lies in forms of manipulation, what I shall call *image reconstruction*. The techniques are multiple: enlargements (through trajectories of magnification noted before), enhancements (where one focuses in upon particular features and finds ways to make these stand out), contrasts (by heightening or lessening features of or around the objects), and so on. In my examinations I shall try not to be comprehensive, but to remain within the ranges of familiarity (to at least the educated amateur) concerning contemporary imaging. All of these manipulations can and do occur within and associated with simply isomorphic imaging and, for that matter, within its earlier range of black-and-white coloring. Histories of the technical developments which go with each of these techniques are available today and provide fascinating background to the rise of scientific visualism.

The moral of the story is images don't just occur. They are made. But, once made—assuming the requisite clarity and accuracy and certification of origin, etc.—they may then be taken as "proofs" within the visual hermeneutics of a scientific "visual reading." We are, in a sense, still within a Latoureaan laboratory.

2. Translation techniques

Much of what can follow in this next step has already been suggested within the realm of the isomorphic. But what I want to point to here

is the use in late Modern science of visual techniques which begin ever more radically to vary *away from the isomorphic*.

One of these variables is—if it could be called that—simply the variable use of *color*. Returning to early optics, whatever Galileo or Leeuwenhoek saw, they saw in “true color.” And, as we have seen, sometimes that itself was a problem. The transparent and translucent micro-organisms in “true color” were difficult to see. With aniline dyes, we have an early use of “false color.” To make the thing into a scientific or “readable” object, we intervene and create a “horse of a different color.” “False coloring” becomes a standard technique within scientific visual hermeneutics.

The move away from isomorphism, taken here in gradual steps which do not necessarily match chronologically what happened in the history of science, may also move away from the limits of ordinary perception. As noted above, the “new” late Modern astronomy of midcentury to the present was suddenly infused with a much wider stretch of celestial “reality” once it moved beyond optical and visible limits into, first, the humanly invisible ranges of the still optical or light itself, in the ranges of the infrared and ultraviolet. The instrumentation developed was what I have been calling a *translation technology* in that the patterns which are recordable on the instrumentation can be rendered by “false coloring” into visible images. This same technique was extended later to the full wave spectrum now available from gamma rays (short waves) through the optical to radio waves (long waves), which are rendered in the standard visually gestaltable, but false color, depictions in astronomy. All this is part of the highly technologized, instrumentalized visual hermeneutics which makes the larger range of celestial things into seeable scientific objects.

The “realism” here—and I hold that it is a realism—is a Hacking-style realism: if the things are “paintable”¹⁴ (or “imagable”) with respect to what the instruments detect as effects which will not go away, then they are “real.” But they have been *made visible* precisely through the technological constructions which mediate them.

3. Higher level construction

Within the limits of the strong program, I now want to take only two more steps: I am purposely going to limit this attempt to reconstrue science praxis as hermeneutic to contemporary imaging processes which make (natural) things into scientific, and thus “readable,” visual objects. I am not going to address the related, but secondary, visual process which entails *modeling*. That process which utilizes the computer as a hermeneutic device is clearly of philosophical interest, but I shall stop short of entering that territory here.

Computers, of course, are integral to many of the imaging processes we have already mentioned. Medical *tomography* (MRI, PET, fMRI,

etc.) entails computer capacities to store and construct images. What is a visual Gestalt is built up from linear processes which produce data which have to be "constructed" by the computer. Similarly, the digitally transmitted imagery from distance sensing in satellite, space, and other remote imaging processes also has necessary computer uses. Much of contemporary imaging is computer embodied. And computers open the ways to much more flexible, complex, and manipulable imaging than any previous technology. For the purposes here, however, they will remain simply part of the "black boxes" which produce images which mediate perceptions.

The two higher-level constructive activities I want to point to here entail, first, the refinement of imaging which can be attained through specifically recognizing our technologies as mediating technologies which, in turn, must take into account the "medium" through which they are imaging. I turn again to astronomical imaging: the *Hubble* space telescope has recently captured the most public attention, but it is but one of the instrumental variations which are today exploring the celestial realms.

The advantage *Hubble* has is that it is positioned beyond the effects of the atmosphere with its distortions and interferences—the clarity of *Hubble* vision in this sense is due in part to its extra-Earthly perspective. (Science buffs will recall that at launch it had several defects in operation which were subsequently fixed—thus placing the *Hubble* in the usual pattern of needing technical adjustment to make its images clear!) But, in part by now being able to (phenomenologically) vary *Hubble* with Earth-bound optical telescopes, the move to enhancing Earth-bound telescropy through computer compensations has become possible. Astronomy is moving toward technoconstructions which can account for atmospheric distortions "on the spot" through a combination of laser targeting and computer enhancements. Earth-bound telescopes are today being given new life through these hi-tech upgrades which "read" atmospheric distortions and "erase" these processes which can make clearer new "readable" images. *Science* regularly publishes an "imaging" issue devoted to updating what is taken as the state-of-the-art in imaging (in 1997 it was the 27 June issue). A description of how one "undoes the atmosphere" is included, which entails computer reconstructions, telescopes in tandem, and adaptive optics. This process, *Science* claims, "combat[s] the warping effects of gravity on their giant mirrors . . . reclaims images from the ravages of the atmosphere . . . [and] precisely undoes the atmospheric distortions."¹⁵

But alongside *Hubble* are the other variants: the infrared space observatory, the *Cosmic Background Explorer*, and other satellite instrumentation which produces imagery from the nonoptical sources. All these

technologies are variants upon the same multidimensioned variables which produce readable images, or make things into readable scientific objects.

The final set of instrumental productions I wish to note are the *composites* which produce variants upon "wholes." Chapter 4 deals with "whole Earth measurements" which constitute one realm of composite imagery. To determine whether or not sea levels are rising overall, the composite imagery produced combines (1) multiple satellite photo imagery, (2) Earth-bound measurements (such as buoys, laser measurements, and land markers), and (3) computer averaging processes to produce a depiction (false colored) which can, in comparing time slices, show how much the oceans have risen. The composite depiction displays a flat-projection map of the Earth with level plateaus in false color spectra which can be compared between years, decades, and so on.

Similar processes occur in medical imaging. The "whole body imagery" available today on the internet is the result of two full-body "image autopsies," one each of a male and a female, whose bodies through tomographic processes may be seen in whatever "slice" one wishes. The linear processes of tomography show, slice-by-slice, vertically, horizontally, or in larger scans, the full bodies of the corpses used. The dimensions can be rotated, realigned, sectioned, and so on. Tomography also allows one to "peel," layer by layer, the object imaged—from skin, to networked blood vessels, to bones, and so on. (Both the whole Earth and whole body images are probably among the world's most expensive "pictures.") Moreover, all the manipulations which entail enhancements, contrasts, colorings, translations, and the like are utilized in these "virtual" images. Yet, while these virtual "realities" are different from the examination of any actual cadaver, they clearly belong to the visual hermeneutics of science in the strong sense. Things have been prepared to be seen, to be "read" within the complex set of instrumentally delivered visibilities of scientific imaging.

Chapter 13

1. Nigel Henbest and Michael Marten, *The New Astronomy*, 2d ed. (Cambridge, 1996), p. 6.
2. Bettyann Holtzmann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick, N.J., 1997), p. 20.
3. Kevles provides a time chart, paralleling the various developments in the multiple imaging instrumentation.
4. *Science* 274 (13 December 1996): 1870-73.
5. *Science* 276 (30 May 1997): 1331-34.
6. *Scientific American* 276 (August 1997): 46-47.
7. *Science* 243 (31 March 1989): 1663.
8. *Science* 277 (11 July 1997): 176-78.
9. *Scientific American* 276 (August 1997): 61-65.
10. The visit to the Cholula pyramid and conversations with anthropologists occurred during the 9th International Conference of the Society for Philosophy and Technology, November 1996.
11. Postmodernism is more thoroughly discussed in *Postphenomenology* (Evanston, 1993).
12. *Micropaedia*, *Encyclopaedia Britannica*, 15th ed. (Chicago, 1994), vol. 10, p. 514.
13. Kevles, *Naked to the Bone*, p. 15.
14. I refer to Hacking's "if you can spray them then they are real" in *Representing and Intervening* (Cambridge, 1983), p. 23.
15. *Science* 276 (27 June 1997): 1994. This rhetoric is an example of the more-than-neutral language often employed by science reporting.

Chapter 14

1. Bettyann Holtzmann Kevles, *Naked to the Bone: Medical Imaging in the Twentieth Century* (New Brunswick, N.J., 1997), p. 13.
2. Zermelo is well known in biological circles for his pioneering work in ecology and evolution.
3. *Scientific American* 276 (June 1997): 84-87.
4. Internet printout from Lynx site provided by Marshall Spector.
5. Edward Tenner, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences* (New York, 1996), pp. 43-44.
6. See Robert Crease, *The Play of Nature* (Bloomington, Ind., 1993), especially chapter 4.

Afterword

1. Larry Laudan, perhaps as good a spokesman for these positions as any, repeatedly affirms the fallibilist consensus for all the interlocutors in his *Science and Relativism* (Chicago, 1990).

DEAR SCIENCE AND OTHER STORIES

.....

FAILURE (MY HEAD WAS FULL OF MISTY FUMES OF DOUBT)

.....

In March 2014, *Harper's* published the report "Chronicle of a Death Foretold."¹ In this piece, Monte Reel describes a program implemented by Chicago schools in 2009 that would "determine exactly which of their 400,000 students would get shot."² The program became known alongside an initiative called "The Culture of Calm." Consultants from the Massachusetts Institute of Technology and the University of Chicago developed an algorithm that scanned juvenile detention and school attendance records, as well as test scores, and used these archives to prognosticate the preventable death of youths. When I first came across this report, I could not read past the first page: the report begins with Davonte Flennoy, a young man who was—to use an awkward nonword—"algorithmmed." More specifically, data was pulled from Flennoy's archival file, and this led to interpretable paper scores; in the application of the algorithm, his well-being and his psychic and biologic life were rendered in excess of a deterministic set of discursive calculations. To put it simply, the algorithm mathematically refused all aspects of his livingness. Flennoy's archive—his records, his test scores—were culled and collated, and he was determined to be highly killable, or "ultra-high-risk."³ Indeed, in

The subtitle of this story, "My Head Was Full of Misty Fumes of Doubt," is from Zora Neale Hurston, *Dust Tracks on a Road* (1942; rpt., New York: HarperCollins, 1991), 195.

1. Monte Reel, "Chronicle of a Death Foretold: Predicting Murder on Chicago's South Side," *Harper's*, March 2014, 43–51.

2. Reel, "Chronicle of a Death Foretold," 43.

3. Reel, "Chronicle of a Death Foretold," 46. On risk thinking see Nikolas Rose, "At Risk of Madness," in *Embracing Risk: The Changing Culture of Insurance and Responsibility*, ed. Tom Baker and Jonathan Simon (Chicago: University of Chicago Press, 2002), 209–237.

many ways his life only enters the mathematical equation as death. The algorithm was granted more energy and vitality—through the act of application—than Flennoy (the object and outcome of the mathematical analysis). After the predictive system algorithmically anticipated his death, and measures were taken to prevent his death, Flennoy was killed in June 2012. This report sat on my desk for just over two years, and I read the first page over and over. I could not fully integrate into my psyche the idea of an algorithm that was manufactured to assume, anticipate, predetermine, and foretell deadly violence; at the same time, I did not want to consume, yet again, what I and we already know. I read that first page over and over for about two years, noticing that the compulsion to repeat put me in a state, to borrow from Dina Georgis, “of simultaneously not wanting to forget and not wanting to know.”⁴

When I returned to the report and completed reading it, I learned that the predictable algorithmic model saw both funding cuts and ineffectual results: the key to the program was to run the algorithm, identify ultra-high-risk people, and prevent their deaths by providing them with mentors who would support, teach, counsel youths. The cost was about \$15,000 per student, annually, and the funding model was unsustainable; as well, gunshot victimization did not decrease among the algorithmed.⁵ Soon after, a similar predictable-analytics formula was adopted by the Chicago Police Department—one we are all familiar with and referred to as the predictive policing model: this algorithm identifies a series of “hot spots” and “hot lists” that single out criminals and their attendant geographies.

I begin this story with the *Harper's* report not because what is uncovered is new or astonishing but because it shows how blackness and race are implicit to mathematical codes, discourses, and problems. The report, without reserve, situates black youths in the midst of what Bernard Harcourt calls “actuarial predictions.”⁶ The predictions—the hot spots,

4. Dina Georgis, *The Better Story: Queer Affects from the Middle East* (Albany: SUNY Press, 2013), 47.

5. Rachel Levenstein, Sue Spote, and Elaine Allensworth, “Findings from an Investigation into the Culture of Calm Initiative,” *University of Chicago Consortium on School Research*, October 2011, <https://consortium.uchicago.edu/publications/findings-investigation-culture-calm-initiative>. Dana Chandler, Steven D. Levitt, and John A. List, “Predicting and Preventing Shootings among At-Risk Youth,” *American Economic Review: Papers and Proceedings* 101, no. 3 (2011): 288–292. Thank you, Nik Theodore.

6. Bernard Harcourt, *Against Prediction: Profiling, Policing, and Punishment in an Actuarial Age* (Chicago: University of Chicago Press, 2007), 2.

the ultra-high-risk youths, for example—emerge from the “mechanical combining of information for classification purposes.”⁷ The question of why or how or under what conditions premature death is predictable is not asked. Instead, death is an analytical and methodological variable in the overall equation. Even the underfunded and defunded program, which was intended to save black life and engender mentorship, grimly assumed loss (the vulnerable were not given life, they were given foreseeable death).

For the two years the report sat on my desk, unread, I thought about the mathematics of black life. I wrote an essay where I wanted to centralize black life rather than preventable and premature death; that essay argues, in a less-than-straightforward way, that one way to imagine black life differently is to rethink the mathematics that underwrite slave archives.⁸ Following Saidiya Hartman’s “Venus in Two Acts,” I explore how archives document and institutionalize sexist and racist practices. I argue that because the archives primarily document instances of violence toward and the death of black enslaved people, racism acts as an eerie origin story that can steer us, analytically, toward death. What the archive tells us is what we already know and what we resist, but it can also structure and frame how we enter into the present and future in our writing: Middle Passage and plantation systems formalized and made ubiquitously mundane, in writing and practice, violence against black people, black subordination, and racism, and we sometimes use this as a blueprint to understand and struggle against oppression. Anything in excess of violence, racism, and subordination—black life, black joy, the practice of loving, for example—is either absent or perversely tied to the dehumanizing logics of white supremacy. My central questions for that essay were: If the archive is a knowledge network that records and normalizes black subordination, how do we understand this network outside of itself? What happens to our understanding of black humanity when our analytical frames do not emerge from a broad swathe of numbing racial violence but, instead, from multiple and untracked enunciations of black life?

What I want to think about in this story, in a similar but different way, is how black life is absent from the classificatory algorithms that are applied to statistically organize our world. This absence affirms how the

7. Paul Meehl quoted in Harcourt, *Against Prediction*, 16–17.

8. Katherine McKittrick, “Mathematics Black Life,” *Black Scholar* 44, no. 2 (Summer 2014): 16–28.

premature death of black people, and, more broadly, the acute marginalization of the world's most vulnerable communities, are entrenched in algorithmic equations. What I am struggling to work out, then, is twofold: that premature death is an algorithmic variable; that black life is outside algorithmic logics altogether.⁹ It follows that coded infrastructures and patterns that are instituted to name and/or resolve social problems are bound up in biocentric thinking and, as well, that we are already grasping an alternative knowledge system when we analytically privilege black life. I am not, I want to underline, suggesting that we replace the dead with the living; I am not seeking to dismiss our losses. I want, instead, to reimagine blackness—as life and living memory and whatever is in between—as emerging from a black sense of place. My concern is therefore, broadly, methodological: How do we come to and formulate answers and what do we want from these solutions, politically? How might a black sense of place rethink the demand to fix and repair black humanity by lifting black folks up, from subhuman to a genre of human that cannot bear black life? What if black life opens up question marks and unanswerable curiosities?

A black sense of place draws attention to geographic processes that emerged from plantation slavery and its attendant racial violences yet cannot be contained by the logics of white supremacy. A black sense of place is not a standpoint or a situated knowledge; it is a location of difficult encounter and relationality. A black sense of place is not individualized knowledge—it is collaborative praxis. It assumes that our collective assertions of life are always in tandem with other ways of being (including those ways of being we cannot bear). A black sense of place always calls into question, struggles against, critiques, undoes, prevailing racist scripts. A black sense of place is a diasporic-plantocratic-black geography

9. If a nonuniform problem enters the data processes machine, it generates a noncomputable form and the output may not be predictable or calculable. The process of working with and working out the equation might: result in infinite calculation; or, alternatively (depending on the mechanics underpinning the working with and working out), the data processing machine might be offered a different set of rules through which to accommodate the nonuniform problem and resolve it. Gualtiero Piccinini, "Alan Turing and the Mathematical Objection," *Minds and Machines* 13 (2003): 23–48. If black life is the nonuniform problem, we might sit with this and its attendant noncomputability. If entered (recorded, logged), within the context of computation, black life might offer us multiple ways to unthink the problematic enfleshment of algorithms because it is an irresolvable variable; if entered (recorded, logged) into the equation, and within the working with and working out stages, the unsolvable also provides the opportunity to sit with unpredictability-entropy as this relates to the potential, not only the death-dealing, technologies of human life.

that reframes what we know by reorienting and honoring *where* we know from.¹⁰ This is a place where, to borrow from Édouard Glissant, “analytic thought is led to construct unities whose interdependent variances jointly piece together the interactive totality.”¹¹ A black sense of place is a methodology and an analytical frame that believes in and believes black humanity. So I ask: What does a black sense of place *do* to algorithms that presume, in advance, black premature death? How might we shift our methodological questions so that we do not end up in an analytical bind that affirms rather than undoes racial violence?

A black sense of place draws attention to uncomfortable relationalities yet understands these as a method through which we can wade through the horrific uneasiness of black death that is, as we know, posited as an easy resolution to a vast range of social problems. What I also want to signal, as I move through this story, is how some geographies get called up as answers to problems. To put it simply, solving crimes often involves surveying and marking black and/or impoverished geographies and claiming that this is not profiling because places, rather than people, are being targeted. In other words, social problems are resolved through producing calculations, equations, and problem-solving operations; these problems (black people) are translated into cartographically itemized racial codes.¹² Part of our task, then, is to notice how algorithms have a place and take place and produce place and how blackness—*where* we know

10. Katherine McKittrick, “On Plantations, Prisons, and a Black Sense of Place,” *Social and Cultural Geography* 12, no. 8 (2011): 947–963.

11. Édouard Glissant, *Poetics of Relation*, trans. Betsy Wing (1990; rpt., Ann Arbor: University of Michigan Press, 1997), 92.

12. These problem-solving operations can be imagined in relation to the Du Boisian question “How does it feel to be a problem?” In this case, the calculations and other mathematical operations require the uneasy embodiment of racial and racist designation and resultant structures of feeling (how does it feel to be?). The mathematics seek to resolve (solve, find an answer to) us. We are the repository of the mathematical operations. The affective work Du Bois points to is taxing. We know that problems are trouble. Problems are harmful and problems get in the way. Problems need to be resolved. Problem is dilemma, nightmare, mess. How does it feel to be a problem? It feels oppressive. It feels worrying. It feels forever. It feels awful. W. E. B. Du Bois, *The Souls of Black Folk* (New York: Vintage, 1990), 7; W. E. B. Du Bois, “The Study of the Negro Problems,” *Annals of the American Academy of Political and Social Science* 11 (January 1898): 1–23; Nahum Chandler, X—*The Problem of the Negro as a Problem for Thought* (New York: Fordham University Press, 2014); Paul Gilroy, *Against Race: Imagining Political Culture beyond the Color Line* (Cambridge, MA: Harvard University Press, 2000). She is a loose cannon, a problem. Remove her.

from—understands and reorders these geographies. I also focus on geography to dislodge crude identity politics, to cast the net beyond the individual and to emphasize that *where* we know from—rather than what we already know about our seemingly authentic selves—is a more generous and difficult political project that takes into account interhuman geographies. With this in mind, I suture a black sense of place to these mathematics and problem-solving practices in order to unthink the violence that often accompanies the production of space.

An algorithm “applies to any mathematical procedure consisting of an indefinite number of steps, each step applying to the one preceding it.”¹³ The steps are, in fact, massive calculations that are set up to accomplish a task; most algorithms stop on finding the answer. In addition, algorithms are intended to solve problems correctly and efficiently.¹⁴ According to Khan Academy, the reason algorithms matter is that the massive calculations “do things people care about.”¹⁵ While algorithms are best known within the context of computer science, they are attached to longer practices of statistical data collection. The aforementioned “hot spots,” “hot lists,” and “risky people” were the result of computer algorithms, as are trending hashtags, credit application scores, job application scores, prison sentencing decisions, publication impact factors, Netflix and Amazon recommendations, and so on. Algorithms also assess voter information environments, extract personal information, accumulate data sets, transfer data to capitalist stakeholders, ergo, profoundly remaking our sense of place (task accomplished).¹⁶ These computer-generated algorithms are

13. Tobias Dantzig, *Number: The Language of Science* (1930; rpt., New York: Plume, 2007), 33.

14. Khan Academy, “What Is an Algorithm and Why Should You Care?,” accessed May 19, 2016, <https://www.khanacademy.org/computing/computer-science/algorithms/intro-to-algorithms/v/what-are-algorithms>.

15. Khan Academy, “What Is an Algorithm and Why Should You Care?”

16. Carole Cadwalladr, “The Great British Brexit Robbery: How Our Democracy Was Hijacked,” *Guardian*, May 7, 2017, https://www.theguardian.com/technology/2017/may/07/the-great-british-brexite-robbery-hijacked-democracy?CMP=share_btn_link. In addition to being linked to the military industrial complex and surveillance, Cadwalladr likens voter information extraction to a “massive land grab.” She also refers to the data and generation of computer information as an “ecosystem” that can be mapped. Data mining: to quarry, to excavate, to remove. The spatial terms are dizzying given that computer data is not, in fact, a three-dimensional space that we can touch and/or inhabit. Instead, the data ecosystem is made up of computer codes. The ecosystem is produced by scripting languages like C++ or Frege or Python or Objective-J and it is upheld by software architecture. In many

automated-decision-making-software: they are computer codes that are given a problem, that seek and compile patterns and themes, and then spit out solutions.

An important feature underlying many algorithms is predictability: they are not only used to work out problems; they know the problem in advance and are tasked to achieve a specified result. So the accomplishment, the answer, the result, what we care about, comes before the equation. An important example of this is predictive algorithm models. In his study of policing and profiling, Harcourt explores predictive parole models alongside the overlapping fields of sociology, criminology, and statistics. Beginning in roughly the 1930s, statistical information on prisoners—such as immigrant status, employment history, personality type, and characteristic traits—was gathered to determine the likelihood of repeat offenses.¹⁷ While his study is very extensive, what can be deciphered from his text is that what these early statistical systems knew in advance was tied to “characteristic traits” that ostensibly shape recidivism and other decisions about prison life. It is not news, of course, that “characteristic traits” are underpinned by differential racial histories and privileges. What we learn from predictive algorithms, then, is that the mathematic

ways, the land does not exist and therefore cannot be grabbed or mined: the goal is, Jiawei Han and Micheline Kamber argue, “the extraction of patterns and knowledge from large amounts of data, not the extraction (mining) of data itself.” Jiawei Han and Micheline Kamber, *Data Mining: Concepts and Techniques* (Burlington, MA: Morgan Kaufmann, 2001), 5. However, Cadwalladr’s language is powerful precisely because it nods to a much longer history of racial and colonial violence and, at the same time, allows our mind to leap and think about how data produces real three-dimensional geographies. Data grabbing and data mining are certainly not the same as massive transnational land transactions and land grabs, spurred by violent “development” logics that necessarily displace and destroy the lives of the world’s most vulnerable. But the data grabbing—think Brexit and US president Trump, for example—remakes place and perhaps might be an anticipatory shadow in less immediate histories that were underwritten by displacement and accumulation by dispossession. Here, the work of Sharlene Mollett is instructive: land grabbing is not novel or recent; land grabbing is long-standing and routinely operationalized to naturalize racial hierarchies and racist “whitening logics.” Sharlene Mollett, “The Power to Plunder: Rethinking Land Grabbing in Latin America,” *Antipode* 48, no. 2 (March 2016): 412–432. Land grabbing is a self-replicating system that provides the avaricious conditions for the data grab. They are not the same, but they are both tied to colonialism and capitalism and they are both entwined with the production of space. The task of data grabbing is to remake our sense of place, heartlessly. Thank you, Paul Gilroy.

17. Harcourt, *Against Prediction*, 57.

answer or result is, at least in part and sometimes in whole, tied to a larger colonial and plantocratic logic: a trait is, as we know, a genetically determined characteristic—like eye color. Traits are the variables that underlie a biocentric system of knowledge.¹⁸

In contemporary contexts, sometimes race is written into the predictive formula. A Violence Prediction Model Variable counts and assesses:

African American;
Hispanic;
School Per Capita Shooting History;
Times Shot Previously;
Serious Misconducts Per Day;
Math Score; Reading Score;
Percent of Days Suspended;
Percent of Days Absent;
and so on.¹⁹

And sometimes race is obscured by the predictive formula. A Risk Terrain Model counts and assesses:

Drug Arrests, Gang;
Territory;
At-Risk Housing;
Risky Facilities;
Shootings;
Gun Robberies;
and so on.²⁰

Violence. Terrain. Predictive algorithms and actuarial patterns did and still do rely on genetic variables to help solve problems and get results and do things people care about. We should also note that the characteristic traits that underlie early algorithms get coded over and coded

18. Sylvia Wynter and Katherine McKittrick, “Unparalleled Catastrophe for Our Species? Or, to Give Humanness a Different Future: Conversations,” in *Sylvia Wynter: On Being Human as Praxis*, ed. Katherine McKittrick (Durham, NC: Duke University Press, 2015), 26–30.

19. Chandler, Levitt, and List, “Predicting and Preventing Shootings among At-Risk Youth,” 288–292.

20. Leslie W. Kennedy, Joel M. Caplan, and Eric Piza, “Risk Clusters, Hotspots, and Spatial Intelligence: Risk Terrain Modeling as an Algorithm for Police Resource Allocation Strategies,” *Journal of Quantitative Criminology* 27, no. 3 (2011): 339–362.

over and coded over, so that the variables (the traits) within the original equation that was fashioned to do things we care about sometimes get weighed down and lost underneath mathematical cyphers (as seen in the “Risk Terrain Model”). The weight that conceals traits also hides the work of the coders and translators: those workers who fuel algorithms by collecting and collating the data yet remain unseen and unacknowledged. These workers, Neda Atanasoski and Kalindi Vora write, are the “surrogate technologies” whose labor facilitates the ease of coming to an algorithmic conclusion.²¹ The work and process of coding conceals a long biocentric statistical history that continues to define “traits”—our genetic characteristics—as variables. A variable is a symbol that represents a quantity in a mathematical expression. What unfolds are measurable numbers—often abstracted from human input—calculating resolutions that we care about.

If we understand algorithms in this vein, we can begin to tease out how numbers and mathematical equations are tied to a biocentric system of knowledge. What becomes increasingly clear, then, is not simply that the results and answers are racist (e.g., your traits mathematically result in your incarceration), but that the work of administering algorithms (e.g., what we *do* to solve the problems that we care about) requires biocentric methods and methodologies that can only produce dehumanizing mathematical results. In other words, black inhumanity, specifically the biocentric racist claim that black people are nonhuman and unevolved and a priori deceased, is a variable in the problem-solving equation before the question is asked, which means that the work of the algorithm—to do things people care about, to accomplish the task—already *knows* that Flennoy’s life and well-being are extraneous to its methodology. What comes into clear view, then, is not simply the racist result but the administrative and methodological steps that require racism before they begin to work through and toward the problem.

A large number of articles and books speak to these themes—particularly in relation to predictive policing but also in relation to other algorithmic patterns: predictive algorithms are racist, predictive algorithms imitate a racist system, predictive algorithms are technologies of racial

21. Neda Atanasoski and Kalindi Vora, “Surrogate Humanity: Posthuman Networks and the (Racialized) Obsolescence of Labor,” *Catalyst: Feminism, Theory, Technoscience* 1, no. 1 (2015): n.p., http://feministtechnoscience.org/ojs/index.php/catalyst/article/view/ata_vora.

profiling, predictive algorithms are antiblack, algorithms harm communities of color, algorithms threaten democracy.²² I subscribe to the “Algorithm” page on Flipboard, which algorithmically gathers a range of recommended articles on big data and algorithms and presents them to me because I care about algorithms. Headlines include “Beauty Contest Regrets Using Robots for Judges after Only White People Win,” “Facebook Algorithms Can’t Replace Good Judgment,” “It’s Getting Tougher to Tell if You’re on the Phone with a Machine or Human: Algorithm Can Accurately Mimic Human Voices, Including Breathing,” “Could an Algorithm Replace the Pill?,” and “How Algorithms Can Destroy Your Chance of Getting a Job.”²³ The widely circulated *ProPublica* article “Machine Bias” draws attention to how the software and formulas used to determine future criminals are racially biased: regardless of their criminal history—a history that may include no criminal activity at all—black people are cast as more unlawful and culpable than white people.²⁴ We also know, as well, that there is widespread support for predictive models, which are described as beneficial, proactive, promising, strikingly successful, cost-

22. Ezekiel Edwards, “Predictive Policing Software Is More Accurate at Predicting Policing,” *Huffington Post*, August 31, 2016, http://www.huffingtonpost.com/entry/predictive-policing-reform_us_57c6ffe0e4boe60d31dc9120; R. Joshua Scannell, “Broken Windows, Broken Code,” *Real Life*, August 29, 2016, <http://reallifemag.com/broken-windows-broken-code/>; Cathy O’Neil, *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* (New York: Crown, 2016). Ruha Benjamin, *Race After Technology: Abolitionist Tools for the New Jim Code* (Cambridge: Polity, 2019).

23. Amanda Fama, “Beauty Contest Regrets Using Robots for Judges after Only White People Win,” *Elite Daily*, September 9, 2016, <https://www.elitedaily.com/news/beauty-contest-robot-judges-regrets/1606213>; Navneet Alang, “Facebook Algorithms Can’t Replace Good Judgment,” *Globe and Mail*, September 9, 2016, <https://www.theglobeandmail.com/opinion/facebook-algorithms-cant-replace-good-judgment/article31805498/>; Dave Gershgorin, “It’s Getting Tougher to Tell if You’re on the Phone with a Machine or Human,” *Quartz*, September 9, 2016, <https://qz.com/778056/google-deepminds-wavenet-algorithm-can-accurately-mimic-human-voices/>; Cory Doctorow, “Blackballed by Machine Learning: How Algorithms Can Destroy Your Chance of Getting a Job,” *BoingBoing*, September 8, 2016, <https://boingboing.net/2016/09/08/blackballed-by-machine-learnin.html>; Emma Lundin, “Could an Algorithm Replace the Pill?,” *Guardian*, November 7, 2016, <https://www.theguardian.com/lifeandstyle/2016/nov/07/natural-cycles-fertility-app-algorithm-replace-pill-contraception>. Read with: Marcus Gilroy-Ware, *Filling the Void: Emotion, Capitalism, and Social Media* (London: Repeater Books, 2017).

24. Julia Angwin, Jeff Larson, Surya Mattu, and Lauren Kirchner, “Machine Bias,” *ProPublica*, accessed June 20, 2016, <https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing>.

effective, incredibly accurate, and so on.²⁵ These incredibly accurate algorithms are also often posited as delinked from race, thus pushing up against the *ProPublica* thesis. The website for PredPol (a well-known company that produces predictive policing software) reads, “PredPol uses only three data points in making predictions: past type of crime, place of crime and time of crime. It uses no personal information about individuals or groups of individuals, eliminating any personal liberties and profiling concerns.”²⁶

Type. Place. Time. In some of the studies I read, there are often short definitions of what a predictive algorithm is, or what predictive policing algorithms are, but the racial shadows behind numbers are often unspoken-unwritten. The already existing biocentric logic does not necessarily inform the administration of the algorithm (how we *get to* what we care about is not relevant). Instead, what is highlighted, discussed, are the answers: finding bad illegal geographies and disciplining the bad criminal people that inhabit these places. This kind of analytical move refuses racism, capitalism, and white supremacy while presenting their logics and outcomes—dysselection—as objective truths. Samuel Greengard writes:

Feed reams of data—particularly data focused on the time, distribution, and geography of past events—into a database and ferret out patterns that *would not be apparent to the human eye or brain*. With the resulting data, it is possible to adjust patrols and other resources to create a stronger deterrent, but also to predict *where* crimes are likely to take place and be in a better position to apprehend suspects.²⁷

What I am trying to work through is, then, how the racist biocentric logics that inform the algorithmic queries and their answers are quietly yet securely tied to the mathematics of black lifelessness. What we have is a system wherein black people are dehumanized in advance, and this

25. Walt L. Perry, Brian McInnis, Carter C. Price, Susan C. Smith, and John S. Hollywood, *Predictive Policing: The Role of Crime Forecasting in Law Enforcement Operations* (Santa Monica, CA: Rand, 2013); Andrew Guthrie Ferguson, “Predictive Policing and Reasonable Suspicion,” *Emory Law Journal* 259 (2012): 261–313; Samuel Greengard, “Policing the Future,” *Communications of the ACM* 55, no. 3 (March 2012): 19–21.

26. Predpol, “About,” accessed February 1, 2017, <http://www.predpol.com/about/>.

27. Greengard, “Policing the Future,” 19 (emphasis added).

dehumanization is hardened and made objective by mathematical codes. The tensions between these analytical approaches—the biological and the mathematical—function to produce a series of “objective facts” precisely because they are grounded in a positivist system of knowledge that indexes simultaneously, racial, sexual, economic, geographic, and temporal differences. The algorithm expresses, almost perfectly, the brutality of racism precisely because it is an accounting system that produces what Sylvia Wynter calls “adaptive truth-for” terms that are specific to our present order of consciousness.²⁸ The numbers that come before, comprise, and complete the algorithm are devoid of black life yet filled up with acts of black dysselection. It is a process typical to what we already know: a biocentric system is mathematically confirmed; it unfolds and is, in theory, seemingly absent of racism because the methodology cannot comprehend black well-being in the first place; the system and methodologies cannot bear black livingness, and the math and coding behind the algorithm provide an alibi for racism because black life is not relevant to the “things people care about.” What is also revealed is the tendency to bifurcate the science of the biological and science of mathematics: even though we know in our hearts algorithms imitate a racist system, within our present system of knowledge, the numbers do not and cannot lie.

Josh Scannell adds to this by exploring how algorithms are “real social processes” that “enshrine contested neo-plantation systems of rule as technocratic abstractions, infrastructural, and inevitable.”²⁹ The information behind algorithms is cast as “spectral data bodies” that produce a “metrics of prehension” that is spatially enacted. Indeed, if the numbers cannot lie, the spatialization of these numbers, expressed across multiscalar geographies, ensures what Ruth Wilson Gilmore calls the “fatal couplings of power and difference signified by racism.”³⁰ Geography matters because it functions to illuminate how algorithmic answers to our problems—what we care about—are embedded in place. Interestingly, the more we research these connections between geography and algorithms, the more

28. Sylvia Wynter, “Unsettling the Coloniality of Being/Power/Truth/Freedom towards the Human, after Man, Its Overrepresentation—an Argument,” *CR: The New Centennial Review* 3, no. 3 (Fall 2003): 280.

29. R. Joshua Scannell, “What Can an Algorithm Do?,” *DIS Magazine* (2016), accessed September 26, 2016, <http://dismagazine.com/discussion/72975/josh-scannell-what-can-an-algorithm-do/>.

30. Ruth Wilson Gilmore, “Fatal Couplings of Power and Difference: Notes on Racism and Geography,” *Professional Geographer* 54, no. 1 (February 2002): 22.

we notice how the former, geography, is racially codified. Predictive algorithms are not only imitating a racist system, they are refusing an already refused black humanity by marking black geographies predictably criminal. In many ways, then, the answer to our problems is revealed as the multiscalar dispossession of the dispossessed. This geographic layer perfects the algorithmic alibi by using mathematical procedures to abstract human activity from racist problem-solving practices and by depersonalizing black geographies. PredPol: “Using only three data points—past type, place and time of crime and a unique algorithm based on criminal behavior patterns, PredPol’s powerful software provides each law enforcement agency with customized crime predictions for the places and times that crimes are most likely to occur. PredPol pinpoints small areas, depicted in 500 feet by 500 feet boxes on maps—that are automatically generated for each shift of each day.”³¹ Type of crime, place of crime, time of crime. Type. Place. Time.

In addition to studies like “Machine Bias,” there has been some valuable work on reclaiming and recoding algorithms, recognizing coders who critique and refuse predictive models, highlighting nonpredictive and eternal algorithms, thinking about the algorithm as similar to the Code Noir or as a form of plantation neoliberalism or as enacting a Foucauldian panopticon.³² There are algorithmic poetics and code-work that index and map different sites of safety and violence.³³ There have also been algorithmic mappings of Negritude, opacity, slave ship routes, city sounds, deaths since Ferguson, and more. So even though the numbers do not lie, many are working hard to counter-code or renarrate or simply tell the certainties that underlie the brutal statistics, traits, and mathematics of dysselection.

31. Predpol, “About.”

32. Wendy Chun, “On ‘Sourcery,’ or Code as Fetish,” *Configurations* 16, no. 3 (Fall 2008): 299–324; Christopher Taylor, “Plantation Neoliberalism,” *New Inquiry*, July 8, 2014, www.thenewinquiry.com/essays/plantation-neoliberalism/; Louis Henderson, “Black Code/Code Noir: The Algorithm as Necropolitical Control,” *Khiasma*, June 2016, <http://www.khiasma.net/magazine/black-codecode-noir/>; Colin Koopman, “The Algorithm and the Watchtower,” *New Inquiry*, September 29, 2015, <http://thenewinquiry.com/essays/the-algorithm-and-the-watchtower/>.

33. Micha Cárdenas, “Trans of Color Poetics: Stitching Bodies, Concepts, and Algorithms,” *Scholar and Feminist Online* 3, no. 13–4, no. 1 (2016), <http://sfonline.barnard.edu/traversing-technologies/micha-cardenas-trans-of-color-poetics-stitching-bodies-concepts-and-algorithms/o/>.

What all of this has led me to—the codes and the recodes, the equations and problems, the predictions and spatial alibis, the software and the numbers, all covered in blood and death and things we care about that would not otherwise be apparent to the eye or the brain—is a lesson in methodology. I am interested in algorithms because of what they tell us about *how* we do the things we care about. Much of this story has centralized how many algorithms are future-making mathematic equations. They are anticipatory computations that tell us what we already know, but in the future. If we want different or better or more just futures and worlds, it is important to notice what kind of knowledge networks are already predicting our futures. As we know, as well, futurity and futures are deeply meaningful to black folks: we see this playing out in a number of ways, in reconceptualizations of time and space, in Afrofuturisms, in black science fictions and speculative fictions, in the unmet promises of modernity, in the freedom yet to come; in the syllabi and the calls for papers and the conferences and the books and articles and blogs; in the keywords and in the museums; in the recent and not-recent-at-all turn to string theory and theoretical physics and quantum mechanics (within the context of black studies, for example); in the unending and open-ended circulation of the spectacles, the litanies, the lists of those we, you, I have lost; in the lists we cannot bear to draw up; in the poems and the theories we write and the poems and theories we will not write; on the streets, and in parks, and around our tables, and in artworlds, and in our sighs and side-eyes, in our tiredness and dreams; in the demand to keep it up, keep it up.³⁴

If algorithms are future-making mathematical equations, they matter to black studies and black people because they are predicated on the negation of black life: this negation demands we keep an eye on algorithmic fictions because we cannot live with, we do not want to live with, the future outcome they produce; this negation also highlights, boldly, that black life is rebelling against that system of negation precisely because it is unimaginable within the practice of (automated) decision-making. Predictive black life is the antithesis to those technologies of race that repli-

34. “Never stop the action / keep it up / keep it up”: Grace Jones, “Jones the Rhythm,” *Slave to the Rhythm*, Island Records, 1985. Also recall Jones’s live performances of “Slave to the Rhythm,” where she hula-hoops throughout the entire song, often for over eight minutes—no beat lost. See Grace Jones, “Slave to the Rhythm—Live AVO Session,” YouTube video, 8:33, posted June 26, 2010, <https://www.youtube.com/watch?v=yPHmJLRFv8c>.

cate what we already know about racial violence. Predictive black life. If algorithms provide a generalized template that requires the absolute negation of black humanity, and black life is in excess of this self-replicating system, then the equations, the algorithms, the big data, *cannot adapt to black life*. This opens up a methodological opportunity for us, because the algorithms signal that what is outside this and other systems of big knowledge—black life, black well-being, black livingness—is a genre of humanness that is poised to decode, or is already decoding, this system and, at the same time, enunciating a worldview that functions within, across, and outside oppressive technologies and infrastructures. This is the demonic ground Wynter writes about in her piece on *The Tempest*: a different and alternative space-time—a black sense of place, *where* we know from—that can and does reorder our present system of knowledge because it is not, in fact, measurable on colonial terms. Part of what I am suggesting is a monumental demand—to reorder how we know, to produce a new science of black mnemonic livingness—but I think it is a meaningful demand. We might engender and honor black life as methodology—human being as praxis coupled with diasporic interdisciplinarity that cannot be measured or pinned down. The demand can, therefore, be grasped on a smaller scale by posing new and different academic questions that emerge from a black sense of place (where we know from).

What happens to our questions if we insist our methodologies are, in themselves, forms of black well-being? What happens if the nonmeasurability-noncomputability of black life is indicative of, necessary to, our analytics? What if we are not seeking outputs, answers, conclusions that end with only describing racism within our present system of knowledge? What if the answers that emerge from our colonial and plantocratic blueprints are not good enough? What if there is not a learning outcome? What if we taught and wrote not as problem solvers who count and assess variables (and creative texts can, at times, be theorized as variables) but as intellectuals who, with all our hearts, believe in opacity and giving on and with rather than finding, grasping, and having?³⁵ The answers that emerge from our colonial pasts are not good enough precisely because they are given in advance of the questions. If the depth and richness of our lives are absented from our analytics—if our questions recite what we already know—we risk working with and reproducing a system that

35. Glissant, *Poetics of Relation*, 144.

cannot adapt to black life. This positions the algorithm not as something we should abandon but, instead, as a warning sign that signals the limits and possibilities of how we do what we do. The features of the algorithm are disquieting and familiar because they loom over and under the disciplining methodologies that make the academy what it is: the question, the answer, the massive calculations that are set up to accomplish a task; the push to solve problems correctly and efficiently. I am not arguing that the algorithm is the same, methodologically, as discourse analysis or text-based analyses or participant observation or other methodological processes we employ to do what we do. I am, though, suggesting that our academic worlds celebrate problem solving, learning outcomes, accomplishments, reviews, and mandates—and, in the case of my university, master plans, strategic plans—and that these features often lurk behind our questions. If we shift our focus to embrace, more boldly and confidently, an analytic of black life and livingness, we centralize black humanity—not eschewing racism and racial violence but, rather, understanding that these practices have always engendered a different form of life that privileges our collective well-being.

When I was writing this story, I stopped several times because I didn't want to finish it. I felt tired and defeated. In fact, I hated my argument and I came to despise algorithms. I realized that the work of coding—the practical science of computer science—was impenetrable and unwelcoming to a person who has not been trained in the discipline. I hated what I wanted to know and why I wanted to know it. My curiosity diminished. I am not a computer scientist: everything I read that *was* intelligible—the articles and books that spelled out how algorithms are undemocratic and racist—affirmed racism. What I read did not take me anywhere new and, at the same time, gave me a future I did not want. I didn't know anything yet I knew something. The only transparency for me, a non-computer scientist, was premature and preventable death. I also resented the context through which I and we are writing and thinking—normalized racial violence, lists of the dead and dying, the same old thing: “rampant textuality” coupled with excessive unspeakable violence that leads us on a linear path to a future of unfreedom.³⁶

36. The term “rampant textuality” is from Paul Gilroy, *The Black Atlantic: Modernity and Double Consciousness* (Cambridge, MA: Harvard University Press, 1993), 78.

I confess my anger and frustration because I adore and believe, with all my heart, that radical (rogue) interdisciplinarity (method-making) and patient relational thinking offer ways to rethink our present system of knowledge; the reason I originally turned to algorithms is because I wanted to write a story about how these mathematical equations organize our world and I wanted to put them into conversation with creative texts that would, perhaps, take us somewhere new. What I also confronted, during my research, is that sometimes the seduction of interdisciplinarity can take us so radically outside our own sense of place that we lose sight of why we do the work we do. Part of my confession, then, is that I don't really know—in a confident and academic sense—how algorithms are made. I am still learning. It's like my interest in physics: I learned a lot and continue to learn, even though I am not sure I have the energetic knowledge base to unsettle *both* physics and blackness. What I learned from my research on computer science, for the most part, was the outcome. I came to despise the work because my interdisciplinarity project was foiled by what I did not know and what I could not know, as a non-computer scientist. I tried to make my own algorithm. I failed. I then had the grand idea to algorithmically mash up what I wrote here with something a colleague sent me. I wanted to produce an endless list of scrolling words that come from two senses of place. I could not do it. I did not know how to write the code. Defeated, the most I could bear was to input the words from this story into one of those word-cloud generators. I felt sick to my stomach. Those word clouds were, at one time, promotional narratives—part of the master plan, the strategic plan—for my university. “Gender” in large block letters, “women” in smaller letters, “queer” in tiny letters, “international” in medium-sized letters, “black” nowhere. I became and am offended and sickened by the word cloud.

But all of this led me to something I already know but keep returning to in a kind of compulsive and repetitious way. To do radical interdisciplinary work, from a black sense of place, that changes the kinds of questions we ask is not just about reading outside our discipline, researching, and using slices and terms from people we do not normally read; it is about sharing ideas comprehensively and moving these ideas into new contexts and places. In a different story I asked that we read creative texts *as* theoretical texts; I asked, What happens if the groove or the song gives insight to the theoretical frame? For this story, I checked in with my partner, Zilli, who is a musician and coder. When I told him what I wanted to do—to learn how to code, to create an algorithm that shows that predic-

tive policing algorithms are not the only ways of knowing or doing black geographies, to learn how algorithms might be made into something new or different—he told me that was the wrong path. More specifically, he asked me: Why are you beginning with outcomes? What do you want the algorithm to do? I could not formulate satisfactory answers. I could only produce a nonfunctional and brutally individualistic formula: I begin with Flennoy, as outcome, I want my algorithm to change this outcome, or allow me to forget it, or bring him back, or give me some ethical distance, or . . . me, I want the algorithm to help me. Zilli and I had many conversations about the back end of algorithms, about how the politics of algorithms—even endless ones—are actually demands for clear and clean answers; they always already know. We also talked about Markov chains and Alan Turing, about AI and *Minority Report*. What I learned about algorithms is that the questions I ask in my own research emerge from difficult and often unbearable encounters—these encounters are riddled with impatience and are endless repetitive burdens that are ongoing and never resolved. I learned that I wanted something I could not get from an algorithm because all it could provide—in my reading, not everyone’s reading!—was a predetermined codified answer. I also learned that there is a sexiness to algorithms—imagine, I thought, if I could actually code a poetic-politics of blackness, an algorithm of resistance, and publish it as part of my book.³⁷

My conversations with Zilli led me down an important path because I came to understand that *not* knowing what an algorithm is, in an academic sense, opened up bigger questions about how we come to know blackness, in an academic sense. I began to dwell on praxis and methodology and to think differently about the production of knowledge in relation to race. The encounter did not produce a sexy coder with sexy codes; it produced an unfinished mess and a still-worried and still-curious person who continues to be deeply suspicious of how we come to know, where we know from, and the ways in which many academic methodologies refuse black life and relational thinking. But the conversation with Zilli is what I want to underscore—for if we are to reorient our analytics and privilege black life as we practice radical interdisciplinarity, we must engage, deeply, in conversation and share ideas generously. This is to say that relationality, like a black sense of place, must be praxis—a praxis that does not assume or desire resolved outcomes. Paying close attention to,

37. Disaster.

drawing out, and forging relational knowledges will provide us, as people who are invested in undoing the normalized workings of racial violence, with analytical mechanisms that allow us to do anticolonial work in a variety of university settings that, as we know, were not built to support or recognize black communities and black work.

Part of our intellectual task, then, is to work out how different kinds and types of texts, voices, and geographies *relate to each other* and open up unexpected and surprising ways to talk about liberation, knowledge, history, race, gender, narrative, and blackness. The task, as I have repeatedly noted throughout these stories, is not to track and quantify marginalized peoples and seek reparation through centering their objectification, but, rather, to posit that many divergent and different and relational voices of unfreedom are analytical and intellectual sites that can tell us something new about our academic concerns and our anticolonial futures. This story, then, is a long plea to be uncomfortably satisfied with the unmeasurability of black life and to engender interhuman relationalities, with all our heart; it is a plea to practice radical interdisciplinarity without fraying its connection to black life; it is a plea to honor a black sense of place and where we know from, rather than mobilizing crude identity politics as the answer and the fix. This is a plea to keep it up and a plea to foster and share intellectual spaces—sometimes crammed into the corners of the academy, sometimes not—for and with each other in order to methodologically and analytically redefine what they think we are.

Chapter Title: doing theory

Book Title: The Body Multiple

Book Subtitle: Ontology in Medical Practice

Book Author(s): annemarie mol

Published by: Duke University Press. (2002)

Stable URL: <https://www.jstor.org/stable/j.ctv1220nc1.9>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at <https://about.jstor.org/terms>



JSTOR

Duke University Press is collaborating with JSTOR to digitize, preserve and extend access to *The Body Multiple*

chapter 6 **doing theory**

It can be done. It is possible to write an ethnography of *disease*. This book shows that this is the case. It has presented a patchwork image of atherosclerosis of the leg arteries: a single disease that in practice appears to be more than one—without being fragmented into many. Thus, a body may be multiple without shifting into pluralism. So instead of tracing paradigmatic gaps, this ethnography-of-a-disease became a study into the coexistence of multiple entities that go by the same name. In its turn coexistence comes in varieties and takes different shapes. Here we have explored addition, translation, distribution (over different sites in the hospital, different layers of the body, and different moments in time), and inclusion. And if one begins to study the interferences between the enactments of two or three multiple objects (such as atherosclerosis *and* sex difference), then the complexities start to grow exponentially—though these are complexities to be investigated elsewhere, for this is the point where this study stops. It has done what it set out to do. A single/multiple disease has been described as a part of the practices in which it is enacted.

But what is it to do this? What is done along with it? The stories in this book do not finally unveil the truth about medical practice. Nor would I want to pose as a member of a small avant-garde of theorists who finally know what ontology is *really* about. None of this. Mind you, the stories assembled in this book are true and in as far as they are not, they need to be put right. And I take the theoretical apparatus mobilized and/or developed here to be worthwhile. But veracity is not the point. Instead, it is interference. Like any other representation, this book is part of a practice, or a set of practices. Attending to the multiplicity of the body

and its diseases can be done, or it can be left undone. It is an act. So in this final chapter I draw no final conclusions. Instead I briefly explore the act(s) this book engages in and point to some of those that it leaves undone.

How Sciences Relate

Shifting from understanding objects as the focus point of various perspectives to following them as they are enacted in a variety of practices implies a shift from asking how sciences represent to asking how they intervene. Over the past few decades many philosophers have stressed the importance of intervention as the dominant modern way of acquiring knowledge: epistemology lost its reverence for contemplation a long time ago. But, even if interference was important, interfering was not the point. The crucial issue in relating to objects was to get to know them. This book is part of a recent wave of studies that takes a further step away from disembodied contemplation. This means that it no longer follows a gaze that tries to see objects but instead follows objects while they are being enacted in practice. So, the emphasis shifts. Instead of the observer's eyes, the practitioner's hands become the focus point of theorizing.

Thus, this book contributes to a philosophical shift in which knowledge is no

Method

There is a large literature about method. Or rather there are three.

The first of these is of a legislative kind. It discusses how method should be shaped in such a way that the knowledge it helps to generate is *valid*. Valid knowledge should not contain the traces of the subjects who engage in knowing, nor of the situation in which the knowledge is articulated. It must be *pure*. No biases, no noise, should spoil a science's clear mirror image of the object. In this legislative tradition scientific knowledge should indeed be a mirror image of its object. The question of how this might be achieved is answered in a lot of different ways: very many legislative texts about method have been written. What holds this literature together is a quest after a method that is *good* in that it generates object-dependent, uncontaminated knowledge. (But what to refer

to? There is too much of it. No single title representative. But see, for example, Suppe 1977.)

The second genre in the literature is critical. It undermines the first. It tells that those who join the quest after a sound method have so far not found it. Along the way the main effect of their attempts at legislation has been to demarcate science from other kinds of knowledge. Such boundary setting has helped to protect some communities, those that succeeded in calling themselves "scientific," against outsiders. A large variety of examples are presented—not of method, but of the way it fails to keep out *bias* even though it is socially effective in keeping out *strangers*. Thus, we have come to learn about the manifest sexism contained in twentieth-century medical textbooks (e.g., Dreifus 1978). And about the subtle sexism, too (Jacobus, Fox Keller, and Shuttle-

longer treated primarily as referential, as a set of statements *about* reality, but as a practice that interferes with other practices. It therefore participates *in* reality. And various other shifts follow from this. One of these is that we need to reconsider the character of the relations between the sciences. Since the nineteenth century the various branches of science (physics, chemistry, biology, psychology, sociology) have been understood as differing not primarily in method (as was earlier the case), but in their objects of study. These were given by nature. They hung together in reality and ontology was the branch of philosophy that made this coherence explicit—often using the image of the pyramid. Each object domain was like a layer in a pyramid of objects ordered from the small and relatively simple to the largest and the most complex. And each science had the task of studying the entities in one such layer. Thus, at the bottom of the pyramid the smallest particles and the force fields between them formed the object domain of physics, and at the apex the complex social relations between groups of people were to be studied by sociology. One of the dreams that went with this ontological monism was that, in the end, full knowledge about the behavior of the smallest particles would explain everything else. Physics would explain chemical laws; chemistry would predict what happens to living bodies; biology would be able to explain psychological makeup and social relations. Not everyone agreed with this picture. During the twentieth century considerable effort has been devoted to establishing the existence of thresholds in the ontological

worth 1990). And many stories have been told about the way in which midwives and others were marginalized in the nineteenth century, when their skills and knowledges did not come to be taught in universities and thus were not granted the predicate “scientific” (e.g., Böhme 1980).

The third genre in the literature not only abandons the quest for a sound method, but also the critical campaign against it. Instead, “method” is turned into an object of inquiry. A variety of questions is being asked about it—in empirical mode. There are historical studies that go into the question of how the experimental method that is still with us got shaped and how it happened that so much faith was invested in it (Shapin and Schaffer 1985). Others wonder

why it was *method* of all things that came to stand out as the way of demarcating the scientific from the bogus (Dehue 1995). And yet other studies investigate scientific ways of working in an ethnographic mode: the sampling habits, labeling practices, ways of accounting, writing styles that may be found in present-day laboratories, offices, and scientific meetings. The knowledge that results from these ways of working does not mirror its objects. Do they fail to do so? But no. Mirroring is simply the wrong term. Passively rendering an object is not what science’s systematic ways of working *do*. Instead, they actively constitute a traceable link between an object that is studied and the articulations that come to circulate about it. When

pyramid. Thresholds between dead matter and living organisms, which, unlike dead matter, can get ill and die. Thresholds, too, between biological facts about sex difference, skin color or disease, and social events that do *not* follow from these facts and therefore need to be spoken about in specific, social terms: gender, culture, illness.

In this order of things, knowing and talking about *disease* is both a task and the privilege of biomedicine. Chemists, even if they may know all about the molecules out of which cells are composed, cannot hope to explain the organism and its diseases. *Biochemistry* is required, and it needs to include a pathophysiological branch. Medical practice meanwhile requires a further addition. For in order to attend to patients as *a whole*, biomedical knowledge of disease is not enough. The way people live with diseases should be attended to as well. In this way of thinking, “living with disease” was taken to be a psychosocial phenomenon called *illness*. Calls to attend to illness were often cast in critical language. Medicine was accused of prioritizing the physicalities of disease and neglecting its psychosocial aspects. But however harsh the criticism, it was built on a shared understanding of knowledge and the relations between the sciences, which was that knowledge is to be classified in terms of what it talks about and that these objects precede the knowledge. Body or mind. Disease or illness. Blood vessels or trouble with moving about. Biology or sociology.

However, if we come to the sense that knowledge is primarily about partaking *in* a reality, our understanding of the relations between the sciences also begins to shift. For whatever the relations between objects hidden inside the

moving from object to article we do not leave the material realm to enter that of theory and thought, but move, instead, from one sociomaterial practice (observation, experiment) to another (drawing, writing) (see Lynch and Woolgar 1990).

I separate out these three ways of relating to method here. They do not encompass all books that have been written on the topic—but leave some out that deal with different themes or ask different questions. And neither are the three ways separated here, separated out so neatly in libraries, at conferences, or in university departments. So there are fusions, gray zones, interferences. One of these is that

criticism of current methodological legitimations (style 2) feeds into the design of new methods—to turn these into *better* methods (style 1). This comes with hopes, for instance, that if the white male gaze is joined by female and colored optics, unbiased knowledge becomes possible, and objectivity is reached after all (see for a variant of this Harding 1986). In an analogous way empirical inquiries into the way science is practiced (style 3) are mobilized as a resource in writings criticizing methodological pretensions (style 2). If “method” is just a local, practical achievement, it cannot offer a guarantee that the knowledge that comes out of it is true. But

body—atherosclerotic plaque, peak flow velocity, increased cholesterol level—the practices in which these objects exist are concerned with a lot more with expensive or cheap apparatus, blood or flesh, forms or conversations, work hours, self-esteem, or insurance schemes. Treatment decisions are informed by the length of a stenosis *and* the length of a hospital stay. In practice, such diverse phenomena do not belong to different orders. It makes no sense to delegate them to separate layers of reality. They are all relevant and have to be somehow reckoned with together. What different sciences have to offer practice is different points of leverage, different techniques for intervention, and, indeed, different methods. One specialism may have dyes at its disposal, another knives, and a third the technique of humming, but in hospital practice they must somehow align and coordinate their objects.

However physical an intervention, the practicalities belonging to the so-called social are always and inevitably implicated in it. That is not to say that they are handled well. The quality of handling disease/illness and the rest of the world in hospital practice has not been the explicit concern of this study. But if a critic wanted to criticize physicians for attending poorly to, say, patients' experiences, the present analysis suggests a different way of framing this criticism. The point is not that in such cases some object remains outside medical attentiveness. It is rather that some intervention receives insufficient attention when

this reflects back on the empirical study of science: its own methods hold no guarantees either. Then what makes *science studies* better than the self-interpretation of scientists, or lay opinion? What are the grounds for its own claims to expertise (Ashmore 1989)?

An important question, but not one that has to be posed in this paralyzing way. What turning method into an object of empirical inquiry has taught us is indeed that no knowledge is beyond critique. Another method might have lead to different conclusions. Thus, there is no longer a formal reason to go with this, that, or the other product of science, however sound its method. But this comes with another shift, which is that knowledge should not be understood as a mirror image of objects that lie waiting to be referred to. Meth-

ods are not a way of opening a window on the world, but a way of interfering with it. They act, they *mediate* between an object and its representations. One way or another. Inevitably. That means that it is not so surprising that the quest for a method for producing faithful representations took so long and that each time some critic was able to find biases that interfered with the objectivity of the results.

Studying methods empirically, then, generates another understanding of what they *are*. No formal guarantees, but specific mediators, interferences. The question to now ask is *how* they mediate and interfere. Donna Haraway has described an example that is illuminating in its exaggeration. It is a cage—a nuclear family apparatus—designed to study paternal love in monkeys. It was developed in the

medical activities are evaluated. In hospital Z, people with intermittent claudication are only considered for an operation if they report that their daily lives are seriously hampered. This implies that at this point operations are appreciated as a primarily *social* intervention. But this is not the case in studies that evaluate operations. Take the typical clinical trial comparing operations and walking therapy for atherosclerosis of the leg arteries. The list of parameters assessed will include “pain-free walking distance” but most probably not “actual weekly amount of walking,” “changes in daily life,” or “assessment of the intervention” in the patients’ own terms.

How to attend well to the complex list of interventions that each medical activity entails? This question is left open here. But surely the first step is to consistently recognize that there are many entanglements in every action. To keep practicalities unbracketed. To treat everything in medicine as a practice. To engage in a praxiography. Praxiographic stories have composite objects. Disease is not different in kind to hospital stays or daily life. Each flows into the other. This means that the stories in this book are about disease itself just as much as they are about the practices in hospital Z that are intended to cure, alleviate, prevent, or investigate disease. The disease *as much as* the medical practices that intervene in it: the two go together. A microscope is used to look at plaque, while plaque, if it is to be practically relevant in a hospital, needs a microscope (and dissection, slicing, and staining techniques) to make it visible. Similarly, conversational skills (of both doctor and patient) and the complaint “pain when

sixties and seventies in the laboratory of Harry Harlow at the University of Wisconsin in Madison. Harlow first made “cloth mothers” and “bottle mothers” to test which of these offered the greater maternal love to monkey infants (who, faced with this awkward choice, preferred warm cloth over food bottles). Now it was the fathers’ turn. “Each infant in the nuclear family apparatus, a planned social environment worthy of Disney Worlds, had access to the whole neighborhood, including his or her own father. ‘Their parents, however, always remained home together’” (Haraway 1989, 240).

The nuclear family apparatus made it possible to isolate the variable “paternal

love” as a specific behavior of male monkeys. This phenomenon wasn’t available for study before the apparatus. The object wasn’t lying there and waiting patiently. The apparatus delineated it. But if the monkeys hadn’t responded so well, the use of the apparatus would soon have been abandoned. Did the monkeys respond well? “The fathers were nicely social with the babies and showed that they had a function in family life: threatening external enemies (experimenters mostly, Harlow recognized, in his always honest jokes)” (241). The nuclear family cage helped different observers (“experimenters”) to make comparable reports. That was what it was made to do. But it did

walking” depend on one another. As do blood velocity and the duplex machine measuring it. And without the statistical calculations for extrapolating data from small samples there would be no at-risk populations on national scales.

This is why an ethnographic study may talk about disease. In the traditional ordering of disciplines, an ethnographer talking about disease transgresses the thresholds separating the layers of reality in the pyramid of objects. But the move made here is different. It is not a matter of turning the arrow round so that instead of the natural sciences explaining social phenomena a social explanation of molecules, cells, or bodies is being presented. Instead, another axis has been introduced, another approach taken: that of practice. The latter encompasses molecules and money, cells and worries, bodies, knives, and smiles, and talks about all of these in a single breath. Thus, it stands in an oblique relation to explanatory knowledge and the static pyramid of objects to which this refers. It approaches knowledge and object as parts of life, elements in a history, occurrences in strings of interrelated events. But no. To talk of an *oblique* relation is not quite right either, because this might seem to imply that the ontological pyramid, approached differently, is left standing as it is. But it is not. If practice becomes our entrance into the world, ontology is no longer a monist whole. Ontology-in-practice is multiple. Objects that are enacted cannot be aligned from small to big, from simple to complex. Their relations are the intricate ones that we find between practices. Instead of being piled up in a pyramid, they rather relate like the pages in a sketch book. Each new page may yield a different image, made with a different technique and in as far as a scale is recognizable, it may again, each time, be a different one. There is no fixed point of comparison.

more. It literally constructed the 1950s U.S. suburban nuclear family in a monkey version.

The point of stressing this is not to say observers should *not* interfere. They always do. In the same book Haraway beautifully shows how the ethologists who went to study primates out in Africa interfered as well. They pretended they were modest outside observers, who, by building no cages, left the reality of “their” primates untouched. But they made the animals *theirs* even so. They set up camps, appropriated the primates by giving them names

in order to recognize them and communicate about them, arranged for them to get used to the observational presence of the ethologists, and so on. All this is not *bad* because it is interference. But it is interference. And the question of how to evaluate it shifts to a question of content. *How* does it interfere—and what to think of that?

Asking this question opens up a fourth and relatively new way of attending to method. A way that is normative again, and interested in the good: what is a good way of doing research, of going about the assembling and the handling of material?

The praxiographic approach allows and requires one to take objects and events of all kinds into consideration when trying to understand the world. No phenomenon can be ignored on the grounds that it belongs to another discipline. This doesn't make description easier. And since not everything can be held together in a page or two, other ways of delineating the world have to be found. Of course, there are many candidate traditions. In the present book I have built mainly on ethnographic techniques of observation and writing. But in various traditions of writing history, events have also been described with all their sociomaterial entanglements. It is no accident that history fails to fit into the ordered list of sciences where each is responsible for a slice of the ontological pyramid. History has always taken another entrance into reality. Another quite different but equally interesting resource for praxiography is found in the *material and methods* sections of scientific articles. In theory these specify as much as possible about the practices of investigation. They instantiate the recognition that the practices forcing an object to speak are crucial to what may be said about it. This recognition not only exists in written form but also resonates in interesting ways with the day-to-day self-reflection of medical professionals: a further resource for praxiography. In hospital Z, the death of a patient was always followed by a discussion in the staff meeting. The responsible doctor was required to describe the train of events that led to the patient's death. In this story, no particular "layer of reality" was privileged over any other. Deviant cells figured next to deviant dripping fluids; unexpected allergies next to the failure to check for them; heart problems were talked about in a single breath with names and

This time, however, the register in which *the good* is being played out has changed. Knowledge is no longer good in as far as it faithfully represents some object *as it is*. Objects do not slide silently, untouched, from reality into a text. Instead, there are cages or chairs, there is touching, asking questions, cutting up continuities, isolating elements out of wholes here, and mixing entities together a little further along. The new normative question therefore becomes which of these interferences are good ones. And when, where, in which context, and for whom they are good. Good knowledge, then, does not draw its worth from *living up to* reality. What we should

seek, instead, are worthwhile ways of *living with* the real.

Self-reflexive desperation about the foundation of our (whose?) knowledge is no longer required. We would be wiser to spend our energy on trying to come to grips with what we are doing when crafting academic knowledge. What are we doing—when we go into fields, observe, make notes, count, recount, cut, paste, color, measure, slice, categorize, and so on. What are we doing when we tame materials, when we publish, give talks, stage stories for various audiences. Asking such questions means that we need to abandon the methods section of the library and

doses of drugs administered. If any actor was most central to these stories it was not the sick body but the speaking professional, for the leading question invariably was what, if anything, he and his colleagues might have done better.

The distinction between knowing *in* medicine (about disease) and knowing *about* medicine (that is about its practice) is blurred, not just in praxiographic studies like the present one, but also in historical studies, in material and methods sections, and in the hospital itself. Objects enacted and practices of diagnosing and intervening belong together. They are intertwined. They jointly differ from other object/practice constellations. The concomitant relevant axis of difference in the sciences, then, is no longer between the social and the natural sciences, or, more specifically, between *classes of objects* and the sciences referring to them. Instead, the axis of difference needing further exploration is between *versions of objects* and the (science-related) practices in which they are enacted. If a disease like atherosclerosis is more than one, it becomes relevant to ask which one “it” is made to be. Which one of its various versions is enacted at any specific site or in any particular situation? Is it an X-ray picture and the atherosclerosis that encroaches the arterial lumen; or is it a patient history and the atherosclerosis that gives pain-on-walking? Are surgeons operating on clogged vessels or are patients engaged in walking therapy encouraged by their physical therapist? This, then, is the crucial question in a world where ontology is accepted to be

move to the shelves that tell about the politics of academic work. Here I won't relate to that literature as a whole, but confine myself to what is on a single shelf. The shelf with the books that reflect on the effects of writing styles. (There is a lot on this shelf! But see, for example, Bazerman 1988; Trinh Minh-ha 1989; Clifford and Marcus 1986.) In different ways these three books tell us that what we are doing when writing academic texts depends not only on how the material is assembled. At least as important are the ways in which it is processed, rendered, mobilized. Written.

Is nature made to speak, or is a *materials and methods* section put somewhere prominently? Is “a culture” presented as if it existed out there, independent of the ethnographer who happened to come round

to study it, or is it made clear throughout the writing that the stories told depend on scenes the author was a part of, even if it was only as an observer? Is the *subject* of writing staged as an observing outsider present in scenes she turns into “material,” or rather as someone who approaches the field with fascinations, passions, and theoretical baggage that deserve a lot more attention than they get in methodological attempts to rule them out? (For general anthropological work, this is explored in, for example, Okeley and Callaway 1992. For a good example of what this may mean in science and technology studies, see Law 2000.) And what difference does it make if one presents one's study as a detective story, not just by using metaphors like “discovery” and “finding clues” but, more elaborately, by bringing

multiple: what is being done and what, in doing so, is reality in practice made to be?

Doubt

When I presented drafts of my articles or chapters of the many drafts of this book to my informants they were pleased when they recognized themselves and each other in my stories. Sometimes they suggested small corrections at points where I hadn't properly understood some technicality. Sometimes they nodded: yes, this is how it goes. But they also said they felt alienated. Somehow I made the familiar sound so *unfamiliar* to them. So strange. And yet one might say that hospital Z was not just the place where I assembled my material, but also a place where I learned a lot about the theoretical insights that I have presented here. For instance, the most concise way of articulating the idea that objects enacted depend on practicality was suggested by the resident who was my informant in the department of pathology. It was he, not me, who qualified his "this, here, is atherosclerosis" with the crucial *under the microscope*.

In hospital Z it happens time and time again that the practicalities of enacting a specific version of atherosclerosis are underscored. For instance, the techni-

this narrative plot to the fore and playing with it (as is done in Latour 1996)?

Texts are active. And they do so much. One cannot possibly engage in an explicit and articulate way with all of these activities in detail in any one text, all the more so if the text has something else as its core topic. Here, therefore, I've picked out a single stylistic characteristic to attend to. All academic texts somehow relate to the literature. The question I've posed to myself, and you, throughout this book, is how to do this. *How to relate to the literature?* By inserting a title. By presenting a quote. By relating a story. By giving one's text its place among others.

Rationality

When research is presented as requiring *method* in order to result in valid knowledge, the analogous recommendation for practice is that it must become more *ratio-*

nal. In a variety of ways this has been claimed and propagated over the past few decades: medical practice is too messy and in need of purification. The irrational should be washed out of it. There is a large literature about *how* to do this. Its quest for rationalization comes with the hope that scientific order can come to rule practice. There is a second literature arguing that rationalization shouldn't be strived after. Neat ordering isn't possible since practice has a specificity of its own, different from that of science. A third literature investigates *what exactly alters* when rationalization strategies are actively put into practice. It takes "science" as a set of practices as much as "practice" and wonders what happens in the interferences between different working styles.

The present study is intertwined with, or could be read as a part of, the third kind of literature. It helps to undermine

calities in *materials and methods* sections of articles also get a lot of attention in research meetings. “But in how many patients did you find that?” Or “Why did you measure pressures only in rest and not after exercise?” Or “What did you say you used as a calcium antagonist?” For the participants in the research meeting it is a truism that the outcomes of a research project follow from such details. They shape the facts. As long as there is reason for or an occasion to doubt, the technicalities of an investigation are kept in focus. As long as various roads may still be taken, the entire trajectory so far is kept into view. It is only once outcomes are accepted as facts that the methods by which they were reached are, at least for the time being, abbreviated, allowed to fade out, forgotten. The two movements seem to go together: the consolidation of a fact and the bracketing of the means of its production.

In the diagnostic process something similar occurs. If a doctor doubts the diagnosis of a colleague, then questions about technicalities are raised. “But *how* did you ask when this pain occurs?” Or “Your pressures are odd: are you sure the arteries weren’t calcified?” Or “Who the hell decided to make an angiography of this patient?” Once an indication for treatment is written down, however, once there has been a conversation with the patient about it, and once the treatment is scheduled, such doubts tend to evaporate. It is on to the next task. A crucial bifurcation point is passed, the past is closed off, the practicalities of diagnosing are erased—all that remains of them is their results and a plan for treatment.

the presumptions of the other two, which both differentiate between scientific order on the one hand and mundane practice on the other. The praxiographic way to go about these issues is not to propagate rationalization strategies in general terms, neither is it to warn against them in equally general terms. Instead, it is to investigate what they bring along. What they do. It is to open up the question of *how* rationalization strategies alter what they interfere with. There are a lot of ways to handle this question. Here, I will present you with just a few examples of this third approach. They come from different places and each bring their own concerns with them but all tackle the question of the improvement of health care.

The first book on my little list is *Health and Efficiency: A Sociology of Health Economics* (Ashmore, Mulkay, and Pinch 1989). It pays a lot of attention to the question of how *health economics* manages to present itself as rational in the first place. How does it stage its capability of improving the way decisions in health care are being taken? How does it present itself as being able to help increase the (market) quality and decrease the (financial) costs of health care—all in one go? The authors state that the economists’ claims of expertise are strengthened by their shifting between two versions: a strong one (that holds big promise and suggests that if its own economic rationality was obeyed things would get better) and a weak one

“Obstruc. fem. art. left; bypass to below the knee” or something like that. If, however, something unexpectedly goes drastically wrong at a later stage, it is almost always possible to go back in time. To take out the photos and have another look at them. To search the file for small traces that were missed earlier on. The treating physician who traces a history after someone has died is likely to look back into the past in this way. Was there a moment when we were sure about something, but we should have stayed a while longer in doubt?

Attending to practicalities also happens when some treatment is doubted. It helps to make space for other possibilities. An internist critical of operations on leg arteries said to me in an interview: “They [the surgeons] look at these angiographic pictures and come to think that they can *see* atherosclerosis. There it is: a pipe that is blocked and they need to unplug it.” And then he added: “But by staring at an angiographic image one would never invent walking therapy.” The image of the pipe that needs unplugging makes atherosclerosis into something unlikely to be improved by walking therapy. After all, walking does not unplug the pipe that looks so stenotic on the angiographic image. In an attempt to raise doubt about the necessity of surgery, the internist tries to undermine the reality effect of the angiographic images. Do not think that it is *atherosclerosis* you see there, but keep the specificities of the imaging technique in mind.

In this book I have argued that different practicalities of research, diagnosis, and/or treatment each address a slightly different “atherosclerosis.” This idea is not alien to the hospital: I may even have learned it there. But there is a differ-

(that can be fallen back on in case of resistance: we know there are other matters to take into account as well). The authors analyze the contents of the economists’ expertise as well. They look into the specificities of option appraisal, clinical budgeting, and the evaluation of interventions by assessing their (positive or negative) effects on people’s quality of life.

Meanwhile the authors self-reflexively attend to their own claims of expertise. What is it to present one’s stories as *knowledge about* health economy? In their desire to be serious about establishing a symmetry between economic expertise and their own sociological expertise, Ashmore, Mulkay, and Pinch have written a book that

is full of mockery. (At this point I must insert a remark. An aside. However much “writing” has become a topic that is theoretically discussed, there still aren’t many books that *do* something to enrich, complexify, and change academic writing practices. Writing methods are still not taken as seriously as methods of gathering and analyzing material. *Health and Efficiency* is among the few exceptions. It brims with conversations, shifts in scenery, alternative presentations of material, self-reflexive remarks, and jokes. How to relate to that? In awe or with mere admiration?) So. So claims of expertise are robbed of their foundation.

The issue is not that health economics

ence. In hospital Z the other repertoire exists as well: that of bracketing practicalities. That of speaking about atherosclerosis *tout court* without mentioning microscopes, interview techniques, angiographies, or any other modality of enacting the disease. Of atherosclerosis in isolation. At such moments what one might think of as a virtual common object is projected into the body, an object that is hidden underneath the skin. An object that may be approached in various ways, that shows a variety of aspects, but that in the end is one. There it is, and suddenly it no longer seems to be a part of practice, but a referent in a pre-existing reality: overwhelmingly real. At such moments doubt is smothered and certainty is being manufactured. “But surely we are all fighting the same disease? We share a goal, don’t we? Obviously we all want to improve the health and lives of our patients.” At such moments someone might say (to me, for instance, in reaction to this text): “But listen, people die, people suffer. There is a *real* disease out there.” As if the certainty of death and misery necessarily brought with it the singularity of the real.

So in the hospital there are, at least, these two repertoires. Keeping the practicalities of enacting disease visible so that what happens may be doubted, *and* bracketing practicalities while working along and being confident in doing so. Making space for other enactments of reality, other versions of the disease to

should seek a better foundation from now on. “No, it is not the epistemological status of applied economics in any abstract sense that concerns us but rather the specific moral and political implications of its underlying assumptions” (187). If the authors have problems with health economics, its lack of rationality is not among these. The point is that in various instances interferences are made that could have been made otherwise. Had this been so, other outcomes would have followed. These are problems of *content*. An example. The QALY is a *quality-adjusted life year*. It is added to earlier epidemiological assessments that measured only survival. The addition is that the *quality* of the years patients survive an intervention are taken into account. But how? The QALYS obviously do so in a specific manner. One that allows accounting. One that

fits into the forms of quantitative studies. One that supposes that “aggregate data on preferences correctly represent the individual evaluations from which they originate” (192). Ashmore, Mulkay, and Pinch point out that sociological investigations into people’s appreciations of their life could also proceed differently.

However, Ashmore, Mulkay, and Pinch do not develop an alternative health economics. They cast doubt since their primary concern is with the arrogance with which economic expertise is presented as lying beyond doubt. A predicate of scientificity is used to close off discussion. The economists put themselves *above* the practice they aim to improve. An extensive quote here, for Ashmore, Mulkay, and Pinch have put it in a way that asks to be quoted. (In relating to the literature one comes across this style characteristic:

be diagnosed and treated, or closing off alternatives so as to move ahead on a given track. Doubt and confidence: in the hospital they alternate. My informants know how to shift between them; I abstain from doing so. This suggests that the strangeness of this book lies not in its novelty, but in the persistence with which it never comes to rest in a sure, single, mortal body, but keeps on pointing at the practicalities of living. Being so stubborn is like remaining in doubt. An analysis like this opens up and keeps opened up the possibility that things might be done differently. Look, they *are* being done differently: a little further along. If something is self-evident here, then in that other site and situation it is not. If atherosclerosis is a thick vessel wall here (under the microscope), it is pain when walking there (in the consulting room), and an important cause of death in the Dutch population yet a little further along (in the computers of the department of epidemiology). Reality is varied.

In stressing ontological multiplicity this book lays bare the permanent possibility of alternative configurations. The doubt that might lead there isn't always practiced, but it *may be*. Medical practice is never so certain that it might not be different; reality is never so solid that it is singular. There are always alternatives. There is no body-isolated that may offer us a place beyond doubt. But this means that no version of atherosclerosis should necessarily be practiced "because the body itself leaves us with no alternative." Bodies enacted are being

some texts are *quotable*, while others, even if they are well written, are not.) "Efforts at reform and change must, and will, continue. Applied social scientists of all kinds will continue to make a major contribution to these efforts. And as they do so, they will, like the health economists, be faced with the fundamental problem that the very practices they wish to alter will tend to frustrate their efforts. The point we wish to emphasize is that confronting this 'problem,' if it is understood in the way we suggest in this book, is the essential first step towards a better form of practice (if we may be permitted such a blatant evaluation): one that consists of a willingness to work with, rather than against, the actors in the domain of application; one that is collaborative rather than imperious; modest rather than megaloma-

niac; and wishing to learn rather than itching to instruct" (195).

This literature link is strong. The present book presents a very different study, but it leads to the same conclusion (or has this been one of its driving forces, a conviction that informed this study all along?). If there are so many *rationalities* in practice, in the plural, mixing with one another, interfering, then why present oneself as an outsider, who, with a single mode of ordering, may change everything? Why do so as a rationalist, a radical, a revolutionary, a rightist of whatever kind? The tenacious character of such hopes is all the more surprising when one looks at what happens, in practice, with rationalist schemes when they are introduced to a specific site or situation. It never happens that everything gets subsumed under the newest head-

done, which means that they cannot answer the question *what to do*. However uncomfortable this may be, this question, what to do, is a question *we* have to face. Not in circumstances where anything is possible, but still. Reality used to be a standard to live up to, but given the proliferation of technoscience the question that now needs asking is “what reality should we live with?” That means that reality moves. It can no longer play the role philosophy cast for it a few centuries ago, the role of something to get in touch with. The role of something to grasp. To hold on to. To be sure about. The crucial philosophical question pertaining to reality was: *how can we be sure?* Now, after the turn to practice, we confront another question: *how to live with doubt?* It isn’t easy. But somehow we must come to terms with the fact that we live in an underdetermined world, where doubt can always be raised. Somehow we must learn to understand how it is that, given this possibility, we can still act.

This, then, how to live with doubt, how to live in an underdetermined world, is another question that this book leaves open. However, part of the answer lies in shifting repertoires when considering action. If the question *what to do* no longer depends on *what is real*, then what else might it be linked up with? I suggest that if we can no longer find assurance by asking “is this knowledge true to its object?” it becomes all the more worthwhile to ask “is this practice good for the subjects (human or otherwise) involved in it?” If faithful representations no longer hold the power to ground us, we may still seek positive interventions. Thus, instead of truth, goodness comes to the center of the stage. Or rather,

ing. Instead, one more mode of ordering is added to the many others that are already there. This is what we learn from the next book on my list: *Rationalizing Medicine: Decision-Support Techniques and Medical Practices* (Berg 1997). This book tells a few stories. A first is that rationalization strategies may claim to *improve* medical practices, but the standards by which good and bad, and thus “improvement,” are assessed do not precede them. They are, instead, framed in the process of developing and introducing the rationalization strategies—with which they are inextricably linked up. A second story told is that the opposition between a messy practice and a single rationality that comes to

its rescue does not hold because there are serious incongruencies between the various rationalities involved. Computer-based diagnostic tools incorporate a quite different rationality than clinical decision analysis. Protocols are different yet again, and so are expert systems.

And then there is a third story in this book, one that says that when it is introduced into a practice an ordering device does not *expunge* messiness, but shifts it. Pushes it along. An expert system, for instance, may solve some problems, but creates others. It may suggest useful interferences between the data it is fed with and a diagnosis, but it obliges the people working with it to feed it with data and

not *goodness*, as if there were only one version of it, but *goodnesses*. Once we accept that ontology is multiple and reality leaves us in doubt, it becomes all the more urgent to attend to modes and modalities of seeking, neglecting, celebrating, fighting, and otherwise living *the good* in this, that, or the other of its many guises.

A Politics of Who

The recognition that medicine is entwined with *the good* has led to the call for what is sometimes called “patient autonomy.” Rather than professionals, “people themselves,” “patients,” are to decide what is good for them. Their norms are to be given weight. They have to make the judgments, and the role of professionals is simply to present patients with the options. Patients choose. A large industry (of literature, conferences, and committees) has grown to specify how to implement this requirement. What if the medical ideal of benefiting people clashes with the ideal of granting them autonomy? Are there moments when a professional should step in and decide for a patient? What to do with patients who are not capable of expressing their will in an articulate manner? Ignoring the complexities of such issues here, I want to stress that the growing interest in medicine’s normativity has predominantly focused on *who* questions. Questions about *who* is being put, or should be put, in the position to decide what counts as good.

There are, roughly speaking, two ways in which “patients” are put in the position of making supposedly crucial normative decisions, two ways of living out a right to choose. The first is that of the market. Here, medical interventions are

then adapt these where they do not fit. What, for instance, if the system wants one to locate pain in the back or the front, while a patient tells about pain that moves from one place to the other? Practitioners working with systems that want to be fed with discrete information must constantly negotiate their fluid findings. And it is, finally, story four that tells that while decision-support tools claim to simplify practice, in fact they do not do so. They introduce, and thus *add on*, a further logic to those that are already there. Something that is likely to complexify practice yet further. This is not an argument

against decision-support tools. A hammer may also complexify building practices and yet be a welcome extra tool. The question to pose, however, is what it might imply for designing tools. How, or so Berg asks, to build tools that help to improve practice, without fantasizing complexity away? Again a question that resonates with the stories I’ve been telling here. Improvement and rationalization are not quite the same.

The third book on my list is a socio-historical case study. The case studied is that of the *clinical trials* set up to assess the value of drugs against the human immunodeficiency virus in the United States.

displayed as if laid out on a counter. Professionals turn into sellers who supply a product plus the information that allows the patient-customers to choose between the products on offer. The patient is to make the value judgments—even if to some extent everything on offer in a market is, by definition, a *good*. In a market, goods that are entirely worthless are supposed to disappear; there is no demand for them. Even so, the health care market is heavily controlled. Professionals are required to be licensed and to check the quality of their own and each others' products. Although in actual markets money is central, the crucial element of the market metaphor in the context of medicine is that the individual patient, being the customer of health care, is the actor of an individualized choice for or against some “care act” or isolated “intervention.” An ideal patient-customer is able to find the goods that fit his or her specific needs and situation.

The second genre of handling choice is civic in character. Here, medical interventions do not figure as goods on a market, but as policy measures. They are interventions into modes of living—configuring professionals as kings rather than hawkers. The civic metaphor tends to turn the patient into a citizen who deserves to have jurisdiction over the interventions into his or her own body and life. Decisions have to be singled out, and the patient must then be able to argue civically for one course or action or another. But the civic metaphor doesn't necessarily argue for individual choice. Intervening in one life, after all,

The book is *Impure Science: AIDS, Activism, and the Politics of Knowledge* (Epstein 1996). It underlines the fact that clinical trials depend on the cooperation of many—the patients not the least among these. In the trials for drugs against HIV, some of the exigencies built into local definitions of good universal science were incongruent with the way most patients perceived their own interests. In the United States, getting enrolled in a trial may be of direct interest to patients because it provides them with free treatment. Moreover, being enrolled in a trial was often the *only* chance of receiving an antiviral treatment at all. But patients were obliged to refrain from taking drugs other than the one being tested in the trial. For some-

one with AIDS who has opportunistic infections, this is an unreasonable demand. Epstein describes how ACT UP, a movement of patient advocates, came to voice this and similar issues. First, they made their voice heard in angry protests against the way trials were designed. And then, as a next step, they were invited to come and sit on the committees that designed the trials.

The designs were adapted. At various points there appeared to be elements to contest. The question of who was included: at the outset participation was limited to (mainly white) males who had been infected through gay sex. It was only after ACT UP protests against this that first women were included and then drug ad-

also influences others. This brings with it the requirement that individual decisions should not harm others. But where does harm start? If one person chooses to have offspring through in vitro fertilization, this alters the meaning of being childless for others; if one would-be parent chooses to abort a fetus with Down syndrome, this touches on what parenting a child with Down syndrome does to others. To account for the effects of policy measures into a single patient's situation on the situations of others, the civic metaphor has been further developed. Interventions are understood as a way of organizing not just individual life, but that of the entire *polis*, the *body politic*. They concern us all, as patient-citizens. This implies that in the civic version of the *politics of who*, "patients" must represent themselves whenever decisions (about the organization of health care, allocation of money, research efforts, and so on) are being made.

The market genre and the civic genre have a common concern with the question of *who* decides. Both genres are informed by the same suspicion of professionals who patronizingly decide what is good for the rest of us. Ethicists together with social scientists investigating health care have contributed greatly to the articulation of this suspicion and have stressed the importance of the question of who decides in medicine. They have contributed to a politics of who. But

dicts (more often of color). The rules about taking other drugs were altered; with some adaptation of the statistics used this could be done. Then there was another intriguing issue: what should be taken as a parameter to mark the success of treatment? The primary choice of the epidemiologists had been to count the number of deaths in the treated and in a control population. But when survival became a little more prolonged it was argued that this was too slow. An intermediate parameter, a T-cell count, was chosen, a measure that was later discarded again. An appropriate parameter was difficult to find. What is interesting in the light of the present book is that in this specific case it became clear to all those concerned that what makes a parameter *appropriate* is a complex question. Statistical issues, the immune system's behavior, patients' hopes and expectations, health care finances, the pharmaceutical indus-

try's research style, government regulations—all of these are intertwined. The loudness with which the various elements are heard may differ depending on the specificities of the situation. And in this case, a patient-advocate movement willing and able to engage with the details of the science involved was crucial.

There is still a lot to learn about such engagements. What they require, for instance, is that the professionals involved allow themselves to be addressed, that they listen to what others have to say and take it as an argument to be included in the accounts. What they also require is that the "others" in question are able to mobilize the arguments with which to engage in such "addressing." Epstein stresses that the ACT UP people were highly educated—if in different fields. They didn't take long, moreover, to educate themselves in clinical epidemiology as well. This is not

such a politics of who has some problems. The first is that, although the customer and the citizen may be protected against such things as monopolies of suppliers or the power of the state, their will and their desires are supposed to be set, predetermined, and clear. The analyst takes the position of a lawyer for the patient movement whose task it is to make space for the patients' silenced voices. But the position of the lawyer is not the only possibility. What if the analyst takes the position of the patient himself or herself? Then it may well be that other matters become important. For instance, "how might we gain the right to decide" may be displaced by the at least equally urgent question "what should be done?" What might it be good to do? What might the good *be*, here and now, in this case or that other? The problem, then, is that in trying to give "the patient" a say, a politics-of-who remains silent about what, if one is a patient, one might actually say at the crucial moment.

The second problem with a politics-of-who is that it isolates moments when a choice is being made. It separates decision-making moments from the series of long layered and intertwined histories that produce them, as if somehow normative issues could be isolated and contained within those pivotal points. As if they were, indeed, pivotal points. Take the situation of a consulting room where a decision is being made about whether or not an operation would be a good thing for the patient who has come to seek help. A decent doctor would explain quietly about what is wrong with the patient's arteries and about the pros and

a story in which assembled experts were confronted by individual lay people who were only knowledgeable about their own case. ACT UP activists draw their insights from many people involved. They brought their own expertise along. Expertise about the daily lives of patients, to begin with. This allowed them to help build interferences between the daily lives of patients and the exigencies of doing clinical epidemiology research.

Thus, however much Epstein's story starts out from a sociological curiosity about the way lay people came to speak *inside* science, the lines of difference tend to be more complex than lay/professional divisions. For epidemiologists who had been involved in cancer research, for in-

stance, the ACT UP points were less alien than for those who so far dealt with acute infectious diseases. The committees designing trials welcomed the expertise on patient's concerns and daily lives ACT UP brought along. Without this they knew they risked setting up studies nobody would want to participate in. And ACT UP people in the end became so involved in the clinical epidemiology that they in their turn found themselves confronted with outsiders in the movement speaking out in the name of daily life. So the *who* question weighs heavily in Epstein's sociohistorical account. He persistently asks questions about who speaks and who does not. But what Epstein also makes clear is that once they were listened to, all those in-

cons of an operation. But to concentrate on *this* situation hides many others. For instance, that—at least in the Netherlands—the patient is present without having to think about the costs of various diagnoses and treatments. Or that no structured walking therapy was ever offered and that, despite huge investments, no drug is so far good enough (maybe the grant application that would have led to the drug was turned down—so what about *that* decision?). Or that some other hidden factor made this patient's atherosclerotic process go so far as to give pain on walking, so why wasn't that process ever intervened in? Or how come the patient had not considered this pain (as others might have done) as simply a part of getting old? Every single moment always hides endless contingencies—which, if we look at them carefully, are likely not simply to be contingent. That means that most elements relevant to making or unmaking the *goods of life* involved in making a decision escape the moment of that decision.

The third problem with a politics-of-who is that it is designed to push the power of professionals back, claiming some choices, and then more and yet more, for patient-customers or patient-citizens. But this same politics of who has trouble getting inside professionalism. It does, after all, grant professionals the facts. It requires of them that they give information—as if, from the beginning, there were a neutral set of data to lay out on the table. But there is not. My informants in hospital Z would stress that however much they tried to give “neutral information” they always found that the way they presented the facts made an impressive difference in how these facts were evaluated. But there is

involved, professionals and lay, preoccupied themselves primarily with another question: *what*. What is important, what should be done? Actors who have gained rights to speak no longer worry about getting heard, but wonder what to say. Maybe it is a matter of time: one question is not in tension with but follows after the other. If so, I would like to mobilize Epstein's book here as a support for a claim. This claim. It is time, in health care, to assemble and develop the theoretical repertoires needed for a politics of *what*.

Locality

Where do texts come from and where do they go? What place or places do they carry

along or within them? If we think of the present book, this question comes in various forms. One is that the material mobilized here may be situated as stemming from what in *anthropology*, despite energetic debate, is still called a culture. The way professionals and patients described here behave, calmly carrying out conversations, for instance, could be called *Dutch*. And so could the primarily clinical orientation of “my” vascular surgeons, highly consequential for what I say about the character of medicine. A second, *sociological* typification of the provenance of the material I have explored would be quite different: many sociologists would say that the object that I describe is micro. It is local in

more. Which facts should be presented? Which facts are pertinent to the reality of atherosclerosis: those of pathology or those of the clinic; hematological or epidemiological facts; duplex graphs or angiographic pictures? This is not simply a matter of which textbook page to turn into a nicely illustrated, suitably didactic leaflet. It is also a practical issue. Which machine to put to use, with what money to pay for it? Which hurts to evoke and which casualties to risk? Information, presenting some version of reality, does not come after practice. Neither does it precede it. Instead they are intertwined.

This book does not try to show that *the social* is larger than we took it to be while *the technical* is smaller. Instead, it suggests that technicalities themselves, in their most intimate details, are technically underdetermined. They depend on social matters: practicalities, contingencies, power plays, traditions. Thus, technicalities should not be left to professionals alone. They affect us all, for they involve *our* ways of living. But this does not mean that they are not also technicalities. That is why the present book does not try to push back the role or the power of the medical professionals a little further by revealing further patches of the medical domain where values exist alongside facts—and where, therefore, laypeople should make the decisions. What if values reside inside the facts? Then it may be better to stop shifting the boundary between the domains of professionals and patients and instead look for new ways of governing the territory together. But this suggests that ethnographers, philosophers, and soci-

the sense that it comes from somewhere small. The big picture is not sketched out. The social organization of health care, long-term developments in the biomedical sciences, the distribution of power, the flow of capital, what have you—all such macrophenomena escape the microsocial framework of the book. And then there is a third possibility. The *philosophical* tradition situates texts differently yet again. It does not link them to their places of origin, but rather to their destination. True philosophy, or so the dominant tradition suggests, comes up with *universally* valid theories. These transcend the specificities of any single site and move everywhere, without transportation costs. And since this book has generated no universalities, it would be said to fail as philosophy. If it deserves

to be taken seriously at all, it is as *mere* social science.

So we have three different modes of localizing. Let's look at them in a little more detail. First, then, culture. There is the question of the so-called cultural specificity of the events that take place in hospital Z. Are they distinctively and locally Dutch? One of the reviewers of this book, a North American, kept on insisting on this. With an ocean between us, he or she saw *Dutchness* running as a thread through every page—and challenged me to acknowledge this. So what to say about this? First, yes, there is a topic here. But second, it is one that deserves its own investigation. What might *Dutchness* be? In the local bookstore I found a book on the topic, a book that draws together a

ologists of medicine as, or just like, patients need to explore and engage with professionalism. Once inside the hospital, the *who* question is linked to, or even overshadowed by, *what* questions. There, time and again, the question to share is: *what to do*. What to do, this is a question *we* face, and the “we,” or so I would want to argue, should be taken as widely as can be. But what kind of resources do “we” need if we are to face this question? Framing languages and shaping practices for dealing with the question “what to do” is part of a *politics of what*.

A Politics of What

For the medical profession, *what to do* has always been an important question, indeed recognized as having a normative dimension. However, the norms involved were naturalized. Saving lives, improving health—that was what medicine set out to do. The value of life and health was deemed to be given with our physical existence and beyond dispute. When patients may die of pneumonia if it is not treated and survive when an antibiotic is prescribed, no further questioning of the normativity of such treatment seemed necessary. And if insulin postpones the imminent death of patients with diabetes for decades its *goodness*, again, is accepted as obvious. When it is clear that the overall health of the population improves when people do not smoke, then warnings are printed on

lot of anthropological field studies done in the Netherlands. Not coincidentally, it is a book in Dutch (van Ginkel 1997).

The book situates the beginning of the anthropology of the Netherlands (beware: *Holland* is only a province of this country!) in an American text. It is a text written by Ruth Benedict in 1944 while at the Office of War Information in Washington. Dutch anthropologists had been active for decades in Dutch colonies, studying villages in Java, irrigation in Bali, rituals in New Guinea, and so on. The aim was to bring such places closer to administrators, merchants, and planters. But there was no need to bring home *itself* closer—for the Netherlands were nobody else’s colony. But then, in the Second World War a lot of U.S. soldiers were to be stationed in the Netherlands. In order to reduce friction between the soldiers and the Dutch popu-

lation, each group had to learn about the other. And this is why Benedict assembled whatever written material about the country she could lay her hands on and sent out students to interview Dutch immigrants. With this material she wrote an exposé of *the Dutch character*, not so much stressing our obsession with clean houses (something travelers had remarked on over the centuries) as the self-assuredness of the Dutch. The Calvinist majority in particular, Benedict wrote, is convinced that it has Right on its side. Quote: “One can fairly say that the typical Hollander is so sure of himself that he does not submit to dictation. He stands up for his rights. He hates sentences beginning ‘You must . . .’ A so-called true story illustrates the Dutch attitude: The postmaster asks a little boy at the stamp window, ‘What must you?’ (a colloquial phrase). The little boy answers,

packages and doctors tell us not to smoke. Medicine never concealed its normative character. But its self-reflection was not directed at its central goals: postponing death and improving health. It became the profession's central concern, instead, to see if its interventions indeed helped to achieve these goals. Since roughly the 1950s more and more *clinical trials* have been conducted to evaluate which medical interventions succeed and which others fail to bring about improvement. Clinical trials have become the dominant mode by which the value of interventions is judged by the profession.

Trials, however elegant instruments though they may be, are not sufficient if we are to engage in a *politics of what*. They were designed in a time when, indeed, the goals of medical intervention were taken to be given with the natural characteristics of the body. Survival and health. At some point these goals have proved to be insufficiently specific. The first difficulties arose in cancer research. As long as "survival" is accepted as a goal, a treatment for cancer may seem successful if those who receive it live, say, an average of six months longer than those who do not. However, the patients and the physicians and nurses engaged in their day-to-day care weren't always convinced that such "survival" entails an improvement. Six months in and out of a hospital, with a disintegrating body, with pain from both disease and treatment, may well lead to more suffering than relief. In the discussion that followed, the goal of "survival" lost its self-evidence. Maybe it wasn't a natural good after all. Maybe the extra life treatment may bring was only a good if it was spent well, if the months gained

'I must nothing. But you must give me a stamp of two cents' " (Benedict 1997, 226).

So maybe it is no wonder that I show resistance when a reviewer presses me to attend to the Dutchness of my text. Must I write on Dutchness? Oh no! I must not! (My Dutch character has arguments to support it, too. After all, only *exotics* are required to culturally localize themselves. And, one may wonder, what kind of imperialist power [benevolent or not] hides behind the interest this time?) But more is going on here. *How* to account for, how to typify *Dutchness*? Attributing a character to "a typical Dutch person" may have been useful to the writers of a pamphlet to be dropped from airplanes to inform the in-

habitants of the country about the foreign soldiers. It may even have led to an instructive leaflet for the soldiers who needed to realize they differed from the natives. (The crucial point being that they were not to expect the prudent Dutch girls to be inclined to have sex with them.) But in most other contexts it has little pertinence. A large half century later anthropologists no longer tend to delineate national cultural characters at all. Anthropology has shifted from this to the investigation of patterns of shared meaning, and then on again to other ways of articulating similarities and difference.

Notities over Nederlanders lists a variety of ethnographic studies done in the

were indeed worth living. The term *quality of life* was coined to fill the gap left by many people's disappointment with survival alone.

So in current practice, clinical trials assess medical action not just against physical parameters, but also compare the impact of treatment on people's quality of life. Another step, maybe, toward a politics of what, but there are many more to take. For instance: in the quantitative research tradition of the trial, the question about what gives life quality and what does not is still taken up in a quasi-naturalizing way. A sociologizing way, or so one might say. What *the good life* might entail is not recognized as an essentially contested and thus a political issue. Instead, research is set out in a way that objectifies this good. Surveys are used to record individual opinions, weights are attributed to these, and they are entered into statistically sophisticated accounts. In this way quality becomes a quantity. Values are turned into facts, social facts. All the controversies around the question of what a *good life* might be are stifled. That people have different investments in life, that we clash when it comes to striving after the good, is turned into a mere calculative challenge. We are each accorded our own opinion. Here, fill in your form, of course your opinion will be taken into account. Not as a political act, however, but as a social given. Instead of being staged in a theater of discords, differences are flattened out onto a spreadsheet.

If I advocate a politics-of-what here, it is not to suggest that the state should get involved in every detail of what happens in the hospital by proliferating laws. It is, instead, to stress that all these details involve "the good life." Relating this to clinical trials, one might say that not only issues now categorized as relevant

Netherlands. Some unravel the fishermen's trade, others stem from field work in orthodox Protestant villages, yet others follow heroin users in Utrecht or boy prostitutes in Amsterdam. They all explore the specificities of these different sites and situations. However, if we take them together they make it more difficult rather than easier to answer questions about *Dutchness*. What might these sites and situations have in common with each other? What do they share with hospital Z? Some works are presented that report on care practices, the most intriguing being by visiting anthropologists from India who studied, horrified, the way in

which elderly people in the Netherlands live: isolated, institutionalized if in need of care, far from their families—and not even wishing their daughters to take care of them. Very Dutch, to be sure. But then again, this specific setup differs little from the arrangements in Germany, Sweden, Denmark—or a range of other European countries.

The boundaries around the Dutch state do not map on to a cultural domain. This is not to say that the cultural domain is simply larger; say *Europe*. There are striking differences between different European countries. For instance, Madeleine Akrich and Bernike Pasveer have com-

to our *quality of life* are “more than natural,” but everything evoked in trials. The end points, the very goals of medical interventions, are essentially contested. They are intertwined with different, dissonant, ways of life. It is in this sense than one may say they are political. Take the question of how to compare bypass surgery and walking therapy for patients with atherosclerosis in their leg arteries. Which parameter should be improved after these treatments? If an angiographic picture were used to evaluate both treatments, walking therapy would never stand a chance of coming out as a successful intervention: it doesn’t alter the width of the stenotic lumen. If pressure drop over the stenosis is measured, surgery will again appear to be the more successful treatment. As it even may if “a patient’s pain-free walking distance after three weeks” is turned into the parameter of success. Walking therapy improves other parameters: it has different strengths. It is more likely to come out as a successful intervention if the patient’s overall walking capabilities after six months are assessed. Or if the patient’s gain in self-confidence is taken into account.

A politics-of-what assumes that the end points of trials, the goals sought for, are political in character. But there is more. Interventions have other effects, too. They bring about more than they seek to achieve. In current practice, trials deal with a few of these, so-called side effects. Usually, they take one or two calamities into account—like the risk of dying from an intervention (more real in bypass surgery than in walking therapy, although there, as everywhere in life, it may

pared childbirth practices in France and the Netherlands, countries only a few hours by car or train—but also worlds apart (Akrich and Pasveer 2001). Whereas in France pain is driven as much as possible from the scene of birth, Dutch women learn to *dive into* their pain, endure it, and use it to get attuned to—no, not just to what is happening to them, passively, but to what, actively, they are doing. Whereas in France women are tied to an apparatus measuring their physicalities, in the Netherlands they are advised to move about and find a position that best suits their bodies. Whereas a French father is just about allowed to be present during childbirth, a Dutch partner is expected to help his or her woman breathe properly to control her contractions. So there are

differences, contrasts. National cultures at last? No, Akrich and Pasveer hesitate to summarize their findings under two neat headings, French versus Dutch. What kind of entities are these? Where is the boundary between them? And what about the stories told to them by French women that resonate more with what happened in the Netherlands than with what went on in their own neighborhood—and vice versa?

So differences may be huge, even if not easy to *nationalize*. On the other hand, sometimes similarities between what is going on across borders are at least as impressive. But this raises further questions, instead of leading us to “cultural commonalities.” Take David Armstrong’s *Political Anatomy of the Body* (1983). To me, reading this book was astonishing. At the

occur). And alongside side effects, economic value enters evaluation: low cost is accepted as an important good. But most other aspects of the *mode of life* that come with enacting a disease in one way or another may enter clinical deliberation but have trouble getting represented in evaluation studies. Going twice daily for a serious walk requires a great amount of self-discipline: is that a good or not? Being taken care of by a devoted surgical team may be a treat—or not. And is it a rich experience or grossly alienating to become acutely aware of the color of the tissues beneath one's skin?

A politics-of-what explores the differences, not between doctors and patients, but between various enactments of a particular disease. This book has tried to argue that different enactments of a disease entail different ontologies. They each *do* the body differently. But they also come with different ways of *doing* the good. In each variant of atherosclerosis the *dis* of this *dis-ease* is slightly different. Different, too, are the ideals that, standing in for the unreachable “health,” orient treatment. These and the other *goods* medicine tries to establish require further exploration. The study of ontology in medical practice presented here deserves to be followed up by an inquiry into the diverging and coexisting enactments of *the good*. Which goods are sought after, which bads fought? And in which ways are these goodnesses set up as being good—for there are huge

time, I was engaged in a joint research project into Dutch medical knowledge in (the second half of) the twentieth century. All *our* material was Dutch: medical professional journals, in Dutch, written by Dutch authors. And yet in Armstrong there were quotes that were almost literally the same. Armstrong attended to subtle shifts in professional investments in “the patient” and what this figure's characteristics implied for how patients should be listened to. This was one of our topics, too. And it became almost a game for me to compare the dates at which new configurations emerged. These did not run exactly parallel, but neither was one country always ahead of the other. Sometimes the British appeared to be a year or two earlier. At other times it was the Dutch. (If you want to make the comparison yourself, see Mol and Van Lieshout 1989.)

But what to make of this striking similarity? Instead of evoking *culture* in one way or another, it seems more promising to look at *money*. Due to the way health care was financed from the 1940s onward, general practitioners were relatively strong in Britain as well as in the Netherlands. In order to consolidate these arrangements, general practitioners came to stress their own specific strengths in contrast to those of the expanding medical specialists. These, they suggested, lay in the way they kept track of entire families over long periods of time, and not just individual patients; in attending not just to sick bodies but difficult life circumstances as well; and, finally, in conversational techniques that made them attentive to the points of view of their patients (techniques imported from the social workers with whom they collaborated in giving primary

differences between, say, conversational persuasion, scientific trials, ethical arguments, and economic power play. Or, another dimension of such a possible study, how do we live with lack and badness, and how do we practically handle the limits to the good?

These questions are not answered here. Investigating *the body multiple* merely helps to open them up. In suggesting that we pose them, however, there is a strong suggestion—or should I say sentiment?—that there is not such a thing as a single gradient of the good that “we” (whoever we are) might all agree about (whether convinced by the facts or in an open and honest discussion). Like ontology, the good is inevitably multiple: there is more than one of it. That is why for a politics-of-what the term *politics* is indeed appropriate. For a long time, and in many places, science held (or continues to hold) the promise of closure through fact-finding. In ethics, the promise of closure, or at least temporary consensus, through reasoning is widely shared. In an attempt to disrupt these promises, it may help to call “what to do?” a political question. The term *politics* resonates openness, indeterminacy. It helps to underline that the question “what to do” can be closed neither by facts nor arguments. That it will forever come with tensions—or doubt. In a political cosmology “what to do” is not given in the order of things, but needs to be established. Doing good does not follow on finding out about it, but is a matter of, indeed, doing. Of trying, tinkering, struggling, failing, and trying again.

care—who had in turn imported them from American social work and humanist psychology). And when they got a foothold in medical schools, general practitioners started to teach their conversational techniques to all future doctors. It is *this* that makes visiting a Dutch physician resemble visiting a British physician far more than, say, a German one—even if in seventy-five other ways the differences between Dutch and German “cultures” are much smaller.

So where a text comes from, how to specify its local provenance, is a topic rather than something to be taken for granted. This is an issue much discussed in recent anthropological literature, in part because delineating a site helps in its turn to specify what “a culture” is made to be.

(See, for example, the various texts assembled in Fog Olwin and Hastrup 1997.) Is the specificity of the material in this book its *Dutchness*? Is it that of a country with a generally well-educated population? Or does it have to do with a health care organization where general practitioners are relatively strong? Or with places where most patients get all their health care costs reimbursed? Or can this story only be understood as stemming from an academic hospital in a medium-sized town that is neither in the southern Catholic part of the Netherlands nor in the severely Protestant north? The possibilities are endless. They can be piled up to the point where the material analyzed here can be said to come from hospital Z and hospital Z alone.

Beyond Choice

The goodness ingrained in different versions of any one disease is inevitably contested. But this does not mean that a politics of what can depend on the traditional other of knowledge and reasoning: choice. Multiplicity, after all, is not quite pluralism. Diseases may be enacted differently at different sites, but the *sites* in question are not *sides*. Instead, different enactments of any one disease are interdependent. They may be added up; patients may be distributed between them; and they may include each other. There are innumerable tensions inside medicine but clashes between fully fledged paradigms are rare. Even an internist who scolds surgeons for focusing on clogged up lumens while not attending to the atherosclerotic process *has no choice* when called on by a patient whose ulcerating wounds no longer heal due to a lack of oxygen. He sends the patient (with collegial greetings) for an operation.

The interdependence between different versions of any one disease makes “choice” an ill-suited term for articulating the quintessence of a politics of what. And so does the interference between the enactment of disease(s) and that of other realities. Diseases, after all, are not the only phenomena enacted in the hospital. There are many more: sex difference, age and aging, Dutchness and foreignness, professionalism, emotional wisdom and instability, and so on. Thus, when two variants of a disease are separated out as each other’s alternatives, a lot more is at stake than these variants alone. Take, for instance, the reality of “the sexes.” It is implicated in enacting atherosclerosis. The more operations surgeons do, the more important the layers of fat underneath the human skin become for what it is *to be* or *not to be* a woman—or a man. But does

Let us now turn to sociology. Since hospital Z, and only hospital Z, is where the fieldwork for this study was done, many sociologists might be inclined to see it as a *microstudy*. A study into something small. But is it? In his *Postmodern Geographies*, Edward Soja talks about Los Angeles (Soja 1989). A quite different place from hospital Z. Equally small? Well, measured in square kilometers it is somewhat larger, but those who set the *micro* against the *macro* might still say that it is pretty small. However, Soja escapes such attempts at scaling. He aptly shows how the town he chose to study includes “everything.” *It*

all comes together in Los Angeles—as one of his chapter headings goes. One reason for this is that people from literally all over the globe have come to live there. And they have brought their clothes, food, marriage customs, language—everything—with them. But Los Angeles is a big container for another reason. Everything that Soja takes to be crucially important for postmodern times can be signaled in this single city: all the shifts and changes that have to do with cities, their (absence of) planning, their distances, their patterns of trade, their transport systems—everything that geographers take to be important is

that argue for or against operations? With every health care statistic produced, the difference between the sexes gets more difficult to disentangle, for the pre-printed forms all ask one to come out as either M or F and thus tend to add yet another M/F difference to the pile that is already established. Setting normal values for each person individually, by contrast, empties out the relevance of differentiating between two sexed populations. It goes on and on. There are ever so many interferences between “atherosclerosis” and “sex difference.” But how might those inform “choices” to be made as a part of a politics of what? It is difficult to see how to take just this single other relevance, let alone all realities enacted into account: one just cannot gain an overview. And one’s evaluation of the enactment of any *one* object may well contradict one’s evaluation of the other.

There is a third difficulty with the term “choice.” If practices enact not just one entity, but evoke a world, then it is not only diseases that come in varieties, but people, too. They, or maybe it is better to say, *we*, whether figuring as professionals, patients, or something else, are caught up in this. We do not master realities enacted out there, but we are involved in them. There are, therefore, no independent actors standing outside reality, so to speak, who can choose for or against it. Take the surgeon. That figure varies along with the rest of reality. If atherosclerosis is enacted as a deviant condition that happens incidentally and accidentally, a surgeon is enacted as the welcome savior of an unfortunate patient. If, however, atherosclerosis is enacted as a slow process that should be

present in Los Angeles. And since it is all there, there is no need for the analyst to travel all over the place. There is no need to look for a *big* object. This single city serves. It contains everything.

The same is true for hospital Z. It makes little sense to talk of its size, let alone to call it small. Again, this is not just because the actual physical entities present in the building come from a lot of places. There are American journals; German measurement machines; Japanese televisions; computers made in the Philippines; there is South American coffee—and so on, as in all modern hospitals. People working in Z have also circulated—I mentioned before that some of them come from elsewhere (China, Portu-

gal, Switzerland, Britain) while others may have been born in the Netherlands but have spent a few years doing research in Paris, Seattle, or Toronto—or practicing in some small African town. But there is more. If one wanted to study, say, angiography, then what kind of large place would one try to find? Sure, there are hospitals slightly bigger than Z, but one cannot study the workings and usages of an X-ray apparatus somewhere “macro.” It is always “micro,” in a particular place. And the same is true for surgery: this is done on one body at a time. Or talking to a patient. Or thinking about how to treat. Adding up figures that come from ten or a hundred hospitals doesn’t give a *bigger* picture—it simply depicts something else. It

stopped early on, a surgeon is someone who is always too late—someone who only alleviates symptoms and is quite incapable of getting at the real disease. The identity of the very surgeons who might want to “choose” between modes of enacting atherosclerosis interferes with the “choices” to be made.

Patient identity is equally at stake. What a patient is is not given once and for all and is not so strongly established outside the hospital that it may be carried along into the consulting room, the ward, the operating theater, or the research lab. With every enactment of atherosclerosis there comes another patient. An example. If atherosclerosis is enacted as a genetically based deviance, you are simply burdened with it if you have the wrong genes. However, in so far as the development of the disease is enacted as a lifestyle matter, someone with atherosclerosis may be accused of having led a bad, unhealthy life. In this context, then, the patient is marked as irresponsible. This is not only a strange qualification to opt for if one had a choice, but also one that disqualifies one's abilities to handle options.

So there are incongruencies between what is implied in the notion of choice and the coexistences and interferences between different versions of reality described in this book. All in all, “choice” may not be the best term to capture what needs to be done, and what is going on, in the politics of what that *we* as medical professionals, ethnographers, sociologists, philosophers, and, yes, as patients too engage or may engage in. We need other terms. We have some other terms: discord, tension, contrast, multiplicity, interdependence, coexis-

conveys, say, epidemiological rather than individual facts; a numerical rather than a narrative reality; aggregations rather than events. (Why is it still necessary to argue against the idea that there is such a thing as a big picture? The argument was made *in the literature* quite a while ago. The scientist shuffling with paperwork on a desk, Bruno Latour explained in 1984 in French, handles not *more* variables than the hunter armed with arrows out in the field but, usually, far *less*. The scientist's numbers are just simplifications from a wide territory skillfully drawn together. And instead of residing in some *macro* place, they are on a desk. For the English version of this argument, see Latour 1988.)

Events are necessarily local. Somewhere. Situated. And in as far as this book tells about events, its object is necessarily local, too. But the main object of this book is not even events, but something different yet again. *Coexistence*. Theoretically speaking, this book is about the modes of coordination, distribution, and inclusion that allow different versions of a “single” object to coexist. But where, in what *place*, might coexistence be studied? There may be long distances between the entities that coexist under a single name. Take McDonald's. It is a fascinating multiple object, with endless similarities and differences between its various outlets, worldwide. (The idea that there is such a thing as the one and

tence, distribution, inclusion, enactment, practice, inquiry—but we could do with more. Which ones? That is another of the questions this book opens up rather than answers. For now, the point is this. In contrast with the universalistic dreams that haunt the academic philosophical tradition, the world we live in is not one: there are a lot of ways to live. They come with different ontologies and different ways of grading the good. They are political in that the differences between them are of an irreducible kind. But they are not exclusive. And there is no *we* to stand outside or above them, able to master them or choose between them: we are implied. Action, like everything else, is enacted, too.

Clinical Medicine

That there are alternatives to each particular practice does not turn the hospital, or health care, into a state of permanent turmoil. Tensions crystallize out into patterns of coexistence that tend to only gradually dissolve. Though nothing is sure or certain, the permanent possibility of doubt does not lead to an equally permanent threat of chaos. Even if stability is never reached, tensions are tamed. There are recurrent patterns of coexistence between different enactments of any one disease. Addition, translation, distribution, inclusion: they keep the hospital together—just as they assemble the body and its diseases.

Describing health care in this way, or so I claim, is an act. How far this act may reach, whether and if so how this text will make a difference in practice remains to be seen. It depends on where this book is moved to, on who might run away with it, on the number of copies sold, on the (non)accidental overlaps between its concerns and those of some of its possible readers. What are you,

only, successfully globalized, McDonald's is done away with in Watson 1997.) But then again, if one is interested in modes of coexisting, it may well be that hospital Z *contains them all*. Coordination, distribution, and inclusion, at least these three, are all to be found in Z. It isn't even necessary to roam through the entire building to achieve this—there are lots of sites and situations in hospital Z that aren't mentioned in this book. A few practices relating to atherosclerosis of the leg vessels seem to compose a field *big enough* to contain as many patterns of coexistence as can be analyzed in a single book.

All this suggests that the precise *size* of a field is of little importance to the theorist who does not try to map that field, but tries to discern patterns in it, modes and modalities of, say, coexistence (but it might be something else as well). But if the size of the field is irrelevant—indeed unmeasurable—this does not mean that the fact that there is a field is of no importance. The patterns of coexistence described here exist *somewhere*. Whatever the place is called: hospital Z; the enactments of atherosclerosis; health care; the Netherlands; the last decade of the twentieth century; well-insured surroundings;

reader, going to do with my words? That is beyond me—it is up to you. But I can try, have tried, to be articulate about what this text does intellectually. In theory, so to speak. It does not engage in criticism. I have *not* pointed, here, at the wrongs of medicine in general nor at those of the treatment of atherosclerosis in hospital Z in particular. I do not seek to confirm that all is well, but have argued, instead, that separating out right and wrong is only possible if one has a standard. I have not deployed such a standard here, but have analyzed the co-existences of different enactments of reality and have claimed that ever so many standards, different ways of grading *the good*, come with them.

However, this is not a neutral book either. Far from it. Analyzing medicine as enacting different realities and different ways of qualifying the good is not just a way of talking about medicine but also a way of talking inside it. Inside the medical world, this book is one of many voices that resist the idea that rationalization is the ultimate way of improving the quality of health care. Rationalization as an ideal starts from the idea that the problem with the quality of health care resides in the messiness of its practice. However, even if it may be messy, practice is something else as well: it is complex. The juxtaposition of different ways of working generates a complexity that rationalization cannot flatten out—and where it might, this is unlikely to be an improvement. In those sites and situations where a so-called scientific rationale (be it that of pathology, pathophysiology, or, most likely at the moment, that of clinical epidemiology) is brought into practice, with sufficient effort it may well come to dominate the other modes that are already at work. But this does not so much improve medicine as impoverish it. And that loss is borne by the clinic.

medical practice. There is a lot more to say about these ways of naming, localizing. But what I want to stress for now is just this one thing: that my theoretical investigation into the coexistence of the various versions of a multiple object were, indeed, *localized*. That a philosophical interest in ontology was linked up here with the empirical study of a field. This goes against the dominant tradition in philosophy. For a long time, the endeavors united under the banner of *philosophy* were presented as having a peculiar relation to place. They were *universal*: valid everywhere—and rooted nowhere in particular. Philosophical concepts had to

be of universal value. Norms had to be justified by arguments of universal pertinence. But all this could be done here and now. What was right in theory was supposed to be transportable anywhere—so easily that no attention was paid to what it might mean to transport “rightness.” Universalities need no landing strips, telephone lines, or even satellites. The question of their transport is simply not posed. (For the obviously slightly more complicated history of the relation between philosophy and *place*, see Casey 1997.)

Some philosophers have opened up ways of leaving that dream of universality

In stressing multiplicity, this book lends support to clinical medicine. Clinical medicine is the tradition that departs from patient histories and presenting symptoms rather than from physicalities isolated in lab-like circumstances. The tradition, too, that lives with adaptable subjective evaluation rather than requiring objectified figures. A tradition of case histories rather than counting. This book doesn't support the clinical tradition by critically pointing out where it has lost, or is losing, ground. Instead, it does so by stressing its present, under-acknowledged, importance. The surgeons of hospital Z, after all, only open up arteries if their patients' daily lives are likely to gain from it as a result. Clinical considerations are crucial to their treatment decisions. And only those patients who present themselves with complaints make it to the hospital in the first place.

The proliferation of medical techniques may give reason to fear that the lab is taking over, but something quite different is equally possible. Since each diagnostic outcome diverges from the others, the idea of *gold standards* may get undermined rather than strengthened. And if each therapeutic intervention achieves something different, what counts as improvement may similarly tend to become less obvious. The question "is this intervention effective" then dissolves into another question: "what effects does it have?" Clinical considerations, however fuzzy they may be, however badly they fit into forms and accounting systems, may well prove obdurate and tenacious. After all, they con-

behind. Walter Benjamin offers a wonderfully radical example. His *Passagen-Werk* (1999) was *both* situated in philosophy *and* somewhere *earthly* in particular. Paris. The modern city. Its architecture. Arcades. Encounters between strangers. It is this overt attentiveness to the *situatedness* of thinking (its objects, its possibilities, its enactment, its preformative effects) that marks the philosophical literatures that figure in the background of this book and form its venerated ancestors. The one to conclude with is Michel Foucault. In his writings it is an acute sense of situatedness that turns philosophy into something worthwhile in the first place. Something forever shifting, changing. A mode of engaging in philosophy that advertises itself as linked up with the here-and-now, with *ourselves*, cannot be—nor does it hope to be—*universal*. It

is localized. Foucault mainly explored empirical matters in a historical manner—but ethnographic or rather praxiographic extensions easily follow. Please add, therefore "topographical" to the "historical" situatedness that figures in the following quote. So that this subtext relating to the literature may end, as is only fitting, with words *taken from* the literature. "The critical ontology of ourselves has to be considered not, certainly, as a theory, a doctrine, nor even as a permanent body of knowledge that is accumulating; it has to be conceived as an attitude, an ethos, a philosophical life in which the critique of what we are, is at one and the same time the historical analysis of the limits that are imposed on us and an experiment with the possibility of going beyond them" (Foucault 1984, 50).

cern daily lives. And daily life is what, when it comes to it, matters most to people. It is where patients, *we*, have to live with our doubts and our diseases. No, all is *not* well. But where rationalization risks to overrule the clinical tradition with ever more statistics, accounting systems, figures, and other carriers of scientificity, this book sides with those voices that seek to improve the clinic on its own terms. Which terms? How to *do* the clinical good better? These are further questions I leave open here.

So even if it is not critical, this is not a neutral study. There are other modes of partiality than that of passing judgment. Undermining the traditional hierarchy between the sciences is a way of strengthening the disciplines that occupy the lower ranks in the hierarchy. Pointing at the persistent possibility of doubt eats at the self-assuredness (and the convincing power) of the techniques that claim that they are finally able to bring light and science to messy practices. Rather than comparing different interventions within a given dimension, laying open the various dimensions of comparability makes space for and gives visibility to dimensions that currently attract the least attention. Not going primarily with a politics of *who* but stressing the necessity of a politics of *what* helps to open up the professional domain instead of pushing it back. And doubting whether choice is the best term to use in a politics of what (a politics that includes ontology rather than presuming it) acts against rationalist fantasies of what it is to strive after the good. Presenting the *body multiple* as the reality we live with is not a solution to a problem but a way of changing a host of intellectual reflexes. This study does not try to chase away doubt but seeks instead to raise it. Without a final conclusion one may still be partial: open endings do not imply immobilization.

SOFTWARE STUDIES METHODS

Matthew Fuller

What is the consistency of computational culture? What are the ways in which the objects of computer science and its more informal offspring operate in the world? Looking into such issues, it can be readily seen that a cunningly diffuse and multilayered aspect of the question of method is understanding what constitutes the problem. Luckily, for the development of a field such as software studies, computational media cultures are abundantly generative of such things. Problems flourish. From questions about the foundations of computing to the articulation of cultural tendencies and political systems across commodity platforms, via the questions of power, aesthetics, and processes of subjectivity, problems abound, and that is only to mention a few that are properly named as such. Any short survey of methods in the field can therefore only be partial and indicative, picking out a few general trends. The kinds of problems addressed arise, too, at the emergence of software studies at the beginning of this century. However, from such a starting point, software studies has become the grounds for a diversity of methods, concerns, and conceptual and practical resources. This chapter maps a few of these and give some sense of their consistency and trajectories. In this, as a survey, it will necessarily be limited due to the vitality and range of activity in the field. Read it, then, as an aperitif, before investigating further.

To frame the question of the problem, a little genealogy is in order. From a certain set of angles, software studies arises from a background of bemused frustration at the ways in which “high level” media theory would tend toward subsumptive generalization about the “virtual,” or about “cyberspace,” without attending to the howl and screech of a dial-up modem or the particular dance of pixelated entities among the Graphical User Interface (GUI) that constituted everyday activity in the “knowledge economy.” A parallel here can be drawn with software art, which articulated itself in part against the media art and net art that often ignored the specific materials from which it was made, a condition that—as those materials became both increasingly interesting and increasingly overcoded—became untenable. Equally, as social theory drew upon the active constitution of society by systems, media, and tools, alongside those entities that had hitherto been understood to be social, the capacity to recognize what Scott Lash (2002) called “Technological Forms of Life” became pressing. Amid this, too, the imperatives underlying the development of the field are driven by an emphasis on the complexly materialist, fortified by the empiricism of the abstract found in both the more generous reaches of poststructuralist legacies and those aspects of meta-mathematics and computer science that had always recognized the cultural dimensions of their activity.

More recently, software studies finds itself in the curious position of being a scholarly stick-in-the-mud as certain aspects of computational culture become sprinkled like glittery mica on trays of theoretical cupcakes: decorative, indigestible, and garnishing the semiotically retrospective and materially stale. For instance, algorithms are increasingly emphasized as an explanatory actor, although in a surprisingly large quantity of scholarship this explanatory power is asserted without their contextualization within other systems in which they are embedded, and even without ascertaining what an algorithm might be. A scan of the literature shows that it is entirely possible to have a social or literary theorist discourse on “algorithms” without any references other than to others of their ilk. This kind of elective solipsism of disciplines is familiar to those navigating interdisciplinary terrains and is also articulated through the kinds of citation politics that other such fields, such as feminist research, have become all too familiar with (Fábos & Haddad 2013). We are in the amusing position where the emphasis on materiality is elevating technical content to the same kind of generalizations that, say, the more banal pronouncements of postmodernity suffered from in their heyday. Social theory, too, often brings along its upstairs–downstairs split between high theory and empiricism.

There is an art to the interplay between the rigors imposed by attention to material qualities and conditions with all their constraints, limits, and capacities; their specificities and individuations; and those entailed also by the particular epistemic and ontogenetic capacities of abstractions. To address such topics, software studies approaches might characteristically tend to identify specific algorithms, articulate their genealogy, recognize and work with their characteristics, and see them as part of a larger assemblage—one that is not in turn immune to the adventures of conceptual rigor (see Mackenzie 2010). All this requires something of an avidity for research. Such a condition also drives it toward noncanonical texts and sites as sources of interest. This drive in turn is a methodological choice that sets it at a tangent toward theoretical work aiming to array itself solely among well-cited or paternalistically approved books. Showing that one is in dialogue only with those of the correct lineage is a rhetorical technique that has the democratic advantage that the canon is seemingly available to us all, whether we like it or not; but it also may be affected as a technique of foreclosure. Part of this condition is due to the febrile pleasures of academic politics, in which it is assumed that the study of new media has yet to fully establish itself as a legitimate field and, to do so, must exaggeratedly exhibit the habits of conformism and deference special to the various overlapping pyramid schemes that are, among other things, operative in the university.

Another way to frame the question of methods is to partially arrive at it via two fields that contribute to software studies. In different ways, cultural studies and computing both emerged in the aftermath of the Second World War, forged by the necessity for an interdisciplinary bringing together of multiple methods, materials, and problematics. In different times, software studies emerges as a minor mutational fold within these discourses, at the cusp of the inventive enthusiasm of the world wide web and the internet, and the transition to the version of the same which we now inhabit. The various crises and possibilities in knowledge, technology, institutions, and epistemic potential that each of these represents feed into the specific traits of software studies as a field.

With cultural studies, software studies shares a taste for vulgar objects that pass below the threshold of critical perception due to their mundane or tedious nature. Ostensibly boring entities, manuals, slide presentations, and technical specifications are all probed for interesting traces as admixtures of high technology and low theory. Just as crystals grow differently in variable electromagnetic fields, which can in turn be examined through the variations in

growth patterns to which they contribute, the relatively “pure” formalisms that software articulates in such materials can also retain interesting patterns of resonance with wider formations.

Relatedly, one may sense into software by the ways it comes into composition with users. And here, ignorance of software’s conventions has been highly revealing. It must be possible to read software in a way that is partially naïve, stupid, heading in the wrong direction, mysterious, uninformed by a disciplinary history. To watch a person encounter a machine for the first time is exciting; one might learn from their dissonant interpretation what experienced preconceptions have become. Unfortunately, even with the confusions of users moving between operating systems, today the state of inexperience with computational entities is a rare resource. But there are ways in which it is mobilized, bearing indeed some relation to Jacques Rancière’s formulation of the “ignorant,” where people learn by moving along in a manner in which “one shouldn’t move along—the way children move, blindly, figuring out riddles” (1991: 10). Indeed, given its value, ethnographical techniques have been utilized to capture this moment, or to set up a pretext in which it can be removed from the stories of products (Wilkie 2010). There is a kind of sense in which this naivety, as a prerequisite for the genesis of thought, may seek new objects of encounter.

One way such naivety may fruitfully manifest is by asking scrupulously simple questions. Indeed, the cunning and intelligence required for the deployment of a simple question is a key concern for programmers attempting to instruct machines, and for anyone working to elicit material from what is now characterized as big data (Kitchin 2014a; Elmer, Langlois & Redden 2015). The artful projects of the working groups convened by Lev Manovich, such as *Selfie City* (Software Studies Initiative 2014), work in this mode, and one can say that they operate at a number of levels. Ostensibly, they are navigations of certain sets of data. A question is asked of a flow of images that conform to a certain categorical norm, that of date, kind, genre, keyword, location, and so on. These categorical terms are those that arise out of the specific nature of the system, which is partly that of a database whose genealogical roots are in set theory. Corralled as it often is within categorical architectures and tucked behind Application Programming Interfaces (APIs), it is difficult to get significant traction on the material, except in reconfirming its preconditions.

To work around this, data are captured and *withdrawn* from such systems and then subject to other kinds of query: for instance, using color saturation to navigate variations in images tagged with the names of certain cities, or image-recognition software is used to analyze the tilt of the head characteristic of selfies in a certain location. The findings of such work are partly in this activation of the parodically positivist formalisms that undergird computational culture and subtend big data. Genuinely trivial details in aggregate become something else; they constitute part of cultural form. To navigate these and aggregate them in turn becomes part of a dual capacity of critical exploration and seamless involvement that is both troubled and fascinating.

Working through the ways in which computational forms change established modes of culture, politics, and society and establish new ones has—like the traces of forces acting on a crystal—been very palpable in certain cultural-economic forms, such as publishing, music, and film, where they have had massive systemic effects. In other disciplines, such as philosophy, the articulation of these predispositions and capacities has been less immediately discernable but also intriguing, with the development of platforms and the mobilization of previously more marginal actants, but also cognitive speed-ups and conceptual hazing becoming more visible. Here, computational forms become one of the fields in which the crystal grows.

Related in certain ways to the question of operative stupidity and the principle of the pyramid scheme in academic citation patterns is the entrenchment of Pareto-principle-type citation patterns due to the material specificity of contemporary publication (Becker & Stalder 2009). When the search engine becomes the primary basis of scholarly research, the keyword becomes a crucial pivot for the articulation of fields. Thus, in speeded-up research cultures, ever-ready to pronounce what passes for a novelty, it is possible for communities working in related domains to entirely bypass each other's work due to over-dutiful following of links.

Earlier I noted that software studies methods include something of the fastidious, pains-taking work of the archive following a specific object. Here, there is a useful correlation with work suggested by Kopytoff (1986) and in the figure of the boundary object formulated by Susan Leigh Star and James Griesemer (1989). A key factor to note is that many objects in software studies are multiscalar. To fix only on the immediately empirical—say, on the position of a specific procedure within a wider assemblage—would also be to risk missing, via simply descriptive means, some of the more abstract dimensions of such an assemblage. The mathematical and logical conditions of such an entity are also inherently formed among non-uniform fields of metaphysical “radiation” set in motion by mathematical conditions (Fazi & Fuller 2016). Equally, their articulation can be probed in relation to the epistemic conditions of certain kinds of data cultures and economies. To recognize the multidimensionality of the problem is by no means to deny the pleasures or necessity of micro-scalar analyses, but rather to emphasize the ways in which positing an analysis of a part triggers in turn the positing of a putative whole.

To return, then, to the relation of the method to the problem, part of the work of software studies has been to burrow into and articulate the relations between different scales in which software becomes manifest without proposing any pre-existing, hierarchically ordered set of conditions to which such things must correspond, without at the same time failing to notice that such orderings are multiple and highly operative. To this end, there is a discussion of software in terms of the data-structures known as “stacks” in the work of Ben Bratton (2016) and Rob Kitchin (2014b), among others, examining the ways in which the mutual ordering and dependencies of separate scales of abstraction and operation produce functional wholes. When, via an overly normalized and normative empiricism, work in this domain risks a simple recapitulation of systemic technical description, it is also challenged by a materialism operating “below the stack” by, for instance, focusing on the social and even alchemical histories of the minerals that end up in dialogue with software in the work of artists such as Jonathan Kemp, Martin Howse, and the group YoHa. Both of these tendencies afford further dialogue with wider questions of infrastructure and the scholars, from Sergio Bologna (1991) to Keller Easterling (2014), who have traced these inter-relations via political economy and spatial approaches.

Questions of infrastructure appear, too, in much of the work on understanding the fundamental components of large-scale web platforms. There is a sense that a key movement in much contemporary work is an investigation of the operations, significance, and underlying forces and consequences of social media and the apparatuses of production, storage, dissemination, and analysis that they constitute. Numerous articles have seen scholars address the functioning of Google's PageRank or Adwords; Facebook's OpenGraph; the shifting nature of database systems, from relational to NoSQL; and other mechanisms that deftly bring together theoretical resources drawn from different strands of cultural and social theory as well as histories of organization and mathematics (Dourish 2014; Kaldrack & Röhle 2014).

Treating the entities of such “abstract infrastructure” as inherently cultural, social, and political and also interrogating how computational media install and format modes of being and becoming in the present are fundamental to the genesis of software studies methods.

One of the conditions here is the changing status of media. Friedrich Kittler neatly boiled down the condition of media as being those mechanisms to do with the production, storage, and dissemination of information. The systems in the last paragraph added *analysis* to this triad. Here, analysis is the breaking down of complex entities into what, at a certain scale, can be read as nominally fundamental units, and working out their immanent, potential, or emergent relationships. Media have in many cases become a subset of computational systems. As a condition of their constitution as digital systems and, thanks to Alan Turing, as procedural systems that are inherently composed of discrete entities and steps, computers are constitutionally predicated upon analysis. Analysis and control combined are part of what make the move to computational generality such a significant, if not unprecedented, shift. It is in how this power of computational analyses is coupled with other forms native to the arts and humanities that we should now turn.

The collectively authored book, *10 PRINT CHR\$(205.5+RND(1)); : GOTO 10* (Montfort et al. 2014), proposes that the single line of code set out in its title can be read, rewritten, divagated from, and used as the basis for memory and reverie in a compelling way. Here, close reading is the pivot around which a world can be spun out from a crystal of code. In related terms, a number of similarly minuscule objects have been examined for how their minor variations can become highly revealing entry points into a wider set of phenomena. Anne Helmond’s (2013) discussion of the historical changes to the hyperlink or URL—from something hard-coded into an HTML document to an artifact generated on the fly by a database system—exemplifies this approach. By looking at such changes, insights into how websites are used and embody different modes of social and cultural activity can be readily elicited—for instance, in the trajectory from something hand-coded and available to all users to being an ostensibly secure, one-time only transaction. Related articulations of such telling detail are evident in Ben Grosser’s (2014) account of his plug-in, the “Facebook Demetricator,” which removes numerical and temporal data from the interface of the social media site. Another recent approach is to combine analytical methods from police data forensics with a survey of software manuals to articulate a history of metadata for author information (Fuller, Mazurov & McQuillan, forthcoming). In these and many other projects, there are numerous contributions to debates about what constitutes an object of study, entangled with the methodical means of staging such an encounter. Work by Wendy Chun (2011), Alex Galloway (2012), Annette Vee (2012), Taina Bucher (2013), Shintaro Miyazaki (2012), and numerous others propose methods integrated with particular lines of inquiry around certain scales at which software exists.

An additional mode of analysis, drawn from technical practices, is that of reverse engineering. Here, Adrian Mackenzie suggests:

One strategy is to begin by describing the most distinctive algorithmic processes present, and then ask to what constraints or problems these processes respond. From there we can start to explore how software transforms relations.

(Mackenzie 2008: 50)

Such a methodical frame corresponds with the process of observation and decomposition adopted in Robert W. Gehl’s (2014) research on social media. It also provides an impetus

for working directly on software systems via programmatic comparisons between input and output (Feuz, Fuller & Stalder 2011; Skeggs & Yuill 2015). Such research involves setting up one system to interrogate another. Applied to a target such as predominant web-based services, this interrogation may involve establishing user accounts, scripts, and servers that feed data into a system to generate results and then make comparative analyses of them. Sometimes described as an “algorithm audit” (Sandvig et al. 2014) and strongly developed by researchers such as Latanya Sweeney (2013), these techniques are especially notable in formulating a progressive program of research on the empirical operations of computational systems that constitute privatized forms of public resources.

One of the difficulties here is negotiating the privileged position that quantification is allocated in different kinds of discourse, where the numerically describable stands in for the empirical. Such quantitative research is often that most embraced and, if not actually discussed, replicated in the press. Nevertheless, as a means of reflexively working through how computational forms operate, it is an intensely valuable set of approaches. In a context where massive amounts of economic, social, and cultural actions are processed in computational environments, quantitative research is a mode of action conducted on a tactical basis by multitudes of actors, including algorithms employed by competing companies to understand the operations of others. We can say, too, that as reverse engineering becomes a mode of sociability—for instance, one prods a person to see if they elicit the signs taken for friendship—it is also a mode that becomes increasingly omnipresent.

Methods result in many cases from the conjunction of an intensive question with a problem. A case that is interesting to the point of fascination demands subtle attention to cracking it. Here, the mode of study adequate to a digital entity or process achieves the tender revelations of a hack. Exemplary in this regard are the edited volume and exhibitions of artworks put together by Olga Goriunova (2010, 2011, 2014) on the theme of *Fun and Software*. One of the guiding concerns in this strand of Goriunova’s work is to draw out the ways in which software is attached to obsessive pleasures of multiple kinds. This series of projects draws rich attention to the articulation of logics, processes, systems, and other modes of computational artifact as they are not only manifest in—and given grounds and shaped by—the nature of software but also provide a condition of life that is both sensual and abstract. Crucial to note in the *Fun and Software* series is that scholarly modes of research are challenged by those that are anterior to the question of academic form. The condition of software is understood to be fundamentally existential. Aesthetics provides routes into such a condition, but so also do the reflexive accounts of cultural and technical practitioners. There is a close involvement here, too, with the immanent mode of criticism established in software art and the properly speculative dimension required when thinking about the various scales of abstraction and concretion found in software cultures. (Related approaches such as design fictions and speculative design are important to map here.) Here, software studies develops close affinities to the philosophical approaches of writers such as Luciana Parisi (2013) that mobilize reflections on the ontological conditions of mathematical technologies.

Following from this, the question of method is one coeval with multiple modes of being as much as with the problems into which those modes are crystallized. Appropriate methods involve grinding up such crystals to see what they do when ingested, describing what they mix with and the forms they take, or gazing deeply into them to divine the nature of the present.

Further Reading

- Computational Culture: A Journal of Software Studies*, retrieved from www.computationalculture.net.
 Ekman, E. (ed.) (2013) *Throughout: Art and Culture Emerging with Ubiquitous Computing*, Cambridge, MA: MIT Press.
 Manovich, L. (2013) *Software Takes Command*, London: Bloomsbury.
 Ulrik Andersen, C. and S. Bro Pold (eds.) (2011) *Interface Criticism: Aesthetics Beyond the Buttons*, Aarhus, Denmark: University of Aarhus Press.

References

- Becker K. and F. Stalder (eds.) (2009) *Deep Search: The Politics of Search beyond Google*, Vienna: StudienVerlag.
 Bologna, S. (1991) "The Factory-Society Relationship as an Historical Category," trans. E. Emery, retrieved from libcom.org.
 Bratton, B. (2016) *The Stack: On Software and Sovereignty*, Cambridge, MA: MIT Press.
 Bucher, T. (2013) "Objects of Intense Feeling: The Case of the Twitter API," *Computational Culture* 3, retrieved from computationalculture.net/article/objects-of-intense-feeling-the-case-of-the-twitter-api.
 Chun, W. H. K. (2011) *Programmed Visions: Software and Memory*, Cambridge, MA: MIT Press.
 Dourish, P. (2014) "NoSQL: The Shifting Materialities of Database Technology," *Computational Culture* 4, retrieved from computationalculture.net/article/no-sql-the-shifting-materialities-of-database-technology.
 Easterling, K. (2014) *Extrastatecraft: The Power of Infrastructure Space*, London, UK: Verso.
 Elmer, G., G. Langlois and J. Redden (eds.) (2015) *Compromised Data: From Social Media to Big Data*, London: Bloomsbury.
 Fábos, A. and E. Haddad (2013) "Toward a Feminist Analysis of 'Impact': Sondra Hale's Scholarship and Activism in and Beyond the University," *Journal of Middle East Women's Studies* 10(1), 53–81.
 Fazi M. B. and Fuller, M. (2016) "Computational Aesthetics," in P. Christiane (ed.) *A Companion to Digital Art*, Oxford: Blackwell.
 Feuz, M., M. Fuller, and F. Stalder (2011) "Personal Web Searching in the Age of Semantic Capitalism: Diagnosing the Mechanisms of Personalization," *First Monday* 16(2).
 Fuller, M., N. Mazurov, and D. McQuillan (forthcoming) "The Author Field," in G. Bachmann, Y. Hui, and S. Lash (eds.) *Technics and Data*, London: Sage.
 Galloway, A. (2012) *The Interface Effect*, Cambridge, MA: Polity.
 Gehl, R. W. (2014) *Reverse Engineering Social Media: Software, Culture, and Political Economy in New Media Capitalism*, Philadelphia, PA: Temple University Press.
 Goriunova, O. (2010) *Funware* (Exhibition), Arnolfini, Bristol, September–November 2010
 Goriunova, O. (2011) *Fun with Software* (Exhibition), MU and Baltan, Eindhoven, November 2010–January 2011.
 Goriunova, O. (ed.) (2014) *Fun and Software: Exploring Pleasure, Paradox and Pain in Computing*, London: Bloomsbury.
 Grosser, B. (2014) Facebook Demetricator, retrieved from bengrosser.com/projects/facebook-demetricator.
 Helmond, A. (2013) "The Algorithmization of the Hyperlink," *Computational Culture* 3, retrieved from computationalculture.net/aerticle/the-algorithmization-of-the-hyperlink.
 Howse, M. (2015) "–micro research—Martin Howse [London/Berlin]," retrieved from 1010.co.uk/org.
 Kaldrack, I. and T. Röhle (2014) "Divide and Share: Taxonomies, Orders and Masses in Facebook's Open Graph," *Computational Culture* 4, retrieved from computationalculture.net/issue-four-2.
 Kemp, J. (2016) retrieved from xxn.org.uk.
 Kitchin, R. (2014a) *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*, London: Sage.
 Kitchin, R. (2014b) "Thinking Critically About and Researching Algorithms," *The Programmable City Working Paper* 5.
 Kopytoff, I. (1986) "The Cultural Biography of Things: Commoditization as Process," in A. Appadurai (ed.) *The Social Life of Things: Commodities in Cultural Perspective*, New York, NY: Cambridge University Press.
 Lash, S. (2002) "Technological Forms of Life," in *Critique of Information*, London: Sage.
 Mackenzie, A. (2008) "Codecs" in M. Fuller (ed.) *Software Studies*, Cambridge, MA: MIT Press.
 Mackenzie, A. (2010) *Wirelessness: Radical Empiricism in Network Cultures*, Cambridge, MA: MIT Press.
 Miyazaki, S. (2012) "Algorithimics: Understanding Micro-Temporality in Computational Cultures," *Computational Culture* 2, retrieved from computationalculture.net/article/algorithimics-understanding-micro-temporality-in-computational-cultures.
 Montfort, N., P. Baudoin, J. Bell, I. Bogost, J. Douglass, M. C. Marino, M. Mateas, C. Reas, M. Sample, and N. Vawter (2014) *10 PRINT CHR\$(205.5+RND(1)); : GOTO 10*, Cambridge, MA: MIT Press.
 Parisi, L. (2013) *Contagious Architecture: Computation, Aesthetics and Space*, Cambridge, MA: MIT Press.

- Rancière, J. (1991) *The Ignorant Schoolmaster: Five Lessons in Intellectual Emancipation*, K. Ross (trans.) Stanford, CA: Stanford University Press.
- Sandvig, C., K. Hamilton, K. Karahalios, and C. Langbort (2014) "Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms," presented at *Data and Discrimination: Converting Critical Concerns into Productive Inquiry*, a pre-conference at 64th Annual Meeting of the International Communication Association, May 22, Seattle, WA.
- Skeggs, B. and S. Yuill (2015) *Values and Value*, retrieved from values.doc.gold.ac.uk/.
- Software Studies Initiative (2014) *Selfie City*, retrieved from www.selfiecity.net.
- Star, S. and J. Griesemer (1989) "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939," *Social Studies of Science* 19(3), 387.
- Sweeney, L. (2013) "Discrimination in Online Ad Delivery," *Communications of the AMC* 56(5), 44–54.
- Vee, A. (2012) "Text, Speech, Machine: Metaphors for Computer Code in the Law," *Computational Culture* 2, retrieved from computationalculture.net/article/text-speech-machine-metaphors-for-computer-code-in-the-law.
- Wilkie, A. (2010) "User Assemblages in Design: An Ethnographic Study," PhD thesis, University of London.
- Yokokoji M. and G. Harwood (n.d.) "YoHa (English translation 'aftermath')," retrieved from yoha.co.uk.

Print Is Flat, Code Is Deep: The Importance of Media-Specific Analysis

N. Katherine Hayles

English, UC Los Angeles

Abstract Lulled into somnolence by five hundred years of print, literary analysis should awaken to the importance of media-specific analysis, a mode of critical attention which recognizes that all texts are instantiated and that the nature of the medium in which they are instantiated matters. Central to repositioning critical inquiry, so it can attend to the specificity of the medium, is a more robust notion of materiality. Materiality is reconceptualized as the interplay between a text's physical characteristics and its signifying strategies, a move that entwines instantiation and signification at the outset. This definition opens the possibility of considering texts as embodied entities while still maintaining a central focus on interpretation. It makes materiality an emergent property, so that it cannot be specified in advance, as if it were a pre-given entity. Rather, materiality is open to debate and interpretation, ensuring that discussions about the text's "meaning" will also take into account its physical specificity as well.

Portions of this essay have appeared in the Web-based journal *Postmodern Culture* (January 2000) under the title "Flickering Connectivities in Shelley Jackson's *Patchwork Girl*: The Importance of Media-Specific Analysis." An early version was presented at the Interactive Frictions Conference held at the University of Southern California in June 1999. I am grateful to the following people for granting me access to their impressive collections of artists' books: Jennifer Tobias, reference librarian at the Museum of Modern Art in New York; Joan Lyons, director of the Visual Studies Workshop Press in Rochester, New York; David Platzker at the Printed Matter Bookstore in New York; and Nexus Press in Atlanta, Georgia. I wish to thank Fred and Virginia Brandes of Atlanta, Georgia, for kindly giving me access to their excellent collection of telegraph codebooks and for their generous hospitality during my visit there. Finally, I am indebted to Michael Fadden for his help in preparing the manuscript and to Carol Wald for discussions related to this topic.

Poetics Today 25:1 (Spring 2004). Copyright © 2004 by the Porter Institute for Poetics and Semiotics.

Following the emphasis on media-specific analysis, nine points can be made about the specificities of electronic hypertext: they are dynamic images; they include both analogue resemblance and digital coding; they are generated through fragmentation and recombination; they have depth and operate in three dimensions; they are written in code as well as natural language; they are mutable and transformable; they are spaces to navigate; they are written and read in distributed cognitive environments; and they initiate and demand cyborg reading practices.

Lulled into somnolence by five hundred years of print, literary studies have been slow to wake up to the importance of media-specific analysis. Literary criticism and theory are shot through with unrecognized assumptions specific to print. Only now, as the new medium of electronic textuality vibrantly asserts its presence, are these assumptions clearly coming into view.

Consider, for example, Roland Barthes's influential essay "From Work to Text" (1986). Rereading it, I am struck both by its prescience and by how far we have moved beyond it. As Jay David Bolter (1991) and George Landow (1997) have pointed out, Barthes's description of "text," with its dispersion, multiple authorship, and rhizomatic structure, uncannily anticipates electronic hypertext. "The metaphor of the Text is that of the *network*," Barthes writes (1986: 61). Yet at the same time he can also assert that "the text must not be understood as a computable object," "*computable*" here meaning to be limited, finite, bound, able to be reckoned (ibid.: 57). Written twenty years before the advent of the microcomputer, his essay stands in the ironic position of anticipating what it cannot anticipate. It calls for a movement away from works to texts, a movement so successful that the ubiquitous "text" has all but driven out the media-specific term *book*.

Barthes's vision remains rooted in print culture, however, for he defines "text" through its differences from books, not through its similarities with electronic textuality. In positioning text against work, Barthes was among those who helped initiate semiotic and poststructuralist approaches to discourse, arguably among the most important developments in literary studies in the twentieth century. But this shift has entailed loss as well as gain. Useful as the vocabulary of text was in expanding textuality beyond the printed page, it also had the effect, in treating everything from fashion to fascism as a semiotic system, of eliding differences in media. Perhaps now, after the linguistic turn has yielded so many important insights, it is time to turn again to a careful consideration of what difference the medium makes.¹

1. In many ways this is a return to the agenda set by Marshall McLuhan (1994 [1964]). The recent turn in literary studies of earlier periods toward a consideration of the physical char-

In calling for medium-specific analysis, I do not mean to advocate that media should be considered in isolation from one another. Quite the contrary. As Jay David Bolter and Richard Grusin have shown in *Remediation* (1999), media constantly engage in a recursive dynamic of imitating each other, incorporating aspects of competing media into themselves while simultaneously flaunting the advantages that their own forms of mediation offer. Voyager's now-defunct line of "Expanded Books," for example, went to the extreme of offering readers the opportunity to dog-ear electronic pages. Another option inserted a paper clip on the screenic page, which itself was programmed to look as much as possible like print. On the other side of the screen, many print texts are now imitating electronic hypertexts. These range from Don DeLillo's *Underworld* (1998) to Bolter and Grusin's *Remediation*, which self-consciously pushes toward hypertext through arrows that serve as visual indications of hypertextual links. Media-specific analysis (MSA) attends both to the specificity of the form—the fact that the Voyager paper clip is an image rather than a piece of bent metal—and to citations and imitations of one medium in another. Attuned not so much to similarity and difference as to simulation and instantiation, MSA moves from the language of "text" to a more precise vocabulary of screen and page, digital program and analogue interface, code and ink, mutable image and durably inscribed mark, texton and scripton, computer and book.

One area where media-specific analysis can pay especially rich dividends is literary hypertext. Some theorists working in the area of electronic literature argue that hypertext ought to be reserved for electronic texts instantiated in digital media. In my view, this is a mistake. When Vannevar Bush, widely credited with the invention of hypertext, imagined a hypertextual system, it was not electronic but mechanical. His pioneering article (1945) testifies that it is possible to implement hypertext in a wide variety of ways, not only through the "go to" commands that comprise the hypertext link in digital computers. If we restrict the term *hypertext* to digital media, we lose the opportunity to understand how a literary genre mutates and transforms when it is instantiated in different media. The power of MSA comes from holding one term constant across media—in this case, the genre of literary hypertext—and then varying the media to explore how medium-specific constraints and possibilities shape texts. Understanding literature as the interplay between form and medium, MSA insists that "texts" must always be embodied to exist in the world. The materiality of those embodi-

acteristics of books is also related to my arguments here, as Jerome McGann (1991, 2001b) clearly demonstrates. See also Douglas Brooks's essay in part I of this special issue (vol. 24, no. 4) for a critical consideration of the field of book history.

ments interacts dynamically with linguistic, rhetorical, and literary practices to create the effects we call literature.²

In attending to the materiality of the medium, MSA explicitly refutes the concept of the literary work that emerged from eighteenth-century debates over copyright and that has held considerable sway since then, although not without contestations. As Mark Rose has shown in his important book *Authors and Owners: The Invention of Copyright* (1993), legal theorists such as William Blackstone defined a literary work as consisting solely of its “style and sentiment.” “These alone constitute its identity,” Blackstone wrote. “The paper and print are merely accidents, which serve as vehicles to convey that style and sentiment to a distance” (quoted in Rose 1993: 89). Subsequent commentators realized it was not practical to copyright “sentiment,” for some ideas are so general they cannot be attributed to any single author: that men are mortal, for example. Rather, it was not ideas in themselves but the ways in which ideas were expressed that could be secured as literary property and hence copyrighted.

This judicial history, played out in a contentious environment where conflicting economic, political, and class interests fought for priority, had important consequences for literature that went beyond purely legal considerations: it helped to solidify the literary author as a man (the author’s assumed gender in these discourses was invariably male) of original genius who created literary property by mixing his intellectual labor with the materials afforded him by nature, much as John Locke had argued men created private property by mixing their labor with the land.³ Consistently in these discourses, material and economic considerations, although they had force in the real world, were elided or erased in favor of an emphasis on literary property as an intellectual construction that owed nothing to the medium in which it was embodied. Although this conclusion was repeatedly challenged in court and in such literary movements as futurism and imagism (“No ideas but in things,” William Carlos Williams declared), the long reign of print made it easy for literary criticism to ignore the specificities of the codex book when discussing literary texts. With significant exceptions, print literature was widely regarded as not having a body, only a speaking mind.⁴

2. For another account of a reading practice that negotiates with materiality while cautioning against the subordination of interpretation to materialism, see James A. Knapp’s article in part I of this special issue.

3. Mark Rose (1993: 121) explicitly draws this comparison between liberal economic philosophy and the construction of literary property. Locke’s (1988 [1690]) analysis appears in the Second Treatise.

4. Among these exceptions is the long tradition of shaped poetry, including concrete poetry

This split between the physical and verbal has seriously impeded recognition in scholarly communities of the importance of the physical and sub-verbal qualities of texts, as Jerome McGann (1991, 2001b), Johanna Drucker (1996), and John Cayley (forthcoming) have argued, among others. As electronic textuality becomes more pervasive and important in literary studies, a view that insists that texts are immaterial makes it difficult to understand the significance of importing print texts into electronic environments.⁵ It also impedes the development of theoretical frameworks capable of understanding electronic literature as media-specific practices that require new modes of analysis and criticism. The temptation to think of text on screen as essentially identical to text on a printed page, simply because the words are the same, is all the more seductive because the computer is the most successful simulation machine ever created. It is crucially important, however, to recognize that the computer can simulate so successfully only because it differs profoundly from print in its physical properties and dynamic processes. These differences matter in multiple ways and on many different levels, from the macroscale to the microscale—and they matter more all the time as writers of electronic literature and texts become more adept at exploiting the medium's specificity.

In emphasizing materiality, I do not mean to imply that all aspects of a medium's apparatus will be equally important. Rather, materiality should be understood as existing in complex dynamic interplay with content, coming into focus or fading into the background, depending on what performances the work enacts. I can think of many contemporary electronic works that foreground the interplay between natural language and computer code, from John McDaid's *Uncle Buddy's Phantom Funhouse* (1993) to Talan Memmott's *Lexia to Perplexia* (2000), but I know of no work that foregrounds the computer's power cord. Interpretation cannot be generated by the apparatus alone, independently of how it is used in specific works (this is a lesson film studies learned decades ago when it suffered through the overzealous application of "apparatus theory," a phrase that still makes many film theorists break out in hives). The list of physical qualities is potentially infinite, ranging from the chemical formulas for the polymers used in com-

in the twentieth century. Loss Glazier (2002) has an excellent survey of materialist poetics in both print and electronic media.

5. For example, Peter Shillingsburg (1996: 46) argues that "it is possible for the same text to be stored in a set of alphabetic signs, a set of Braille signs, a set of electronic signals on a computer tape, and a set of magnetic impulses on a tape recorder." His conflation of radically diverse media, all qualifying as the "same text," illustrates the problems that a disembodied view of texts engenders. For a fuller version of my argument that texts are embodied, see Hayles 2003.

puter cases to the electronic conductivity of computer chips. Materiality always matters in some sense, but it matters most to humanists and artists when considered in relation to the practices it embodies and enacts.

The crucial move is to reconceptualize materiality as *the interplay between a text's physical characteristics and its signifying strategies*. This definition opens the possibility of considering texts as embodied entities while still maintaining a central focus on interpretation. In this view of materiality, it is not merely an inert collection of physical properties but a dynamic quality that *emerges* from the interplay between the text as a physical artifact, its conceptual content, and the interpretive activities of readers and writers. Materiality thus cannot be specified in advance; rather, it occupies a borderland—or better, performs as connective tissue—joining the physical and mental, the artifact and the user.

To understand these dynamic interactions, media-specific analysis (MSA) is essential. MSA aims to electrify the neocortex of literary criticism into recognizing that strands traditionally emphasizing materiality (such as criticism on the illuminated manuscript, on such writers as William Blake for whom embodiment is everything, on the rich tradition of artists' books⁶) are not exceptions but paradigmatic of the ways in which literary effects emerge from and are entwined with the materiality of texts. Hypertext, understood as a genre that can be implemented in both print and digital media, offers an ideal opportunity to explore the dynamic interaction between the artifactual characteristics and the interpretation that materiality embodies. Like all literature, hypertext has a body (or rather many bodies), and the rich connections between its physical properties and the processes that constitute it as something to be read make up together that elusive object we call a "text"—and that I want now to call instead a codex book or stitched pamphlet or CD-ROM or Web site.

What kind of bodies does hypertext have? To pursue this question, let me suggest a working definition. Following Jane Yellowlees Douglas and others, I propose that hypertext has at a minimum the following characteristics: multiple reading paths; some kind of linking mechanism; and chunked text (that is, text that can be treated as discrete units and linked to one another in various arrangements).⁷ In proposing these characteristics, my intent is not to draw a hard-and-fast line that will distinguish between hypertext and everything else. Rather, the boundary is to be regarded as

6. In view of the importance of a book's physicality, particularly artists' books, where the book's material appearance and operation may be crucial, I write only about books that I have had the opportunity to see and handle.

7. I am grateful to Jane Douglas for making her book available to me in manuscript before it was published.

heuristic, operating not as a rigid barrier but as a borderland inviting playful forays that test the limits of the form by modifying, enlarging, or transforming them. From the definition, it will be immediately apparent that hypertext can be instantiated in print as well as electronic media. A print encyclopedia, for example, qualifies as a hypertext because it has multiple reading paths, a system of extensive cross-references that serve as linking mechanisms, and chunked text in entries separated typographically from one another. These hypertextual characteristics of the encyclopedia form the basis for a print literary hypertext in Milorad Pavić's brilliant *Dictionary of the Khazars: A Lexicon Novel* (1989). Other examples of print hypertexts include Ursula Le Guin's *Always Coming Home* (1987), where the audio tapes afford multiple ways to access this multimedia text; Philip Zimmerman's artist's book *High Tension* (1993), where a multiplicity of reading paths is created through an unusual physical form that allows the reader to fold over diagonally cut leaves to obtain various juxtapositions of text and image; and Robert Coover's "The Babysitter" (2000 [1969]), a short story that pushes toward hypertext by juxtaposing contradictory and nonsequential events, suggesting many simultaneously existing time lines and narrative unfoldings.

If we grant that hypertext can exist in either print or digital media, what distinguishes hypertext instantiated in a computer from hypertext in book form? To gain purchase on this question in the spirit of MSA, I propose the following game. Using the characteristics of the digital computer, what is it possible to say about electronic hypertext as a literary medium? The point of this game is to derive these literary qualities from the interaction of the medium's physical characteristics with the signifying strategies of electronic hypertexts to illustrate how the text's materiality provides resources that writers and readers can mobilize in specific ways. Focusing on the text's materiality, how far is it possible to go? This kind of analysis is artificial in that it forbids itself access to the full repertoire of literary reading strategies, but it may nevertheless prove illuminating about what difference the medium makes. To clarify the medium's specificity, I will also offer examples of how these characteristics of digital media can be simulated in print texts. The point here is to explore what Bolter and Grusin call reverse remediation, the simulation of medium-specific effects in another medium, as when Voyager Expanded Books simulated turning down page corners and marking passages with paper clips. My technique, then, amounts to constructing a typology of electronic hypertext by considering both the medium in itself (its instantiation in digital computers) and the extent to which its effects can be simulated in print (the reverse remediation that blurs the boundary between electronic media and print). As I suggested

earlier, MSA operates not so much through a simple binarism of similarity and difference as through media-specific considerations of instantiation and simulation.

Following these rules, I am able to score nine points, which are first listed and then discussed in detail.

- Point One: Electronic Hypertexts Are Dynamic Images.
- Point Two: Electronic Hypertexts Include Both Analogue Resemblance and Digital Coding.
- Point Three: Electronic Hypertexts Are Generated through Fragmentation and Recombination.
- Point Four: Electronic Hypertexts Have Depth and Operate in Three Dimensions.
- Point Five: Electronic Hypertexts Are Bilingual, Written in Code as well as Natural Language.
- Point Six: Electronic Hypertexts Are Mutable and Transformable.
- Point Seven: Electronic Hypertexts Are Spaces to Navigate.
- Point Eight: Electronic Hypertexts Are Written and Read in Distributed Cognitive Environments.
- Point Nine: Electronic Hypertexts Initiate and Demand Cyborg Reading Practices.

Point One: Electronic Hypertexts Are Dynamic Images

In the computer, the signifier exists not as a durably inscribed flat mark but as a screenic image produced by layers of code precisely correlated through correspondence rules, from the electronic polarities that correlate with the bit stream to the bits that correlate with binary numbers, to the numbers that correlate with higher-level statements, such as commands, and so on. Even when electronic hypertexts simulate the appearance of durably inscribed marks, they are transitory images that need to be constantly refreshed by the scanning electron beam that forms an image on the screen to give the illusion of stable endurance through time. This aspect of electronic hypertext can be mobilized through such innovations as dynamic typography, where words function as both verbal signifiers and visual images whose kinetic qualities also convey meaning (Hayles 1999b). In David Knobel's poem "Breathe" (2000), done in collaboration with Reiner Strasser, lines appear and disappear as the mouse touches colored rectangles, creating an effect similar to breathing in and out when reading poetry aloud. In Bill Marsh's "6-String Aria" (1999), strings dynamically fold and unfold to form the word *Aria* while an aria plays, creating a fusion

of sound, image, and text. Dan Waber's "Strings" (1999) performs a similar fusion through animated lines wriggling into words and shapes that visually and textually evoke an argument beginning and ending, a flirtation, and an embrace. Similar effects are achieved in a different way in Alan Dunning's artist's book *Greenhouse* (1989), which creates a multilayered reading experience by overlaying translucent vellum pages onto opaque pages. Significantly, the five lines of text on the opaque pages are taken from five of Dunning's favorite works of literary criticism, each line set in different typography and written by a different author. As the vellum pages are overlaid onto these, the literary criticism, already interleaved with other critical texts to form a kind of hypertext, is further modified by the visual play set up by the image and Dunning's words printed on the vellum pages.

An important difference between print and electronic hypertext is the accessibility of print pages compared, for example, to the words revealed by the cursor's click in Knobel and Strasser's electronic hypertext. Whereas all the words and images in the print text are immediately accessible to view, the linked words in Knobel's poem become visible to the user only when they appear through the cursor's action. Code always has some layers that remain invisible and inaccessible to most users. From this we arrive at an obvious but nevertheless central maxim: print is flat, code is deep.

Point Two: Electronic Hypertexts Include Both Analogue Resemblance and Digital Coding

The digital computer is not, strictly speaking, entirely digital. At the most basic level of the computer are electronic polarities, which are related to the bit stream through the analogue correspondence of morphological resemblance. Once the bit stream is formed, it operates as digital code. Analogue resemblance typically reappears at the top level of the screenic image, for example, in the desktop icon of a trash barrel. Thus digital computers have an Oreo cookie-like structure with an analogue bottom, a frothy digital middle, and an analogue top.⁸ Although we are accustomed to thinking of digital in terms of binary digits, digital has a more general meaning of discrete versus continuous flow of information. Digital computers do not necessarily have to operate with binary code; in the early days of computing, computers were constructed using the base ten codes commonly used in counting.⁹ These computers were digital not because they used binary code

8. For an exploration of what this Oreo structure signifies in the context of virtual narratives, see Hayles 1999a.

9. ENIAC, the first large-scale electronic computer, operated with a code that used base ten.

but because they used discrete bit streams. Analogue computers, in contrast to digital ones, represent numbers as a continuously varying voltage. In analogue computers and analogue technologies in general, morphological resemblance connects one level of code with another. In this sense, iconographic writing is analogue because it bears a morphological resemblance to its referent (albeit in highly conventionalized ways), whereas alphabetic writing is digital, consisting of a few elements that can be combined to make many words, precisely because the relation between mark and referent is arbitrary (Logan 1986 makes this point). By contrast, iconographic writing requires a much larger symbol set because its elements tend to be almost as multiform as the concepts for which they stand; for example, written Chinese has over forty thousand characters.

Print books and digital computers both use digital and analogue modes of representation, but they mobilize the two modes differently. An example of a print book that makes conspicuous use of a digital algorithm is Emmett Williams's *The VoyAge* (1975), in which all the words are three letters long (to accommodate this restriction, Williams often resorts to creative spelling). Williams imposed the further requirement that spacing between the words increases as the page numbers go up. On page one, the three-letter words are separated by one space; on page two, by two spaces, and so on. The book ends when the number of spaces that must intervene before another word can appear is greater than the spaces available on the page. This example makes clear that the difference between print and electronic hypertext consists not in the presence or absence of digital and analogue modalities but rather in the ways these modes are mobilized as resources. In *VoyAge*, the effect of using a digital algorithm is to create visual patterns through the placement of words on the page, so that the words function simultaneously as analogue image and digital code. When the spacing brings all the words into a single column, for example, the narrator remarks: "NOW/WEE/GET/OUR/POE/EMM/ALL/INN/ONE/ROW" (Williams 1975). Typically the computer employs a digital mode at deeper coding levels, whereas in print, analogue continuity and digital coding both operate on the flat surface of the page.

Point Three: Electronic Hypertexts Are Generated through Fragmentation and Recombination

As a result of the frothy digital middle of the computer's structure, fragmentation and recombination are intrinsic to the medium. These textual strategies can also be used in print texts, for example, in Raymond Queneau's *Cent mille milliards de poèmes* (1961), a book in which each page may be cut

into several strips corresponding to the lines of a poem. By juxtaposing the cut strip on one page with strips from other pages, large numbers of combinations are possible, as indicated by Queneau's title. Another example is Dick Higgins's book *Buster Keaton Enters into Paradise* (1994). To generate this text, Higgins played thirteen games of Scrabble, each of which started with the words "Buster Keaton" orthogonally arranged. He then used the words that turned up in the Scrabble games to create thirteen skits, each corresponding to one of the games. Here fragmentation was achieved using the Scrabble letters, a technique that emphasizes the digital nature of alphabetic writing; recombination is mobilized through the aleatory combinations that make words and Higgins's subsequent use of these game words in the skits.

With digital texts, the fragmentation is deeper, more pervasive, and more extreme than with the alphanumeric characters of print. Moreover much of the fragmentation takes place on levels inaccessible to most users. This aspect of digital storage and retrieval can be mobilized as an artistic resource, reappearing at the level of the user interface. Stuart Moulthrop's "Reagan Library" (1999), for example, uses an algorithm that places pre-scripted phrases on the screen in random order. As the user revisits a screen, the text on that screen gradually becomes more coherent, stabilizing into its final order on a fourth visit, whereupon it does not change further. As if to emphasize that noise is not merely interference but itself a form of information, Moulthrop has designed the piece so that one level of the text moves in the opposite direction from this trajectory. The screens in "Notes," which offer explanatory commentary, actually lose text as the user revisits them, becoming more cryptic and enigmatic the more they are read.

Point Four: Electronic Hypertexts Have Depth and Operate in Three Dimensions

Digital coding and analogue resemblance have specific advantages and are deployed so as to make the most of these advantages. Analogue resemblance allows information to be translated between two differently embodied material instantiations, as when a sound wave is translated into the motion of a vibrating diaphragm of a microphone. Whenever information flows between two differently embodied entities—for example, sound wave and microphone or microphone and recording device—analogue resemblance is likely to come into play because it allows one form of continuously varying information to be translated into a similarly shaped informational pattern in another medium. Once this translation has taken place, digital coding is used to transform the continuity of morphological form into num-

bers (or other discrete codes). Intrinsic to this process is the transformation of a continuous shape into a series of code elements. In contrast to the continuity of analogue pattern, the discreteness of code enables information to be rapidly manipulated and transmitted.

Human readers, with sensory capabilities evolved through eons of interacting with three-dimensional environments, are much better at perceiving patterns in analogue shapes than performing rapid calculations with code elements.¹⁰ When presented with code, humans tend to push toward perceiving it as analogue pattern. Although most of us learned to read using the digital method of sounding out each letter, for example, we soon began to recognize the shapes of words and phrases, thus modulating the discreteness of alphabetic writing with the analogue continuity of pattern recognition. The interplay between analogue and digital takes place in a different way with screen text than with print, and these differences turn out to be important for human perception. With present-day screens, reading speed on screen is typically about 28 percent slower than with print (for an analysis of the factors affecting reading speed on screen, see Muter 1996). Although the factors causing this difference are not well understood, they undoubtedly have something to do with the dynamic nature of screen images. Text on screen is produced through complex internal processes that make every word also a dynamic image, every discrete letter a continuous process.

To distinguish between the image the user sees and the bit strings as they exist in the computer, Espen Aarseth (1997) has proposed the terminology *scripton* (the surface image) and *texton* (the underlying code). In a digital computer, texton can refer to voltages, strings of binary code, or programming code, depending on who the “reader” is taken to be. Scriptons always include the screen image but can also include any code visible to a user who is able to access different layers of program. Textons can appear in print as well as electronic media. Stipple engraving, although it is normally perceived by the reader as a continuous image, operates through the binary digital distinction of ink dot/no ink dot; here the scripton is the image and the ink dots are the textons.¹¹ In electronic media, textons and scriptons operate in a vertical hierarchy rather than through the flat micro-scale/macroscale play of stipple engraving. With electronic texts there is a clear distinction between scriptons that appear on screen and the textons of

10. For a discussion of the comparative ease with which computers and humans recognize patterns, see Satoshi Watanabe's (1985) somewhat dated but still useful analysis. For a more recent assessment, see Friedman and Kandel 1999.

11. I am indebted to Robert Essick for this example, proposed in a discussion of William Blake's strong dislike of stipple engraving and his preference (which for Blake amounted to an ethical issue) for printing technologies that were analogue rather than digital.

underlying code, which normally remain invisible to the casual user. The flat page of print remains visually and kinesthetically accessible to the user, whereas the textons of electronic texts can be brought into view only by using special techniques and software.

In reverse remediation, some books play with this generalization by making print pages inaccessible. David Stairs has created a round artist's book entitled *Boundless* (1983) with spiral binding all around, so that it cannot be opened. A similar strategy is used by Maurizio Nannucci in *Universum* (1969), a book bound on both vertical edges so that it cannot be opened. Ann Tyler also plays with the assumption that pages are visually and kinesthetically accessible to users in *Lubb Dup* (1998), an artist's book in which several pages are double-faced, so that one can see the inside only by peering through a small circle in the middle or prying the two pages apart enough to peek down through the top. These plays on accessibility do not negate the generalization that the flat page is accessible to users, however, for their effect is precisely to make us conscious of the normative rule.

Point Five: Electronic Hypertexts Are Bilingual, Written in Code as Well as Language

Electronic hypertexts, like all electronic texts, consist of multiple layers of text that combine computer code and natural language. Typically, natural language appears at the top (screenic) level, although it is also frequently found at lower coding levels in comment lines. More subtly, it serves as ground for the syntax and grammar of computer languages, which are specifically permeated, as Rita Raley (2001) has argued, with the linguistic structures and grammar of English. Working in a back-formation from electronic textuality, Jerome McGann has recently argued that print texts are also marked (by analogy with HTML, the hypertext markup language used to format documents for the Web). He argues further that print texts, like electronic documents, are coded and generated through algorithms. It is not difficult to agree that all texts are marked; for example, readers familiar with print conventions recognize an indentation as signaling a paragraph break and parse the text accordingly. Thinking of such textual markings as algorithmic, however, obscures the important distinction between processes enacted by the reader/user and those performed by the computer. An electronic text literally does not exist if it is not generated by the appropriate hardware running the appropriate software. Rigorously speaking, an electronic text is a *process* rather than an object, although objects (like hardware and software) are required to produce it. Moreover, an algorithm is normally considered to be a procedure defined by explicit rules that can be

specified precisely.¹² While some rules pertaining to the human understanding of texts can be specified, many literary (and more generally grammatical) practices are notoriously difficult to codify, in contrast to the explicit nature of computer instructions.

The fact that creators of electronic texts always write code as well as natural language has resulted in a significant shift in how writing is understood. Loss Pequeño Glazier (2002) and John Cayley (1998), among others, argue that programming *is* writing. They refuse the distinction between writing that appears on screen as the “real” creative effort, because they deeply understand, through their own creative practices, that screenic text and programming are logically, conceptually, and instrumentally entwined. Increasingly, writers working in electronic media exploit the word/code interplay by crafting a creole, visible on the screen, that comprises English and pseudoprogramming expressions. MEZ (Mary Ann Breeze), for example, has formulated a pidgin she calls “mezangelle,” a bilingual practice that breaks the conventional link between phoneme and written mark, forging new connections between code and English.¹³ In *Lexia to Perplexia* (2000), Talan Memmott formulates a creole that he uses to articulate a version of cyborg subjectivity in which the machine and the self (which he writes as “cell.f”) to suggest its infection by the computational) conjoin in a union that is at once conceptual, linguistic, and technological.

McGann’s redescription of print texts by terms normally employed for electronic texts can be understood as a critical (re)enactment of his editorial work with *The D. G. Rossetti Hypermedia Archive* (2001a), in which he has reproduced Dante Gabriel Rossetti’s print texts on the Web. While pushing toward envisioning print texts in electronic terms, however, he also deeply understands that simulating print texts in electronic environments involves radically different materialities than the print texts in themselves. Along with many writers working in electronic media, he views the work of literary production as *making* and *doing*, not simply spewing out words seen as immaterial entities. It is no accident that McGann, with a background in bibliographic studies, frequently collaborates with Johanna Drucker, a maker of artists’ books as well as a historian and critic of that genre. They share a rich appreciation for the materiality of literature and consequently for reading and writing as material practices. One can certainly arrive at this view without touching a computer, a point made by Loss Glazier (2002)

12. For an extensive discussion on the history and development of the idea of the algorithm, see David Berlinski 2000.

13. See, for example, MEZ 2001, which contains the explanation “.these t.ex)[e][ts r _code wurk_ remnants d-voted to the dispersal of writing that has been n.spired and mutated according 2 the dynamics of an active network.”

in his discussion of typewriter poetry, that is, poetry visually crafted to highlight the instrumental role of the typewriter in producing the text. It is virtually impossible, however, to create an electronic work *without* grasping the significance of the work as a materialist production. M. D. Coverley (2002) makes this point when she compares a print writer who types a sentence and sits back, satisfied, with a writer in electronic media. The electronic author who types the same sentence then goes on to consider what behaviors and animations should attach to the words, in what font and color they should appear, on what background and over (or under) what layers, to what other texts or structures they should be linked, and so forth. In all these activities, the hardware and software are active partners, facilitating and resisting, enabling and limiting, enacting and subverting. The labor needed to program these effects must be seen as intrinsic to the work of creation. Like the creator of an artist's book who manipulates an Exacto knife to make delicate cutouts in heavy white Italia paper and painstakingly sews the pages together, the writer of an electronic text is intensely aware of the entwining of intellectual, physical, and technological labor that creates the text as a material object.

Point Six: Electronic Hypertexts Are Mutable and Transformable

The multiple coding levels of electronic textons allow small changes at one level of code to be quickly magnified into large changes at another level. The layered coding levels thus act like linguistic levers, giving a single keystroke the power to change the entire appearance of a textual image. An intrinsic component of this leveraging power is the ability of digital code to be fragmented and recombined. Although the text appears as a stable image on screen, it achieves its dynamic power of mutation and transformation through the very rapid fragmentation and recombination of binary code. In addition, the rapid processing of digital code allows programs to create the illusion of depth in screenic images, for example, in the three-dimensional landscapes of *Myst* or the layered windows of Microsoft Word.¹⁴ In these cases, both scriptons and textons are perceived as having depth, with textons operating digitally through coding levels and scriptons operating analogically through screenic representation of three-dimensional spaces.

Print books can simulate the mutability of electronic texts through a variety of strategies, from semitransparent pages that overlay onto other

14. To create the illusion of three-dimensional landscapes, the computer takes thin horizontal slices that can be approximated as two-dimensional and stacks them together. This requires massive calculations and would be impossible without the very rapid fragmentation and recombination that contemporary computers utilize.

pages to more elaborate strategies. In Michael Snow's visual narrative *Cover to Cover* (1975), the sequence begins with a realistic image of a door, with the next image showing a man opening the door to go into a rather ordinary room. With each successive image, the previous representation is revealed as a posed photograph, for example by including the photographer in the picture. As one approaches the center of the book, the images begin shifting angles, and at the midpoint, the reader must turn the book upside down to see the remaining images in proper perspective. At the end of the book the images reverse order, so the reader then goes backward through the book to the front, a direction that is then implicitly defined as forward. To facilitate this shift in perspective, the book is bound on both sides, so that either cover can function as "front." Thus such fundamental aspects of the book as forward and backward, up and down, become mutable characteristics that change in the course of reading.

Similar strategies are employed in Karen Chance's *Parallax* (1987), where cutouts and reverse ordering are used to create two narratives, one from the point of view of a straight man who sees gay men as unwanted intrusions in his life, the other from the point of view of a gay man who sees his life threatened by straight people who refuse to acknowledge his existence. A different approach is taken by Tom Phillips in *A Humument: A Treated Victorian Novel* (1997). Phillips took William Mallock's obscure Victorian novel, *A Human Document*, and "treated" each page by creating images that left only a few words on each page untouched. These words are typically connected by pathways or "rivers" of white space, created by surrounding the white spaces between words and lines with colored backgrounds and images. As the rivers meander down the page, they are often arranged in ways that allow multiple reading paths. Other hypertextual effects emerge from the interplay of the words in the pathways, other "treated" text that remains partially visible, and the strikingly diverse images that the treated pages display. Through such manipulations, Mallock's text is made to mutate into an entirely new narrative. Phillips (1997: dustcover) writes: "I took a forgotten Victorian novel found by chance. I plundered, mined, and undermined it to make it yield the ghosts of other possible stories, scenes, poems, erotic incidents and surreal catastrophes which seemed to link with its wall of words." Although this book is not dynamic in the same sense as Java script, the hypertextual effects it achieves through mutation and transformation are complex and dynamically interactive.¹⁵

15. For a fuller discussion of the materiality of *A Humument* and how it serves as a resource for meaning, see Hayles 2002.

Point Seven: Electronic Hypertexts Are Spaces to Navigate

Electronic hypertexts are navigable in at least two senses. They present to the user a visual interface that must be navigated through choices the user makes to progress through the hypertext; and they are encoded on multiple levels that the user can access using the appropriate software, for example, by viewing the source code of a network browser as well as the surface text. As a result of its construction as a navigable space, electronic hypertext is intrinsically more involved with issues of mapping and navigation than are most print texts.

M. D. Coverley's Web novel in progress, *The Book of Going Forth by Day* (in progress), illustrates how navigation becomes a signifying strategy for electronic hypertexts. Modeled after the spatial arrangement of Egyptian hieroglyphs, the interface employs both horizontal and vertical registers. The horizontal panels provide the narrative, while the vertical panels give linguistic, historical, and geographic information about ancient Egypt, modeled after the rubrics that in hieroglyphic texts give information on how to interpret the depicted events. The correspondences between Egyptian hieroglyphs and the interface suggest deep connections between inscription systems, cosmological beliefs, temporal orderings, and geographic assumptions. Ancient hieroglyphic inscriptions were written in all directions, including left to right, right to left, up to down, down to up, edging sideways into margins, or spiraling in a circle, with the order of reading indicated by the direction the figures face. *Going Forth* relates the omnidirectionality of this writing to ancient Egyptian beliefs about the "endless geometry" of the world, in which personages from the past continue over the threshold of death into the present and gods and goddesses manifest themselves in humans alive on the earth. *Going Forth* envisions its own inscription surface as a complex topology, a richly decorated and potentially infinite inscription surface that enables fluid transitions between exposition, narrative, maps, photographs, linguistic information, and historical context. *Going Forth* suggests that there was no clear distinction in ancient Egypt between writing and art. Art did not so much imitate life as it imitated and was imitated by writing, which is another way to say that worldview and inscription system were intimately related. Transported into an electronic environment, these correlations take the form of complex relations between multimedia components and navigational functionalities in which meaning emerges from their interrelations rather than from the verbal narrative alone.

When navigation becomes an issue in a print text, the effect is usually to transform linear sequence into hypertextual multiplicity. In Susan E. King's

Treading the Maze (1993), the book is spiral-bound on both lateral edges. The binding on the left side holds pages displaying images on vellum; the binding on the right side holds blue opaque pages of verbal text. Different narrative orders are created by intermixing opaque and translucent pages. The author writes (on a page that most readers will not find until halfway through the book) that the most complete reading is achieved by turning back all the pages on both sides so the back cover is exposed, then interleaving one opaque page with one translucent page until one arrives at the front. In this reading the last two pages are successive translucent images that overlay a labyrinth onto a woman's body, so that the maze the reader has traversed is imaged at once as a human female body, an exploration of the labyrinth as a visual and conceptual form, and the body of the book experienced as a maze through which many paths may be traced.

Point Eight: Electronic Hypertexts Are Written and Read in Distributed Cognitive Environments

Modern-day computers perform cognitively sophisticated acts when they collaborate with human users to create electronic hypertexts. These frequently include acts of interpretation, as when the computer decides how to display text in a browser independent of choices the user makes. It is no longer a question of whether computers are intelligent. Any cognizer that can perform the acts of evaluation, judgment, synthesis, and analysis exhibited by expert systems and autonomous agent software programs should *prima facie* be considered intelligent. Books also create rich cognitive environments, but they passively embody the cognitions of writer, reader, and book designer rather than actively participate in cognition themselves.

To say that the computer is an active cognizer does not necessarily mean it is superior to the book as a writing technology. Keeping the book as a passive device for external memory storage and retrieval has striking advantages, for it allows the book to possess robustness and reliability beyond the wildest dreams of a software designer. Whereas computers struggle to remain viable for a decade, books maintain backward compatibility for hundreds of years. The issue is not the technological superiority of either medium but rather the specific conditions a medium instantiates and enacts. When we read electronic hypertexts, we do so in environments that include the computer as an active cognizer performing sophisticated acts of interpretation and representation. Thus cognition is distributed not only between writer, reader, and designer (who may or may not be separate people) but also between humans and machines (which may or may not be regarded as separate entities).

Print books can also be structured in ways that create and emphasize distributed cognition. Examples are telegraph codebooks, which matched phrases and words used frequently in telegrams with code groups that were shorter and thus more economical to transmit. The more sophisticated of these codebooks included so-called mutilation tables, which enabled a user to reverse engineer a garbled message to figure out what code element ought to have been there instead of the incorrect element. In this way the distributed nature of the cognition became evident, for part of the cognition resided in the sender, part in the telegraph operator, part in the codebook, part in the mutilation table, and part in the receiver. At any point along this transmission chain, errors could be introduced, making clear that comprehension depended on all the parts working together correctly in this distributed cognitive system.

Point Nine: Electronic Hypertexts Initiate and Demand Cyborg Reading Practices

Because electronic hypertexts are written and read in distributed cognitive environments, the reader necessarily is constructed as a cyborg, spliced into an integrated circuit with one or more intelligent machines. (*Cyborg* is of course a neologism coined from cybernetic organism, part organic being, part machine.) To be positioned as a cyborg is inevitably in some sense to become a cyborg, so electronic hypertexts, regardless of their content, tend toward cyborg subjectivity. This subject position may also be evoked through the content of print texts (for example, William Gibson's *Neuromancer* [1984] and Pat Cadigan's *Synners* [1991]), but electronic hypertexts necessarily enact it through the specificity of the medium. Of the nine points, this is the most difficult to simulate in book technology, which, for all of its sophistication in content and production, remains remarkably simple to use. Book lovers frequently evoke this quality of print, emphasizing that they enjoy books precisely because books do not interpolate them into the speed, obsolescence, and constant breakdown of electronic culture. This distinction between print and electronic forms is itself undermined, however, with the introduction of electronic books that look like print but have electronic hardware embedded in the spine that enable the pixels of the electronic "page" to be polarized in different patterns, so that one page can be any page. (Researchers at MIT Media Lab, among other developers, are experimenting with developing "electronic ink," in which each small segment comprising a letter form can change from white to black and vice versa when the electronic polarities change, thus allowing a given letter to mutate into a new letter or space. The ink is made of polymers

sensitive to electrical charges; because their colors change when the polarities change, the polymers function analogously to LCDs, liquid crystal displays.) Hybrid forms, like the electronic book, show reverse remediation in action: as books become more like computers, computers become more like books.

In the rich medial ecology of contemporary literature, media differentiate as well as converge. Attention to material properties enhances our understanding of how some digital works are evolving along trajectories that increasingly diverge from books as they experiment with the new possibilities opened up by electronic environments. This divergence is strikingly evident in the watershed dividing first-generation hypertexts, such as Michael Joyce's *Afternoon* (1987), from second-generation works, such as Talan Memmott's *Lexia to Perplexia* (2000). *Afternoon*, exemplary of early electronic hypertexts written in Storyspace software, has almost no graphics, and most of the links go from word to word or from paragraph to paragraph. Clicking on a link customarily takes the reader from one screen of text to the next. In retrospect, it is possible to see that the foundational assumption for this kind of linking comes from print books. Although the electronic linking structure differs from turning a page in that it offers multiple reading paths, it reproduces in electronic media the experience of flipping pages. By contrast, second-generation hypertexts mix words with graphics, sounds, images, animation, and a host of other multimedia components. Moreover the links go every which way, from word to navigational apparatus to image to mouseover to animated graphic. In the process, the foundational metaphor of the page as a two-dimensional plane mutates into a very different kind of experience. Instead, the textual space is increasingly represented as a topographic area to explore, with layered strata, hidden openings, crosscutting pathways, links between different world levels, and other spatial and temporal unfoldings that merge the functionality of the artifact—its material and processual properties—with the representations of the imagined world we create when we read.

In retrospect, we can see the view that the text is an immaterial verbal construction as an ideology that inflicts the Cartesian split between mind and body upon the textual corpus, separating into two fictional entities what is in actuality a dynamically interacting whole. Rooted in the Cartesian tradition, this ideology also betrays a class and economic division between the work of creation—the privileged activity of the author as an inspired genius—and the work of producing the book as a physical artifact, an activity relegated to publishers and booksellers. As the means of production moves into the hands of writers and artists for both print and electronic media with desktop publishing, fine letter presses run by artists'

collectives, such as the Visual Studies Workshop Press, and electronic publishing on the Web, the traditional split between the work of creation and the work of production no longer obtains. This shift in the economic and material circumstances in which literary works are produced makes all the more urgent the challenge of rethinking critical and theoretical frameworks accordingly. We can no longer afford to pretend that texts are immaterial or that text on screen is the same as text in print. The immateriality of the text has ceased to be a useful or even a viable fiction.

In urging increased attention to materiality, I hope it is clear that I do not mean to argue for the superiority of electronic media. Rather, I have been concerned to delineate characteristics of digital environments that writers and readers can use as resources in creating electronic literature and responding to it in sophisticated, playful ways. I have also shown how in many cases similar—but not identical—effects can be achieved in print books, as well as describing electronic effects difficult or impossible to duplicate in print. Whether in print or on screen, the specificity of the medium comes into play as its characteristics are flaunted, suppressed, subverted, reimagined.

Many critics see the electronic age as heralding the end of books. I think this view is mistaken. Books are far too robust, reliable, long-lived, and versatile to be rendered obsolete by digital media. Rather, digital media have given us an opportunity we have not had for the last several hundred years: the chance to see print with new eyes and, with that chance, the possibility of understanding how deeply literary theory and criticism have been imbued with assumptions specific to print. As we continue to work toward critical practices and theories appropriate for electronic literature, we may come to renewed appreciation for the specificity of print. In the tangled web of medial ecology, change anywhere in the system stimulates change everywhere in the system. Books are not going the way of the dinosaur but the way of the human, changing as we change, mutating and evolving in ways that will continue, as a book lover said long ago, to teach and delight.

References

- Aarseth, Espen J.
1997 *Cybertext: Perspectives on Ergodic Literature* (Baltimore, MD: Johns Hopkins University Press).
- Barthes, Roland
1986 "From Work to Text," in *The Rustle of Language*, translated by Richard Howard, 56–64 (New York: Hill and Wang).
- Berlinski, David
2000 *The Advent of the Algorithm: The Idea That Rules the World* (New York: Harcourt Brace).
- Bolter, Jay David
1991 *Writing Space: The Computer, Hypertext, and the History of Writing* (Hillsdale, NJ: Lawrence Erlbaum).
- Bolter, Jay David, and Richard Grusin
1999 *Remediation: Understanding New Media* (Cambridge: MIT Press).
- Bush, Vannevar
1945 "As We May Think," *Atlantic Monthly*, July, 101–8.
- Cadigan, Pat
1991 *Synners* (New York: Spectra).
- Cayley, John
1998 "Of Programmatology," *Mute* 11 (fall): 72–75.
forthcoming "Literal Art: Neither Lines nor Pixels but Letters," in *First Person: New Media as Story, Performance, and Game*, edited by Noah Wardrip-Fruin and Pat Harrigan (Cambridge: MIT Press).
- Chance, Karen
1987 *Parallax* (Atlanta, GA: Nexus).
- Coover, Robert
2000 [1969] "The Babysitter," in *Pricksongs and Descants* (New York: Grove).
- Coverley, M. D.
2002 Personal communication with author, July.
in progress *The Book of Going Forth by Day*. Available at califia.hispeed.com/Egypt
- DeLillo, Don
1998 *Underworld* (New York: Scribner).
- Douglas, Jane Yellowlees
1994 "'How Do I Stop This Thing?': Closure and Indeterminacy in Interactive Narratives," in *Hyper/Text/Theory*, edited by George P. Landow, 159–88 (Baltimore, MD: Johns Hopkins University Press).
2000 *The End of Books—or Books without End? Reading Interactive Narratives* (Ann Arbor: University of Michigan Press).
- Drucker, Johanna
1996 *The Visible Word: Experimental Typography and Modern Art, 1909–1923* (Chicago: University of Chicago Press).
- Dunning, Alan
1989 *Greenhouse* (Calgary: Alan Dunning).
- Friedman, Menahem, and Abraham Kandel
1999 *Introduction to Pattern Recognition: Statistical, Structural, Neural, and Fuzzy Logic Approaches* (London: Imperial College Press).
- Gibson, William
1984 *Neuromancer* (New York: Ace).
- Glazier, Loss Pequeño
2002 *Dig[i]Tal Poet(I)(c)s: The Making of E-Poetries* (Tuscaloosa: University of Alabama Press).

- Hayles, N. Katherine
 1999a "Simulating Narratives: What Virtual Creatures Can Teach Us," *Critical Inquiry* 26 (1): 1–26.
 1999b "Virtual Bodies and Flickering Signifiers," in *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, 25–49 (Chicago: University of Chicago Press).
 2002 *Writing Machines* (Cambridge: MIT Press).
 2003 "Translating Media: Why We Should Rethink Textuality," *Yale Journal of Criticism* 16 (263–90).
- Higgins, Dick
 1994 *Buster Keaton Enters into Paradise* (New York: Left Hand).
- Joyce, Michael
 1987 *Afternoon: A Story* (Watertown, MA: Eastgate Systems).
- King, Susan E.
 1993 *Treading the Maze: An Artist's Book of Daze* (Rochester, NY: Visual Studies Workshop).
- Knobel, David, with Reiner Strasser
 2000 "Breathe." Hypertext poem available online at www.workxspace.de/valentine/val_va.
- Landow, George
 1997 *Hypertext 2.0: The Convergence of Contemporary Critical Theory and Technology* (Baltimore, MD: Johns Hopkins University Press).
- Le Guin, Ursula K.
 1987 *Always Coming Home* (New York: Bantam).
- Locke, John
 1988 [1690] *Two Treatises of Government*, edited by Peter Laslett (Cambridge: Cambridge University Press).
- Logan, Robert K.
 1986 *The Alphabet Effect* (New York: William Morrow).
- Macpherson, C. B.
 1962 *Political Theory of Possessive Individualism: Hobbes to Locke* (Oxford, U.K.: Clarendon).
- Marsh, Bill
 1999 "6-String Aria." Hypertext available online at www.factoryschool.org/btheater/works/6strA/aria.html.
- McDaid, John
 1993 *Uncle Buddy's Phantom Funhouse* (Watertown, MA: Eastgate Systems).
- McGann, Jerome
 1991 *The Textual Condition* (Princeton, NJ: Princeton University Press).
 2001a *The D. G. Rossetti Hypermedia Archive*, available at www.iath.virginia.edu/rossetti/fullarch.html (accessed July 2002).
 2001b *Radiant Textuality: Literature after the World Wide Web* (New York: Palgrave).
- McLuhan, Marshall
 1994 [1964] *Understanding Media: Extensions of Man* (Cambridge: MIT Press).
- Memmott, Talan
 2000 *Lexia to Perplexia*. Web media work available at www.uiowa.edu/~iareview/tirweb/hypermedia/talan_memmott/index.html (accessed July 2002).
- MEZ [Mary-Anne Breeze]
 2001 "The Data][H][Bleeding Texts." Hypertext available at netwurkerz.de/mez/datableed/complete (accessed July 2002).
- Moulthrop, Stuart
 1999 "Reagan Library," in *Gravitational Intrigue*, CD-ROM, *Little Magazine*. Multimedia hypertext available at iat.ubalt.edu/moulthrop/hypertexts/RL (accessed July 2002).
- Muter, Paul
 1996 "Interface Design and Optimization of Reading of Continuous Text," in *Cognitive*

- Aspects of Electronic Text Publishing*, edited by H. van Oostendorp and S. de Mul (Norwood, NJ: Ablex). Accessed online at www.psych.utoronto.ca/~muter/pmuter1.htm (July 2002).
- Nannucci, Maurizio
 1969 *Universum* (n.p.: Biancoenero).
- Pavić, Milorad
 1989 *Dictionary of the Khazars: A Lexicon Novel*, translated by Christina Pribicevic-Zorić (New York: Vintage).
- Phillips, Tom
 1997 *A Humument: A Treated Victorian Novel*, 2d rev. ed. (London: Thames and Hudson).
- Queneau, Raymond
 1961 *Cent mille milliards de poèmes* (Paris: Gallimard).
- Raley, Rita
 2001 "Reveal Codes: Hypertext and Performance," *Postmodern Culture* 12.1. Web-based journal available at www.iath.virginia.edu/pmc/issue.901/12.1raley.html (accessed July 2002).
- Rose, Mark
 1993 *Authors and Owners: The Invention of Copyright* (Cambridge: Harvard University Press).
- Shillingsburg, Peter
 1996 *Scholarly Editing in the Computer Age: Theory and Practice*, 3d ed. (Ann Arbor: University of Michigan Press).
- Snow, Michael
 1975 *Cover to Cover* (Halifax: Press of the Nova Scotia College of Art and Design).
- Stairs, David
 1983 *Boundless* (n.p.: D. Stairs).
- Tyler, Ann
 1998 *Lubb Dup* (Chicago: Sara Ranchouse).
- Waber, Dan
 2000 "Strings," *Vispo*. Electronic hypertext available online at vispo.com/guests/DanWaber/index.html.
- Watanabe, Satoshi
 1985 *Pattern Recognition: Human and Mechanical* (New York: Wiley).
- Williams, Emmett
 1975 *The Voyage* (Stuttgart: Edition Hansjörg Mayer).
- Zimmerman, Philip
 1993 *High Tension* (Rochester, NY: Visual Studies Workshop).

Shaping Technology/Building Society

Studies in Sociotechnical Change

edited by Wiebe E. Bijker and John Law

The MIT Press
Cambridge, Massachusetts
London, England

The De-Description of Technical Objects

Madeleine Akrich

Describing the Interaction between Technics and Humans

Although science and technology are often thought to go together, they are concerned with very different subject matters. Science is taken to go beyond the social world to a reality unfettered by human contingency. Perhaps as a result, the sociology of science has studied the ways in which the local and the heterogeneous are combined to create knowledge with the status of universal and timeless truth. By contrast, sociologists have found it difficult to come to terms with technical objects. Machines and devices are obviously composite, heterogeneous, and physically localized. Although they point to an end, a use for which they have been conceived, they also form part of a long chain of people, products, tools, machines, money, and so forth. Even study of the technical content of devices does not produce a focused picture because there is always a hazy context or background with fuzzy boundaries. Thus even the most mundane objects appear to be the product of a set of diverse forces. The strength of the materials used to build cars is a function of predictions about the stresses they will have to bear. These are in turn linked to the speed of the car, which is itself the product of a complex compromise between engine performance, legislation, law enforcement, and the values ascribed to different kinds of behavior. As a consequence, insurance experts, police, and passers-by can use the condition of the bodywork of a car to judge the extent to which it has been used in ways that conform to the norms it represents.

Technical objects thus simultaneously embody and measure a set of relations between heterogeneous elements. However, the process of describing everything about a car in such terms would be a mammoth task.¹ Furthermore, the end product might well be banal. The automobile is so much a part of the world in which we live that its sociography (a description of all the links making it up) would no

doubt look like a collection of commonplaces. It would, in other words, look like a set of places where elements of the technical, the social, the economic, and so on were to be found together, and it would leave observers free to switch between one element or register and another as this suited them.²

I am arguing, therefore, that technical objects participate in building heterogeneous networks that bring together actants of all types and sizes, whether human or nonhuman.³ But how can we describe the specific role they play within these networks? Because the answer has to do with the way in which they build, maintain, and stabilize a structure of links between diverse actants, we can adopt neither simple technological determinism nor social constructivism. Thus technological determinism pays no attention to what is brought together, and ultimately replaced, by the structural effects of a network. By contrast social constructivism denies the obduracy of objects and assumes that only people can have the status of actors. The problem is not one of deciding whether a technology should be seen as an instrument of progress or a new method for subjugating people. It is rather to find a way of studying the conditions and mechanisms under which the relations that define both our society and our knowledge of that society are susceptible to partial reconstruction.

To do this we have to move constantly between the technical and the social. We also have to move between the inside and the outside of technical objects. If we do this, two vital questions start to come into focus. The first has to do with the extent to which the composition of a technical object constrains actants in the way they relate both to the object and to one another. The second concerns the character of these actants and their links, the extent to which they are able to reshape the object, and the various ways in which the object may be used. Once considered in this way, the boundary between the inside and the outside of an object comes to be seen as a *consequence* of such interaction rather than something that determines it. The boundary is turned into a line of demarcation traced, within a geography of delegation,⁴ between what is assumed by the technical object and the competences of other actants.

However, the description of these elementary mechanisms of adjustment poses two problems, one of method and the other of vocabulary. The difficulty with vocabulary is the need to avoid terms that *assume* a distinction between the technical and the social. Because the links that concern us are necessarily *both* technical and social, I develop and use a vocabulary drawn from semiotics that is intended

to avoid this difficulty.⁵ The methodological problem is that if we want to describe the elementary mechanisms of adjustment, we have to find circumstances in which the inside and the outside of objects are not well matched. We need to find disagreement, negotiation, and the potential for breakdown.

There are several areas—for instance, in technological innovation and technology transfer—where objects and their supposed functions, or the relationship between supply and demand, are poorly matched. In what follows I describe a number of cases of “technology transfer” to less-developed countries (LDCs) that are drawn from my own fieldwork. These range from the simple transplantation of a piece of technical apparatus widely used in industrial societies to the development of objects specifically intended for use in LDCs.⁶ In each case I describe the elementary mechanisms of reciprocal adjustment between the technical object and its environment.

I start by considering the way in which technical objects define actants and the relationships between actants. I show that the ease with which the actants assumed in the design of the object are related to those that exist in practice is partly a function of decisions made by designers. The obduracy or plasticity of objects, something that is established in the confrontation with users, is a function of the distribution of competences assumed when an object is conceived and designed.

In the second part of the chapter I consider the way in which technical objects distribute causes. If most of the choices made by designers take the form of decisions about what should be delegated to whom or what, this means that technical objects contain and produce a specific geography of responsibilities, or more generally, of causes. To be sure this geography is open to question and may be resisted. Nevertheless, it suggests that new technologies may not only lead to new arrangements of people and things. They may, in addition, generate and “naturalize” new forms and orders of causality and, indeed, new forms of knowledge about the world. I will consider this process and illustrate the way in which technologies may generate both forms of knowledge and moral judgments.

Subjects and Objects in the Making

From Script to De-Scripton

For some time sociologists of technology have argued that when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into

which the object is to be inserted.⁷ Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of “*inscribing*” this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a “script” or a “scenario.”

The technical realization of the innovator’s beliefs about the relationships between an object and its surrounding actors is thus an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it. To be sure, it may be that no actors will come forward to play the roles envisaged by the designer. Or users may define quite different roles of their own. If this happens, the objects remain a chimera, for it is in the confrontation between technical objects and their users that the latter are rendered real or unreal.

Thus, like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act. Sigaut (1984) gives examples of tools whose form suggests a precise description (*à la* Sherlock Holmes) of their users. The two-handled Angolan hoe is made for women carrying children on their backs. The laborer’s stake, with its single point, can only be driven in by two people, and thus presupposes a collective user. However, once one moves away from such simple examples, it becomes more difficult to uncover the links between technical choices, users’ representations, and the actual uses of technologies. Thus the method of content analysis, as applied to texts, adopts an individual and psychological approach that has little or no relevance to our problem. Indeed, because it ignores the wide range of uses to which objects may be put, it comes close to technological determinism. It is obvious that it cannot possibly explain the wide variety of fates experienced by technological projects—fates that range from complete success to total failure.

One way of approaching the problem is to follow the negotiations between the innovator and potential users and to study the way in which the results of such negotiations are translated into technological form. Indeed, this method has been widely used in sociological and historical studies of technology. Thus, if we are interested in technical objects and not in chimerae, we cannot be satisfied methodologically with the designer’s or user’s point of view alone. Instead we have to go back and forth continually between the designer and

the user, between the designer's projected user and the real user, between *the world inscribed in the object* and *the world described by its displacement*. For it is in this incessant variation that we obtain access to the crucial relationships: the user's reactions that give body to the designer's project, and the way in which the user's real environment is in part specified by the introduction of a new piece of equipment. The notion of *de-description* proposed here has to be developed within this framework. It is the inventory and analysis of the mechanisms that allow the relation between a form and a meaning constituted by and constitutive of the technical object to come into being. These mechanisms of adjustment (or failure to adjust) between the user, as imagined by the designer, and the real user become particularly clear when they work by exclusion, whether or not this exclusion is deliberate.⁸ The case of the photoelectric lighting kit is an example in which exclusion was explicitly sought by no one.

The Photoelectric Lighting Kit: Or How to Produce a Non-User

The photoelectric lighting kit was born from the wish of a government agency to promote new energy sources. As part of its cooperative international activities, the agency wanted to work on and meet the need for lighting—something that well-intentioned informants said was essential for all LDCs. At the same time it wanted to help the French photoelectric cell industry to create a market.

Caught up, as they were, in a specific network involving state support with industry, those involved in its design conceived of the kit as a function of the specific needs and constraints imposed on them by this network. At no point, for instance, did commercial considerations come into play. Accordingly, the shape of the lighting kit can be treated as a description of the way in which this network operated—a network characterized by the circulation of certain types of resources and the exclusion of other actors. The “narrative” patterns and scripts dreamed up by those who conceived the kits were quite specific, a function of their position. Study of the lighting kit (or any other technical object) makes it possible for us to create the “sociology” of the network defined by its circulation.

When I first heard the industrialists and designers talking about the lighting kit, it appeared to be a very simple array with three functional elements. There was a panel for producing electricity, a storage battery, and a lamp that consumed the electricity. However, once I arrived in Africa and started to study the ways in which such kits were actually used, the picture rapidly became more compli-

cated. Those who were responsible for installing and maintaining kits were confronted with considerable difficulties. The first of these was that the wires linking the different components—the panel, the batteries, and the fluorescent tubes—were fixed in length and could not easily be altered because the connections were made with non-standard plugs. This meant that it was difficult to adapt the kits to fit rooms of different sizes. Replacing components with short lifetimes, such as lamps or batteries, represented a second set of difficulties. Neither appropriate fluorescent tubes, nor the watertight batteries chosen to ensure that maintenance problems would not limit the life of the system, were available in markets outside the capital. Local sources of supply were thus of no help to the user. As a result, despite the fact that it was a major element in his or her technical environment, the user lost control over the installation. Suddenly, what had previously been familiar started to become strange (the first question users asked was often “When do I have to add water to the batteries?”). A third factor also worked to prevent the user from appropriating the installation. This was the fact that the contractor who installed the kit forbade him or her to turn to a local electrician in case of breakdown. Instead, the contractor said that he would come to the area twice a year to repair faulty installations. The reason for this embargo on local repairs was the sensitivity of the photoelectric panel. This, as the instructions put it, “converts solar energy directly into electrical energy.” However, the fact that this took the form of direct current with non-equivalent poles meant, at least in the view of the contractor, that it would be risky to call in a local electrician who would have experience of alternating but not of direct current. The danger was that if equipment was connected the wrong way, it might be damaged.

The discovery of these difficulties illustrates an important point of method. Before leaving Paris for Africa, the potential significance of nonstandard plugs, direct current, or waterproof batteries had not occurred to me. It was only in the confrontation between the real user and the projected user that the importance of such items as the plugs for the difference between the two came to light.⁹ The materialization and implementation of this technical object, like others, was a long process in which both technical and social elements were simultaneously brought into being—a process that moved far beyond the frontiers of the laboratory or the workshop.

The fact that the importance of these characteristics only became evident in the interaction between designers and users was not the

result of chance or negligence. Each decision actually taken made sense in terms of design criteria. Direct current is cheaper than alternating current because a transformer consumes a good part of the available power. Watertight batteries and nonstandard connections were chosen to prevent people from interfering with and so potentially damaging the kit. The length of the wiring had to be limited or it would reduce the performance of the equipment. These decisions were intended to ensure that the lighting kit would “work” under all circumstances—an important consideration in the negotiations between the industrialists and their clients. It should be recalled that it was not the latter who were the ultimate users of the kit, but rather the donating agency and the government to which the gift was to be made. Indeed, such was the concern to produce a foolproof kit that the designers decided not to have a separate switch in the circuit because this might become a point of illicit entry into the system. This meant that users often found it difficult to turn the light on or off because the only switch available was attached directly to the light and so was normally out of reach.

So it was that the technical object defined the actors with which it was to interact. The lighting kit (and behind it the designers) worked by a process of elimination. It would tolerate only a docile user and excluded other actors such as technicians or businesspeople who might normally have been expected to contribute to the creation of a technico-economic network. Had the users really been as docile as the designer intended, I would not have seen that the kit represented a large set of *technically delegated prescriptions* addressed by the innovator to the user.

If we are to describe technical objects, we need mediators to create the links between technical content and user. In the case of non-stabilized technologies these may be either the innovator or the user. The situation is quite different when we are confronted with stabilized technologies that have been “black boxed.” Here the innovator is no longer present, and study of the ordinary user is not very useful because he or she has already taken on board the prescriptions implied in interaction with the machine. Under such circumstances some prescriptions may be found in user’s manuals or in contracts. Alternatively, we may study disputes, look at what happens when devices go wrong, or follow the device as it moves into countries that are culturally or historically distant from its place of origin. In the next section I adopt the last of these methods to describe the use of generators in Senegal.

De-Description in Technological Transfer: Reinventing and Reshaping Technical Objects in Use

In rural Senegal generators are widely used by “festive groups.” An administration buys some small generators, which it distributes to youth groups in the villages. With the generators may come lights, a record player, or a loudspeaker. The youth groups use the generators or lend them to their members who pay for the cost of fuel and oil. Again, they may rent them out to other villagers who are also responsible for the cost of fuel and oil. The money that is made by the rental of generators is shared, with part going to the person who transports the generator and part going to the association. In this way a small collection of actors is involved with the generator—actors that can be seen as so many additions to the components that make up the generator.

The generator’s metal trailer means that it is mobile, and so it plays an important part in this process. This is because the field of possible users and the relations between the different actors is defined by the movement of the generator. However, the fuel tank rivals the generator for the starring role because it draws a fundamental distinction between capital costs and operating costs. This distinction is inscribed from the outset in the social setup that brings the generator to the village: there is the administration, which underwrites the investment, and there is the group that actually manages and runs the generator. The technical device reduces negotiations between the two parties to a minimum because it directly suggests a pre-negotiated agreement. Obviously things could be arranged differently. This, however, would mean delegating a whole series of tasks to additional (legal, human, and technical) structures external to the generator and its trailer. It might even entail new systems of measurement—in which case it is not clear whether we would still be dealing with the same object.

The situation would be quite different if we were faced with a device whose costs were concentrated exclusively on the side of investment—as, for instance, with the photoelectric kits. What kind of relationship can there be between the buyer and the user under such circumstances? This was a question faced by those promoting the development of photoelectric cells in French Polynesia. Once these cells had been distributed, it was not always possible to insist that these two classes of costs should be distinguished. Not only did the technology itself fail to discriminate between them, but it offered no method of measurement that could be translated into appropriate socioeconomic terms. Thus no matter how it is used, a photoelectric

panel generates current as a function of climate and latitude. The “standard” relationship between production and consumption (a reflection of the interdependence of two groups of actors) is replaced by an individual, direct, and indeed arbitrary submission to natural forces.

The difference between this and the generator is obvious. In the case of the generator, the fuel tank can be used to measure the relationship between its use and the cost of that use—a relationship embodied in the motor as a whole. The creation of a particular kind of social link, that of renting out, is conditioned by the existence of this relationship, which delocalizes the generator by creating many groups of actors: investors/purchasers, owners/users, associate users, renters, and transporters. The existence of transporters makes the property even “purer,” for they free it from servitude. Their payment marks the boundary of group solidarity, for the work of a single person cannot enrich the community. At the same time the generator builds a space and a social geography. Thus the teachers in one of the villages who needed lighting for their evening classes did not even consider renting a generator. The division between the world of the “market” and the “civic”¹⁰ world may not have been brought into being in the village by the social differentiation entailed in electricity and its uses, but it was certainly modified by the latter.

The lighting kit put itself forward as a “hypothetical” object, whereas the generator was just another piece of equipment integrated into the various sectors of economic life. However, we should not overstate the difference between them. This is best seen in terms of differential resistance. It would take much more effort to (re)dismantle the generator than it would the lighting kit. But in both cases we are dealing with the creation and extension of networks that simultaneously define both the social and the technical. Thus such items as nonstandard plugs and fuses become significant when the real users start to displace projected users. Again, the competence of the youth group, its relations with other elements of village life, the very definition of these elements—all of these are determined at the same time as, and by the same process, that defines the components that make up the generator. If we were to restrict our attention to the “function” fulfilled by this piece of equipment within the youth group, we might imagine that some other technical system (for instance, solar panels or connection to the national grid) would function in the same way. This, however, is not the case, for under such circumstances the relationship between the youth group and others in the village would be different and probably more

fluid. In this sense, then, we can say that our relationships with the “real world” are mediated by technical objects.

Prescriptions as a Way of Enrolling Actors: Or How to Make Citizens

So far I have described technologies that appear to exercise relatively weak constraints over those who use them. If the generator and those who sponsor it nudge some who would otherwise be outside economic relations in the direction of involvement, then this effect is relatively small. In the case of the photoelectric lighting kit, the main danger is that no one will use it at all. However, technologies are not always like this. Sometimes their designers and builders use them to obtain access to certain actors, whom they push into specific roles. This is what happened in the case of the Ivory Coast and its electricity network. Here the physical extension of the network was an integral part of a vast effort to reorganize the country spatially, architecturally, and legally. The object was to create such new and “modern” entities as the individual citizen.

Winner (1980) has argued that certain technologies are inherently political—for instance, nondemocratic. If he is right about this, then the approach I have adopted here would lead to a form of technological determinism. However, the case of electrification in the Ivory Coast shows that even in those cases where there are marked political implications, it is first necessary to interest and persuade the actors to play the roles proposed for them.

Until recently village property in the Ivory Coast was collectively owned and under the control of elders, who allocated tracts of land to villagers as a function of their needs. This allocation was not permanent, and people might move to different areas. When the authorities started to think about electrification, they decided that this should be contingent on a more stable allocation of land, and in particular on a distinction between private and public property. Those developing the new electricity network (who also presented themselves as spokespersons for the general interest) assumed that the network would both contribute to this division and depend on it, as it would be installed on public land. In other words, the electricity network made it possible for the state to create its own space (the space of common interests) that could not be appropriated by anyone else. At the same time, it defined those with whom it would interact. Because only the individual would legally exist in this new system, former collective modes of village representation were thus systematically excluded.

To be sure, the creation of a system that allocated land permanently either to individuals or the state was a function of agreement in the village as a whole about the need for such stability. Through the new property system the electricity company was thus asking the villagers to make a *pre-inscription* witnessing their consent to a certain kind of future. Thus, individual villagers had to undertake certain formalities to secure title to fixed property. From the standpoint of the electricity company, legal ownership could be treated as a token for a range of agreements between different bodies about the future of the village. The new system of property was also the foundation for a series of projects by other utilities (the highway department, the water authority, the medical service, the education system). It meant that electrification could be integrated into various modernization programs, and it established economical procedures for consultation and political negotiation. Finally, the construction of the network itself would put the agreement of the village into practice and stabilize it by making a durable inscription on the landscape.

But why should the villagers agree to enter into a game in which they would, or so it seems, lose a part of their independence? After all, by so doing they would place themselves under the influence of a central authority that would, by virtue of this very fact, increase its power. There are several answers to this question. The villagers wanted to have access to electricity. But there was the question of the way in which the company negotiated with the village. Indeed, to put it in this way is misleading. The company did not negotiate directly with the village. Rather, it negotiated with a spokesperson— invariably someone who had “succeeded” and moved from the village to the capital. Both this spokesperson, who negotiated with a range of central authorities on behalf of the village, and the villagers themselves knew that a series of indirect benefits would follow from agreement with the electricity company. After electrification the village could hope for better teachers, an improved health service, more financial support, and an increase in the number of development projects. In short, electrification was a method for avoiding direct and specific negotiations between the villagers and a series of external agencies. It was a package whose terms were fixed in advance. Those in the village had a choice. They could accept those terms or they could reject them, and overall the package was attractive.

In general an individual becomes a citizen only when he or she enters into a relationship with the state. In the Ivory Coast this was effected through the intermediary of cables, pylons, transformers,

and meters. By contrast, in France individuals are inserted into such a wide range of networks that they have little chance of avoiding citizenship. From the registry office, via obligatory schooling to military service and the welfare state, the mesh of the state with its different superimposed networks draws ever tighter around them. In countries that have been created more recently, specific networks may come to the aid of a weak or non-existent state. The electricity network may create and maintain a relationship between an individual and a place. Thus in the Ivory Coast, where only a minority of salaried workers paid income tax, the electricity bill became the means by which local taxes were collected in recently built towns. Here, then, it was the electricity network that fostered a wider definition of the concept of citizenship.

From Causes to Accusations and Forms of Knowledge

In the examples above I have shown how technical objects define actors, the space in which they move, and ways in which they interact. Competences in the broadest sense of the term are distributed in the script of the technical object. Thus many of the choices made by designers can be seen as decisions about what should be *delegated* to a machine and what should be left to the initiative of human actors. In this way the designer expresses the scenario of the device in question—the script out of which the future history of the object will develop. But the designer not only fixes the distribution of actors, he or she also provides a “key” that can be used to interpret all subsequent events. Obviously, this key can be called into question—consumer organizations specialize in such skepticism. Nevertheless, although users add their own interpretations, so long as the circumstances in which the device is used do not diverge too radically from those predicted by the designer, it is likely that the script will become a major element for interpreting interaction between the object and its users.

Abobo-the-War and Marcory-No-Wire: Where Technology Meets Morality

In this section I focus on one particular process—moral delegation—and discuss devices installed by designers to control the moral behavior of their users. I describe the way in which such devices may measure behavior, place it in a hierarchy, control it, express the fact of submission, and distribute causal stories and sanctions.

As I have indicated, the introduction of the electricity network has established links between individuals in the Ivory Coast. The way in which the individual/consumer relates to the network, and via the network to the electricity company, is codified and quantified by means of a basic technical tool, the electricity meter. This formulates the initial contract between the producer and the consumer. If one or the other fails to meet its obligations, the meter becomes invalid or inactive. Meters have a symmetrical effect on the producer/consumer relationship. The agreement of both is required if they are to tick over. Accordingly, the *set* of meters is a powerful instrument of control. Taken together, the set of meters measures the cohesion of the sociotechnical edifice materialized by the network. Consider the following story, which appeared in *The Kanian*, the electricity company newspaper, in its February–May 1985 issue:

OPERATION STRIKEFORCE AT “ABOBO-THE-WAR”

There is a flashing red light in the DR in Abobo, a lower class suburb of Abidjan, where there are 66,854 subscribers; the network’s rate of return (the relationship between the energy put out by the producer and the energy billed to the clientele) has fallen from 0.93 to 0.87 in the space of one year!

Any reduction in the rate of return can be interpreted as an increase in the number of illicit connections, the work of corrupt employees, or a consequence of trafficking in meters. With both human and technical actors involved, the network measures illicit behavior and determines its character.

The definition of social space also extends to non-electrified areas. These are characterized in terms of their degree of deviance from the norm—that is, from electrification. Thus another suburb of Abidjan, Marcory, was split into two by the network. Each was given a name, and characterized in social terms:

Unlike residential Marcory, Marcory-No-Wire is a Marcory without electricity, without wires. It is well known that Abidjanis have a sense of humour. A suburb with no wires, imagine what kind of a spectacle that offers. For if electricity is a sign of progress, its absence suggests other absences: of hygiene in the streets, of buildings constructed to certain standards, of pharmacists, playgrounds, sportsgrounds and so on. When you add darkness at night to these absences, then the guardians of the peace would say you get a criminal haunt. (Toure 1985)

Even so, the dividing line between the permissible and the impermissible is negotiable. Thus in their strike-force operations, elec-

tricity company agents were told to replace so-called Russian meters that had proved defective without penalizing their owners, even though a simple tap on the meter would block it and allow unbilled electricity to be consumed. Unlike the agents, the “Russian” meters found it impossible to distinguish between licit and illicit behavior, between the actions of humans and nonhumans. Accordingly, although the contract between supplier and consumer remained in force, the meter failed in its prescribed role as the material inscription of that contract.

Each *individual* meter intervened as referee and manager of the relationship between supplier and consumer. Taken together, the *set* of meters operated as police in a collective organization, uncovering irregularities. Such irregularities appeared first as deviations in consumption curves that were neither localized nor sanctioned. They could, however, be quickly translated into “social” terms.

Some techniques move closer to “social control.” They establish norms and punish those who transgress them. Thus the storage and regulation systems in photoelectric kits take the form of batteries and electronic components. The batteries store the electricity so that it can be given out, for example, for lighting when it is dark. However, the control system lies at the heart of a technical, economic, and social imbroglio. If the battery is allowed to run too low, its lifetime will be reduced. On the other hand, if it is overcharged, electricity may leak back into it and ruin the photoelectric cell. Users might, of course, be given meters with which they could plan their electricity consumption while avoiding both of these dangers. In fact this solution is never adopted because the designers do not believe that users will allow the technical requirements of the system to overrule their immediate wishes. Again, the designers could choose to increase the capacity of the system to cope with the likely demands of the users. This, however, is a costly option. Accordingly, the designers adopt the third option of installing a regulator that cuts off the current to the user when the charge on the battery gets too low, and isolates the photoelectric panel when it gets too high.¹¹ As a result, a particular mode of consumption is imposed: the user cannot be too greedy, yet neither can he or she hope to compensate for excess consumption by prolonged abstinence. The penalty for breaking the rules—rules that are both social and technical—is immediate and abrupt: the current is cut off and is not reconnected until the battery is adequately recharged.

This method of regulation is designed to “groom” the user. It offers a set of rewards and punishments that is intended to teach

proper rules of conduct. However, a flaw in the system is that there is no easy way to measure the charge in the battery. Voltage is only a rough indication. What should be done about this? A general who is not sure of the loyalty of his troops has two options. He may choose to do nothing. Or, like the designers in this case, he may redouble his precautions and disciplinary measures. Accordingly, as I have mentioned, a particularly inflexible system with nonstandard plugs was adopted. Thus while the control device was telling the user not to get too big for his or her boots, the nonstandard plugs were imposing even more draconian limitations on conduct. No bypass of the control device was permissible!

Even so, in French Polynesia the control device proved to be a shaky ally for the designers, because the users felt that its sanctions were arbitrary. The result was that they denounced it and expressed their displeasure by telephoning the electrician every time the system treacherously cut off the current while they were quietly sitting watching television. The electrician, who quickly became tired of doing repairs in the evening, tricked the system by installing a fused circuit in parallel with the control device. When the control device shut off the current, users could bypass it with the fuse, and the electrician would only be called out the following morning. The fused circuit thus marked the submission of electricians to the wishes of their clients and allowed them to be present by proxy instead of being summoned in person by irate users.

The precarious and makeshift character of the fuse makes it plain that some kind of intervention was necessary, even if it only took place after the event. In this particular trial it was the electricians who pleaded guilty. In fitting the fuse, they recognized that the control device and their clients were *both* right and moderated the judgments of the former in favor of the latter.

“The Order of Things and Human Nature”:

The Stabilization and Naturalization of Scripts

I have described several cases in which technical objects preformed their relationships with actors and vested them with what could be called “moral” content. Because roles and responsibilities are allocated, accusations and trials tend to follow. In principle, no one and nothing is protected from such denunciation. In the case of the electricity network, the users were accused of failing to respect the contract with the meter. However, the electricity company also accused some of the meters of failing to represent that contract. In the case of the photoelectric kits, it was the electricians, and

indirectly the manufacturers, who found themselves in the dock through the agency of the control device. Indeed, the story of the kits can be read as a long series of reciprocal accusations. The industrialists tended to argue that if it didn't work (technically), this was because it had been misused (socially). The users, or those who claimed to be their representatives, argued that if it didn't work socially, this was because it had been misconceived *technically*. Here, then, we see an almost perfect "reversible reaction" that reveals the lack of a relationship, through the kit, between designers and users. The users did not interest the manufacturers; they were only important to the extent that they made it possible to go to the ministry of overseas development and seek support for a product that did not yet have a market. And in this interaction the kit did not actually have to do anything. Rather it was the *users* who were treated as an instrument for building a relationship between the manufacturers and the government.

In the case of the electricity network, the situation was quite different. It is difficult to imagine a plausible argument for illegal connection to the network—one in which the electricity network would stand in the dock. This is because the network configured a whole range of relationships. I have already mentioned the meter and the way in which it was related to the allocation of property. But relationships were structured by the network in many other ways. For example, it also tended to stabilize living space. This was because, for reasons of security and as a guarantee of solvency, only "permanent" structures were connected to the grid. And of course, once the grid was in place, new commercial networks for distributing electrical equipment quickly sprang up. Thus once it was established, the network tended to promote both physical and social stability. A wide range of elements were brought together and given substance. A small fringe group of "deviants" could not possibly hope to find the strength needed to outweigh the many actors bound together by the grid. Accordingly, the electricity company could call upon the meters to act as unequivocal spokespeople at will. A double irreversibility had been established—a material irreversibility inscribed in space and practice, and a directional irreversibility where accusations and charges could no longer be reversed. Obviously the two were intimately linked.

In this section I have argued that technical objects not only define actors and the relationships between them, but to continue functioning must stabilize and channel these. They must establish systems of causality that draw on mechanisms for the abstraction and simplifi-

cation of causal pathways. In the case discussed above, the replacement of the "Russian" meters was very much part of this process—a process designed to make diagnosis automatic. Farther along the same path lies artificial intelligence.¹²

Conclusion: Toward the Constitution of Knowledge

Once technical objects are stabilized, they become instruments of knowledge.¹³ Thus when an electricity company sets differential tariffs for high- and low-consuming domestic users, for workshops, and for industrial consumers, it finds ways of characterizing and identifying different social strata. If it also chooses categories used in other socioeconomic-political network, then the knowledge it produces can be "exported." "Data" can thus be drawn from the network and transmitted elsewhere, for instance, to economists concerned with the relationship between the cost of energy or GNP and consumption. However, the conversion of sociotechnical facts into facts pure and simple depends on the ability to turn technical objects into black boxes. In other words, as they become indispensable, objects also have to efface themselves. I will illustrate this with an example drawn from Burkino-Faso.

Burkino-Faso is a developing country with a tiny electricity network. Over the past few years it has been government policy to electrify urban centers. The first problem for the engineers and technicians was to judge potential demand and decide how large the network should be. Two different approaches were adopted. The economic studies unit asked potential subscribers what price they would be willing to pay for electricity. This approach assumed that there was a relationship between supply and demand, and that consumption would vary inversely with price. The technical unit adopted a very different method. It drew maps of the towns, marked off the built-up areas, and noted the characteristics of the houses (whether large or small, permanent or temporary, and so on). On the basis of this map they designed a network that would be legally, economically, and technically feasible—a network that would make use of public space and serve only permanent buildings and government facilities.

The results obtained by the two approaches were quite different. In particular, the geographical and legal approach of the technical unit suggested the need for a far larger network than the market-led approach of the economic studies unit. The latter had acted as if

there were no need for technical mediation between price and consumption. They assumed, that is, that this relationship was a fact of nature that would be given concrete form by the electricity network. In a sense they were led astray by the naturalization effect, which occurs when technical systems are completely integrated into the social fabric. It is only when the script set out by the designer is acted out—whether in conformity with the intentions of the designer or not—that an integrated network of technical objects and (human and nonhuman) actors is stabilized. And it is only at this point that this network can be characterized by the circulation of a finite number of elements—objects, physical components, or monetary tokens. Disciplines such as economics and technology studies depend on the presence of a self-effacing apparatus that lies outside their domains. Economists extract one kind of information from technical objects, technologists another. They are able to do this because such objects function in stable situations. The introduction of a new device can thus be assimilated, for example by economists, into the price/consumption relationship. The economy is not cut off from technology; there is no radical disjunction.

This is why it makes sense to say that technical objects have political strength. They may change social relations, but they also stabilize, naturalize, depoliticize, and translate these into other media. After the event, the processes involved in building up technical objects are concealed. The causal links they established are naturalized. There was, or so it seems, never any possibility that it could have been otherwise.¹⁴

We are ourselves no more innocent in this respect than anyone else. For we are able to say that technical objects changed, stabilized, naturalized, or depoliticized social relations only with the benefit of hindsight. The burden of this essay is that technical objects and people are brought into being in a process of reciprocal definition in which objects are defined by subjects and subjects by objects. It is only after the event that causes are stabilized. And it is only after the event that we are able to say that objects do this, while human beings do that. It is in this sense, and only in this sense, that technical objects build our history for us and “impose” certain frameworks. And it is for this reason that an anthropology of technology is both possible and necessary.

Notes

I would like to thank Geoffrey Bowker, who translated this text, John Law, who carefully reviewed the entire text, and Bruno Latour, who helped me arrive at the

more conceptualized form of the conclusions I drew from the various field studies discussed here.

1. Doubtless it could be satisfying to paint on a broad canvas, starting with nuts and bolts, pistons and cracks, cogs and fan belts, and moving on to voting systems, the strategies of large industrial groups, the definition of the family, and the physics of solids. In the case of such an inquiry we would no doubt find a mass of guides (people, texts, objects) ready to suggest ways in which we could extend our network. But such suggestions would be endless. On what grounds would the analyst stop—apart from the arbitrary one of lassitude? Quite apart from the indefinite amount of time such a study would take, there is also the question as to whether it would be interesting.

2. Here we are concerned with what might be called the consensual zone of the automobile, which is defined simultaneously by the major technical elements common to most vehicles and by their generally recognized uses. As is obvious, there are highly controversial zones around the margins, and it is around these points of friction that the battles leading to the establishment of supremacy of such and such a manufacturer or such and such a car are waged.

3. This term is used only as a convenient but imprecise shorthand. Depending on circumstances, the actor (a more general term to be preferred) may be a citizen, a member of a particular social class, a member of a profession, or even a finger or a body with a particular temperature as measured by a system of detection.

4. See Bruno Latour's text (this volume) for further discussion of delegation.

5. This vocabulary is further discussed in Latour's text in this volume and in the joint appendix to our papers.

6. I am aware that the reader may be frustrated by the way in which these examples are used. Within a short article it is not possible to give full details. But as they are intended to exemplify an argument, I hope that the reader will agree that the benefit of using them in this way outweighs the costs.

7. For a striking example of the interrelationship between the definition of technical parameters and the definition of a "world" for which the object is destined, see Callon's article on the electric vehicle in Bijker, Hughes, and Pinch 1987.

8. See, for example, Winner 1980 and Latour 1988a. Winner describes how the height of overpasses on the Long Island Parkway was chosen to prevent the passage of buses, the mode of transport most used by blacks, so that the use of leisure zones was effectively limited to whites. Latour, reinterpreting the example described by Daumas (1977), tells how, in exactly the same way, the radical Paris city council at the end of the nineteenth century decided to build metro tunnels too narrow for standard railway company trains. The objective, which succeeded for seventy years, was to prevent the private railway companies (supported by the right) from getting their hands on the Paris metro, whatever party happened to be in power. Multiple translations are necessary in order to arrive at such results. In Winner's case we need to move from the white/black to the car/bus distinction, and then on to the height of the overpasses. This is only possible because the black/white distinction is already *pre-inscribed* in unequal access to economic resources and, as a consequence, to expensive products such as cars. In Latour's case it is the width of the tunnels that allows the railway (and so the different companies and political parties) to be kept at arm's length from the metro.

9. In the French there is a play of words on *dessein* (design in the sense of plan) and *dessin* (design in the sense of drawing). The two have the same etymology.

10. I am drawing here on the distinction between “marchand” and “civique” discussed by Boltanski and Thevenot (1987). //

11. Naturally, the different parts of the system are reconnected automatically once conditions change.

12. The question of “breakdown” is relevant to this issue and deserves further consideration. A “breakdown” relates closely to the definition I have offered of a technical object. This is because it can only be understood as a part of practice—that is, as the collapse of the relationship between a piece of apparatus and its use. A breakdown is thus a test of the solidity of the sociotechnical network materialized by a technical object. The rapidity with which the search for the causes of breakdown can be completed is a measure of this solidity.

13. Perhaps it would be better to say that the stabilization of a technical object is inseparable from the constitution of a form of knowledge of greater or lesser significance. This hypothesis is powerfully supported by the case described by Misa (this volume): there an industry, a market, and the notion about what was to count as “steel” were all constructed simultaneously.

14. As is well known, Foucault (1975) has described the links between the technology of the penitentiary, power relations, and new forms of knowledge.

Algorithms as culture: Some tactics for the ethnography of algorithmic systems

Big Data & Society
July–December 2017: 1–12
© The Author(s) 2017
DOI: 10.1177/2053951717738104
journals.sagepub.com/home/bds



Nick Seaver

Abstract

This article responds to recent debates in critical algorithm studies about the significance of the term “algorithm.” Where some have suggested that critical scholars should align their use of the term with its common definition in professional computer science, I argue that we should instead approach algorithms as “multiples”—unstable objects that are enacted through the varied practices that people use to engage with them, including the practices of “outsider” researchers. This approach builds on the work of Laura Devendorf, Elizabeth Goodman, and Annemarie Mol. Different ways of enacting algorithms foreground certain issues while occluding others: computer scientists enact algorithms as conceptual objects indifferent to implementation details, while calls for accountability enact algorithms as closed boxes to be opened. I propose that critical researchers might seek to enact algorithms ethnographically, seeing them as heterogeneous and diffuse sociotechnical systems, rather than rigidly constrained and procedural formulas. To do so, I suggest thinking of algorithms not “in” culture, as the event occasioning this essay was titled, but “as” culture: part of broad patterns of meaning and practice that can be engaged with empirically. I offer a set of practical tactics for the ethnographic enactment of algorithmic systems, which do not depend on pinning down a singular “algorithm” or achieving “access,” but which rather work from the partial and mobile position of an outsider.

Keywords

Algorithms, ethnography, multiplicity, tactics, methodology

This article is a part of special theme on Algorithms in Culture. To see a full list of all articles in this special theme, please click here: <http://journals.sagepub.com/page/bds/collections/algorithms-in-culture>.

Terminological anxiety

At a conference on the social study of algorithms in 2013, a senior scholar stepped up to the audience microphone: “With all this talk about algorithms,” he said, “I haven’t heard anybody talk about an *actual* algorithm. Bubble sort, anyone?”¹ Over two days, speakers had covered algorithmic topics from Google’s autocomplete feature to credit scoring, but the questioner was right: they had not examined anything like bubble sort, a simple algorithm for ordering a list. Bubble sort, the questioner implied, was an *actual* algorithm; autocomplete was something else.

The conference, *Governing Algorithms*, hosted at New York University, was an early moment in the growing transdisciplinary field of critical algorithm studies—broadly speaking, the application of humanistic and

social scientific approaches to algorithms.² But already, one of the field’s central tensions was evident: Did these humanists and social scientists, taking on objects that had, until recently, been the domain of computer scientists, know what they were talking about?

As “algorithm” drifted out of computer science and into popular and critical academic discourse, it seemed to signify a renewed concern for technical specificity. Where “Big Data” was vague—originating in an overheated marketing discourse—algorithms were precise. They were the core stuff of computer science,

Tufts University, USA

Corresponding author:

Nick Seaver, Tufts University, Medford, MA 02155, USA.
Email: nick.seaver@tufts.edu



definitionally straightforward and, for many humanists, as distilled a case of rationalizing, quantifying, procedural logics as it was possible to find (see, e.g., Totaro and Ninno, 2014). The work to be done was clear: apply classic critiques of rationality, quantification, and procedure to these new objects and hit “publish.”

Yet, just as critical scholars picked them up, algorithms seemed to break apart. They had become, in the words of *Governing Algorithms*’ organizers, “somewhat of a modern myth” (Barocas et al., 2013: 1), attributed with great significance and power, but with ill-defined properties. Where an algorithm like bubble sort was so simple it could be described in a sentence,³ the charismatic mega-algorithms that had caught scholars’ attention—Google’s search, Facebook’s newsfeed, New York City’s predictive policing system, Netflix’s recommender, and so on—were more complicated and harder to specify. Although these systems were called “algorithms” by the public, academics, and even by their makers, the distance between them and their Computer Science 101 counterparts was unsettling. Maybe, in our inexpert enthusiasm, critical algorithm studies scholars had made a mistake. Maybe we don’t understand what algorithms are, after all.

I take terminological anxiety to be one of critical algorithm studies’ defining features. But this is not because, as disciplinary outsiders, we are technically inept. Rather, it is because terminological anxieties are first and foremost anxieties about the boundaries of disciplinary jurisdiction, and critical algorithm studies is, essentially, founded in a disciplinary transgression. The boundaries of expert communities are maintained by governing the circulation and proper usage of professional argot, demarcating those who have the right to speak from those who do not (Fuller, 1991; Gal and Irvine, 1995; Gieryn, 1983), and algorithms are no different. Our worry about what “algorithm” means has more to do with our positions vis-a-vis other groups of experts than it has to do with our ability to correctly match terms and referents.

Rather than offering a “correct” definition, this article advances an approach to algorithms informed by their empirical profusion and practical existence in the wild—always at the boundaries of diverse communities of practice. It looks to anthropology for inspiration, both because my own training is anthropological and because anthropology proves useful for thinking through encounters between disparate knowledge traditions. It outlines an ethnographic approach to algorithms because ethnographic methods are well suited to the concerns that tend to occupy critical scholars—particularly concerns about how formalisms relate to culture. Ethnography roots these concerns in empirical soil, resisting arguments that threaten to wash away ordinary experience in a flood of abstraction.

Rather than entering the field with a definition in hand, I propose using fieldwork to discover what algorithms are, in practice. After exploring two competing visions of what an anthropology of algorithms might entail, I offer a set of practical tactics for the ethnography of algorithmic systems, derived from my own ethnographic experience.

Anthropology I: Algorithms in culture

A straightforward solution to our definitional crisis would be to take some expert definition as decisive: let computer scientists define “algorithms” and then examine how those things interact with our own areas of expertise. Like many straightforward solutions, this one has complications. As Paul Dourish has noted, “the limits of the term algorithm are determined by social engagements rather than by technological or material constraints” (2016: 3). That is to say, different people, in different historical moments and social situations have defined algorithms, and their salient qualities, differently. A data scientist working at Facebook in 2017, a university mathematician working on a proof in 1940, and a doctor establishing treatment procedures in 1995 may all claim, correctly, to be working on “algorithms,” but this does not mean they are talking about the same thing. An uncritical reliance on experts takes their coherence for granted and runs the risk of obscuring a key interest of critical scholars: what happens at the edges of knowledge regimes.

Given this instability and diversity, Dourish advances an anthropological case for taking on a “proper” expert definition of algorithms: we should do it not because this definition offers “a foundational truth of the nature of algorithms as natural occurrences,” but because it is what engineers do (2016: 2). In anthropological parlance, “algorithm” is an *emic* term, an actor’s term, part of the linguistic architecture through which software engineers make sense of the world and their work. Moreover, taking on such a definition facilitates critical algorithm scholars’ political projects: “Critiques of algorithmic reasoning that set their own terms of reference for key terminology,” he writes, “are unlikely to hit home” (Dourish, 2016: 2). If we want to understand engineers and get them to listen to us, then we need to use terms as they do; it is a matter “of ethnographic responsibility and practical politics” (Dourish, 2016: 2).

But what exactly is the emic definition of “algorithm,” and where should we find it? Dourish’s argument hinges on a definition of group boundaries. He writes:

When technical people get together, the person who says, “I do algorithms” is making a different statement

than the person who says, “I study software engineering” or the one who says, “I’m a data scientist” and the nature of these differences matters to any understanding of the relationship between data, algorithms, and society. (Dourish, 2016: 3)

The boundaries of the “algorithm” are social boundaries: between algorithm people and other “technical people,” and between technical people and their non-technical others, who may not understand the definitions in play. Now imagine an ethnographer encountering these technical people; if she did not know what an algorithm was supposed to be, she would have to suss it out from how they speak and act. (“*These* people say ‘algorithm’ whenever they want *those* people to stop talking...”) “*Those* people talk about algorithms like precious intellectual property, while *these* people talk about them like plumbing...” Dourish suggests that, if an ethnographer does this, she will end up where he begins: “In computer science terms, an algorithm is an abstract, formalized description of a computational procedure” (2016: 3).

This is, however, an empirical question: Do the people who “do” algorithms today actually treat them according to this “proper” definition? Ethnography often throws analytic frameworks into disarray, and this proved true in my own fieldwork with US-based developers of algorithmic music recommender systems. After setting out to study engineers specifically, I realized that many more actors shaped the systems these companies built. Eventually, I interviewed half the employees of a recommender company that at the time employed roughly 80 people. These people’s jobs ranged from summer intern to CEO, and from systems engineer to front-end web developer. All of them, whether “technical people” or not, were party to the production of algorithms, but in the office, the “algorithm” seemed to be nowhere in particular.

So I sought it out, asking people to identify the algorithms they worked on. They typically balked at this question, and even people in the most “algorithmic” roles at the company, working on machine learning infrastructure or playlist personalization, located “the algorithm” just outside the scope of their work, somewhere in the company’s code. One, a senior software engineer with a prestigious undergraduate degree in computer science told me that her training on algorithms in theory was irrelevant to her work on algorithms in practice, because algorithms in practice were harder to precisely locate: “It’s very much black magic that goes on in there; even if you code a lot of it up, a lot of that stuff is lost on you.” The “algorithm” here was a collective product, and consequently everyone felt like an outsider to it.

When my interlocutors talked about algorithms, it was usually as part of a popular critical discourse that pitted algorithmic recommendation against human curators, claiming that “algorithms” could not understand music well enough to recommend it (e.g. Titlow, 2013). These engineers, humans within a system described as inhuman, resisted this framing: “algorithms are humans too,” one of my interlocutors put it, drawing the boundary of the algorithm around himself and his co-workers. Sitting in on ordinary practical work—whiteboarding sessions, group troubleshooting, and hackathon coding—I saw “algorithms” mutate, at times encompassing teams of people and their decisions, and at other times referring to emergent, surprisingly mysterious properties of the codebase. Only rarely did “algorithm” refer to a specific technical object like bubble sort. When pressed, many of my interlocutors could recite a proper definition, but these definitions were incidental to the everyday decision making I observed in the field. In practice, “algorithm” had a vague, “non-technical” meaning, indicating various properties of a broader “algorithmic system” (Seaver, 2013), even in nominally “technical” settings.

So, while Dourish’s argument for emic definition is sound, we cannot know those definitions in advance or assume that they will be precise and stable. If we look to the places where algorithms are made, we may not find a singular and correct sense of “algorithm.” Assuming that we will reifies a vision of the algorithm that risks obscuring humanistic concerns and blinding us to diversity in the field. “Technical people” are not the only people involved in producing the sociomaterial tangles we call “algorithms” and in practice, even they do not maintain the definitional hygiene that some critics have demanded of each other. A diverse crowd of people, using a wide array of techniques and understandings, produce the “algorithm” in a loosely coordinated confusion. Neglecting this is especially problematic for the algorithms that the public and most critics focus on: these are distributed, probabilistic, secret, continuously upgraded, and corporately produced.

Moreover, the “correct” definition of algorithms has been used precisely to isolate them from the concerns of social scientists and humanists, and it has been picked up by advocates and critics alike to set algorithmic processes apart from cultural ones. Dourish suggests that clarifying what algorithms are facilitates a discussion of how they interact with what they are not, and he provides a set of algorithmic “others” (things they are often confused with, but properly distinct from). This list makes clear how the proper definition of algorithms serves to distinguish them from typical critical concerns: algorithms are not automation (thus excluding questions of labor), they are not code (thus excluding

questions of texts), they are not architecture (thus excluding questions of infrastructure), and they are not their materializations (thus excluding questions of sociomaterial situatedness) (2016: 3–5). Such a definition carves out a non-social abstract space for algorithms, artificially setting them apart from the various concerns that they tangle with in practice. The technologist who insists that his facial recognition algorithm has no embedded politics and the critic who argues that algorithmic music recommendation is an exogenous threat to culture both rely on an a priori distinction between cultural and technical stuff.

Let's call this the *algorithms in culture* approach. It hinges on the idea that algorithms are discrete objects that may be located within cultural contexts or brought into conversation with cultural concerns. Understood as such, algorithms themselves are *not* culture. They may *shape* culture (by altering the flows of cultural material), and they may be shaped *by* culture (by embodying the biases of their creators), but this relationship is like that between a rock and the stream it is sitting in: the rock is not part of the stream, though the stream may jostle and erode it and the rock may produce ripples and eddies in the stream. In this view, algorithms can affect culture and culture can affect algorithms *because* they are distinct.

Anthropology 2: Algorithms as culture

Something like what has happened to computer scientists and the term “algorithm” happened earlier with anthropologists and “culture”: a term of art for the field drifted out of expert usage, and the experts lost control. Through the 1980s, American anthropologists were becoming generally skeptical of “culture” as an explanatory concept or object of study (Abu-Lughod, 1991). Its implicit holism and homogenizing, essentialist tendencies seemed politically problematic and ill-suited to the conflictual, changing shape of everyday life in anthropological field sites.

But while this skepticism grew, the culture concept gained purchase outside of anthropology: “cultures” were taken to mark diverse, bounded groups with timeless traditions, often synonymous with ethno-national identities; companies that once described their employees as a “family” might now say they had a “culture,” which designated an attitude toward work and, perhaps, what food and games were in the break room (Helmreich, 2001; Strathern, 1995). While anthropologists debated the usefulness or even existence of culture, it became a matter of concern among people with no obligation to anthropological definitions.

As anthropologists increasingly studied people with the power to resist outside explanations (Gusterson, 1996; Nader, 1969), this became a practical problem,

not just an epistemological one. While anthropologists could critique the use of “culture” by fellow fieldworkers, these new users of “culture” were often influential parts of the social scene anthropologists wanted to describe. Groups of people linked by employer or ethnicity might take up “culture” as a project, making their understandings influential, even if anthropologists disagreed with them; vernacular theories of culture could shape social action in their image.

Consequently, many anthropologists turned from a vision of cultures as coherent symbolic orders to practice as the stuff of cultural life (Bourdieu, 1972; Ortner, 1984). As Lila Abu-Lughod put it, the practice approach to culture “is built around problems of contradiction, misunderstanding, and misrecognition, and favors strategies, interests, and improvisations over the more static and homogenizing cultural tropes of rules, models, and texts” (1991: 147). Rather than a setting for actions, culture might be something people do—an *outcome* of actions. This multiplies culture radically: instead of unified “cultures,” we have an array of loosely coordinated practices that compete and collaborate, sometimes for “cultural” goals and sometimes for other goals—for instance, “technical” ones.

Annemarie Mol has advanced a radical version of this focus on practice through her ethnographic and philosophical work, which she calls “praxiography” (2002). For Mol, reality itself is not prior to practices but rather a consequence of them; in Mol’s “practical ontology” (Gad et al., 2015), actors do not act on pre-given objects, but rather bring them into being—a process she calls “enactment.” Consequently, objects acted on in many different ways become “multiples”: “more than one and less than many” (Mol, 2002: 82). A “culture,” for instance, is not one coherent thing, nor is it a set of disparate things, such that every person enacts and imagines their own in isolation.

Following Laura Devendorf and Elizabeth Goodman, I find this a useful way to approach algorithms—not as stable objects interacted with from many perspectives, but as the manifold consequences of a variety of human practices. In their study of an online dating site (2014), Devendorf and Goodman found various actors enacted the site’s algorithm differently: engineers tweaked their code to mediate between the distinctive behaviors of male and female users; some users tried to game the algorithm as they understood it, to generate more desirable matches; other users took the algorithm’s matches as oracular pronouncements, regardless of how they had been produced. No inner truth of the algorithm determined these interactions, and non-technical outsiders changed the algorithm’s function: machine learning systems changed in response to user activity, and engineers accommodated user proclivities in their code.

We can call this the *algorithms as culture* position: algorithms are not technical rocks in a cultural stream, but are rather just more water. Like other aspects of culture, algorithms are enacted by practices which do not heed a strong distinction between technical and non-technical concerns, but rather blend them together. In this view, algorithms are not singular technical objects that enter into many different cultural interactions, but are rather unstable objects, culturally enacted by the practices people use to engage with them.

This vision of algorithms as culture differs from the notion of “algorithmic culture” (Striphas, 2015), which posits algorithms as an transformative force, exogenous to culture. In this view, a movie recommender is cultural because it shapes flows of cultural material, not because its algorithmic logics are themselves cultural (Hallinan and Striphas, 2016). Nor is it what Gillespie calls “algorithms becoming culture” (2016), which happens when algorithms become objects of popular debate and targets of strategic action (e.g. fans launching a listening campaign to influence a music recommender). Rather, algorithms are cultural not because they work on things like movies or music, or because they become objects of popular concern, but because they are composed of collective human practices. Algorithms are multiple, like culture, because they *are* culture.

Methodological enactments

If we understand algorithms as enacted by the practices used to engage with them, then the stakes of our own methods change. We are not remote observers, but rather active enactors, producing algorithms as particular kinds of objects through our research. Where a computer scientist might enact algorithms as abstract procedures through mathematical analysis, an anthropologist might use ethnographic methods to enact them as rangy sociotechnical systems constituted by human practices. A computer scientist may be concerned with matters of efficiency or how an algorithm interacts with data structures; an anthropologist may care instead about how an algorithm materializes values and cultural meanings. This disparity does not mean one of us is wrong and the other right—rather, we are engaged in different projects with different goals, and just as my discipline’s methods are poorly suited to determining the efficiency of an algorithm in asymptotic time, so the computer scientist’s are poorly suited to understanding the cultural situations in which algorithms are built and implemented.

This recognition of algorithms’ multiplicity may seem destabilizing, causing trouble for efforts to hold algorithms accountable or even to identify their effects. However, I want to suggest that this approach

facilitates, rather than limits, critique, making our accounts more adequate to the practices they describe, and centering those practices as a site of dispute and potential regulation. As Marina Welker puts it in *Enacting the Corporation*: “How we construct corporations as actors has crucial entailments for how we assign responsibilities to them, and vice versa” (2014: 4). We can replace “corporations” with “algorithms” in that sentence, but we do not have to: the algorithms we care about are very often corporate products, and they seem more similar to corporations themselves—in their heterogeneity, diffuseness, and legal architecture—than to textbook algorithms like the bubble sort that I began with. Presuming that algorithms must have a stable and coherent existence makes it harder, not easier, to grapple with their production and ongoing maintenance.

Algorithmic auditing provides a useful case for examining how critical methods enact algorithmic objects. These projects, inspired by historical efforts to expose housing discrimination, treat algorithmic systems as black-box functions: hidden operations that turn inputs into outputs, like mortgage applications into home loans (Diakopoulos, 2013; Sandvig et al., 2014). By varying inputs and examining the corresponding outputs (e.g. constructing personae that vary by apparent race), audit studies can demonstrate “disparate impact”—differences in outcome that affect legally protected classes of people and thus invoke regulatory response. What they cannot do is explain conclusively how that disparate impact came about.

By treating the “inside” of the algorithm as unknowable, these approaches participate in enacting an understanding of the algorithm as a black box, as knowable only through the relation between inputs and outputs. This is not to say that audit approaches are responsible for algorithmic secrecy—they are clearly responding to other efforts to keep algorithmic operations hidden—but they are part of a set of coordinated practices through which algorithms becomes understood as, and remain, secret.

While one might presume secrecy to be a simple matter of hiding facts that could be easily revealed, secrecy in practice is not so clear; secrecy is a social process, enacted by both insiders and outsiders (this is a longstanding trope in the anthropology of secrecy; Jones, 2014; Simmel, 1906). Different methods of engaging algorithmic secrecy enact the algorithm differently, setting its boundaries in different places—at the interface, at a certain point in the code, or at the legal boundary of the corporation. If, as Frank Pasquale (2015) suggests, we take algorithmic secrecy as a legal problem, then our efforts to understand the algorithm need to involve legal reasoning. If, as Jenna Burrell (2016) suggests, one source of algorithmic opacity

is the intrinsic complexity of methods like neural networks, then we might try to engineer “explainable” systems (e.g. Aha, 2017). Thus, details of contract law may be as salient to the cultural functioning of algorithms as the ability of a neural network to “explain” its outputs.

As Daniel Neyland demonstrates through ethnographic work on an algorithmic accountability project, making algorithms accountable often means literally changing them—making them “account-able,” in ethnomedological jargon (2016). To make something account-able means giving it qualities that make it legible to groups of people in specific contexts. An accountable algorithm is thus literally different from an unaccountable one—transparency changes the practices that constitute it. For some critics this is precisely the point: the changes that transparency necessitates are changes that we want to have. This is a plain example of how different efforts to enact an object are both coordinated with each other and potentially in conflict. Transparency is not a revealing of what was always there, but a methodical reconfiguration of the social scene that changes it toward particular ends (see e.g. Ananny and Crawford, 2016; Strathern, 2000; Ziewitz, 2015).

Ethnographic tactics

This discussion recasts the anxiety described at the beginning of this article: concerns about the proper definition of “algorithm” are caught up not only in the boundary work that constitutes disciplines, but also in the methods those disciplines use. As algorithms are enacted by a wider range of methods, these enactments come into conflict with each other, and the work of coordinating among them becomes more challenging. Any method for apprehending algorithms now takes place amidst this confusion.

In this situation, I have found ethnography to be a useful method for enacting algorithms. Given its history in the study of cultural difference, it is well suited to life among plural methods—for engaging the various ways that people go about their lives, rather than trying to displace them. Not everyone needs to become an ethnographer, but ethnography as a method is distinctively appropriate to understanding how diverse methods interact. Ethnography is also good for seeing algorithms *as*, rather than *in* culture—for apprehending the everyday practices that constitute them and keep them working and changing, not just for observing how they relate to a distinct and properly “cultural” domain. Ethnographic methods help us gain purchase on topics that concern critical scholars: the interrelation of people and computers, the local production of abstract representations, and the human sensemaking that pervades algorithmic operations, locating these

within sociocultural contexts that are diverse and changing.

In the remainder of this article, I offer a set of ethnographic tactics following the tradition of the “ethnography of infrastructure” (de Certeau, 1984; Star, 1999), which has directed researcher attention to the often-neglected cultural features of sociotechnical systems. These tactics are not unique to algorithmic objects—they have their origins in a variety of ethnographic domains. Nor should we expect every new object to engender brand new tactics; indeed, one appealing feature of seeing algorithms *as*, rather than *in*, culture is a rejection of the idea that they are new or unique at all. Where many methods for critically engaging algorithms take secrecy as one of algorithms’ defining features, I try here to offer paths away from secrecy, so that ethnographers might ask and answer other questions. Given traditional ethnographic concerns with access, this is a challenge, requiring openness to fieldwork that diverges from canonical imaginaries. I have found these tactics especially useful for making algorithms ethnographically tractable. They are a pragmatic counterpart to the conceptual argument advanced thus far—a set of theoretically informed “tricks of the trade” (Becker, 1998; Star, 1999).

Scavenge

Algorithms are not the only obscure objects ethnographers have tried to study. Hugh Gusterson has studied the culture of nuclear weapons scientists—an extraordinarily secretive group (1996, 2004). Unable to access their workplaces, Gusterson developed an ethnographic method he called “polymorphous engagement”: this meant “interacting with informants across a number of dispersed sites, not just in local communities, and sometimes in virtual form; and it mean[t] collecting data eclectically from a disparate array of sources in many different ways” (1997: 116). For Gusterson, these sources included the local cafeteria, birthday parties, newspaper articles, and a variety of other heterodox “sites.”

Although this heterogeneous and apparently undisciplined approach to ethnographic data collection seems a departure from the idealized image of a fieldworker embedded long-term in a bounded society, it retains what Gusterson describes as “the pragmatic amateurism that has characterized anthropological research” since its origins (Gusterson, 1997: 116). Ethnographers have always gleaned information from diverse sources, even when our objects of study appear publicly accessible. Moreover, the scavenger replicates the partiality of ordinary conditions of knowing—everyone is figuring out their world by piecing together heterogeneous clues—but expands on them by tracing

cultural practices across multiple locations (Marcus, 1995) and through loosely connected networks (Burrell, 2009). These are “entry points, rather than sites,” as Burrell has suggested the networked ethnographer should seek (2009: 190). Access is not a precondition for all anthropological knowledge; as Ulf Hannerz writes, “ethnography is an art of the possible” (2003: 213).

A great deal of information about algorithmic systems is available to the critic who does not define her object of interest as that which is off limits or intentionally hidden. If our interest is not in the specific configuration of a particular algorithm at one moment in time, but in the more persistent cultural worlds algorithms are part of, then useful evidence is not bounded by corporate secrecy. In my own research, I learned from off-the-record chats with engineers about industry scuttlebutt, triangulated with press releases and the social media updates of my interlocutors. Sometimes, interviewees stuck resolutely to the company line; other times, often after several interviews, they spilled the beans. In academic and industry conference hallways, people working in diverse sites talked across their differences and around their various obligations to secrecy, providing a rich source of information about how algorithms and their meanings vary. On mailing lists, in patent applications, and at hackathons, I found arguments, technical visions, and pragmatic bricolage. “Algorithms” manifest across these sites differently: a conference presentation that evaluates an algorithm “properly” for its accuracy in predicting user ratings is followed by a hallway conversation about how that metric is useless in practice, or how the algorithm is too complex to be worth implementing at scale. There is much to be scavenged if we do not let ourselves be distracted by conspicuous barriers to access.

Attend to the texture of access

Nor is access as straightforward as it might seem. Achieving access remains a dream and challenge for would-be fieldworkers, granting the right to say “I was there,” but it may be more important for asserting one’s anthropological bonafides than it is for doing good ethnography—interpreting the ordinary cultural patterns and practices that make up human life, with or without algorithms. This is largely because the Malinowskian imaginary of fieldwork access, in which it happens suddenly and thoroughly—“Imagine yourself suddenly set down surrounded by all your gear, alone on a tropical beach close to a native village” (Malinowski, 1922: 4)—is just that: imaginary. In practice, “access” is a protracted, textured practice that never really ends, and no social scene becomes simply available to an ethnographer because she has shown up.

Rather, ordinary social interaction is marbled with secrecy (Jones, 2014).

I supplemented my own scavenging ethnography with a summer internship at a music recommendation company, where I was free to roam around the office and interview employees. But even in the open plan office, there were always further barriers to access. Conversations in email threads or chat rooms I wasn’t privy to, closed meetings, and coordination with companies external to the office meant that access was not a one-time achievement, but rather a continuous (and exhausting) process. Knowledge might be hidden behind non-disclosure agreements, taciturn interviewees, or inside jokes.

Although it often felt like I was being excluded as an outsider ethnographer, this situation was not unique to me. For people all over the company and the industry more broadly, everyday work was marked by varying levels of access and obscurity. Casper Bruun Jensen has described these “asymmetries of knowledge” (2010), arguing that challenges to access—hidden meetings, reluctant interlocutors, non-disclosure agreements—are part of the field, not simply barriers around it. The field is “a partially existing object emerging from multiple sites of activity that are partly visible, partly opaque to all involved actors, including the ethnographer” (Jensen, 2010: 74). Not even people on the “inside” know everything that is going on, both because algorithms can be quite complex and distributed (Seaver, 2013) and because that is how human social life works more generally. The field site is not a black box that can be simply opened.

Rather than thinking of access as a perimeter around legitimate fieldwork, the scavenging ethnographer can attend to access as a kind of texture, a resistance to knowledge that is omnipresent and not always the same. These challenges are data themselves—about the cultural life of algorithmic systems, how their secrecy is constituted in practice, what kinds of information are so important that they must be kept secret, and what kinds of information are so important that they must be widely known. Ethnographic projects, like the algorithmic systems we want to study, “are characterized by limited presence, partial information and uncertain connections” (Jensen, 2010: 74). Through paying attention to the texture of access, the ethnographer learns about how knowledge circulates, information that is practically useful but also a research outcome in its own right: an algorithm’s edges are enacted by the various efforts made to keep it secret.

Treat interviews as fieldwork

Because the scavenging ethnographer is highly mobile, her fieldwork is likely to be interview-centric; with

less time spent in any given location, it is challenging to settle into idealized participant observation (Hannerz, 2003). Multi-sited ethnographers are often anxious that this reliance on interviews renders their work less ethnographic, because interviews are commonly understood as artificial situations created by researchers. In anthropological methods talk, interviews are cast as the abject other of participant observation: they merely reflect what people *say*, not what they *do*. We all know that talkers dissimulate, misremember, or selectively highlight features of their lives. Interviews are thus framed as unreliable—primarily a source for statements to be falsified by proper fieldwork. Ironically, this framing values participant observation much like how corporations value behavioral data analytics: people *say* one thing (as indicated by their favorite artist on Facebook), but they *do* another (as indicated by their listening history on Spotify).

However, it is worth considering interviews as a form of cultural action themselves—not an artificial situation constructed by researchers, but part of the world in which research subjects live and make meaning. The people who work in and around algorithmic systems live in what Jenny Hockey calls an “interview culture”—they know what interviews are, they witness them conducted regularly in a variety of media, they’ve likely been interviewed before, and often, they’ve conducted interviews themselves (Hockey, 2002; and see Forsey, 2010; Skinner, 2012). When the researcher organizes an interview, she is setting up a known kind of interaction with its own tacit rules and meanings. Interviews do not extract people from the flow of everyday life, but are rather part of it.

Here is an partial list of interviews I conducted during fieldwork: meeting for coffee with an engineer in a San Francisco coffeeshop; setting up a Skype conversation with an interlocutor who insisted that I send him a Google Calendar invite so that our meeting would show up on his work calendar; interviewing a team of research scientists over lunch in the restaurant next door to their office; chatting in a bar with a former employee of a music streaming service that was slowly going out of business; strolling in a park with a long term informant who had become a friend; walking with an academic lab director who insisted we could only talk while he was running his on-campus errands.

None of these interactions were unusual for my interviewees. They fit me into existing patterns in their lives—often in ways that made my work difficult, giving me only 30 distracted minutes or making it hard to take notes or use my audio recorder. They treated me like a prospective hire, a supervisor, an advisee, a journalist, a friend, or a therapist. In these variously formatted conversations, algorithmic concerns manifested in many ways: as technical puzzles worked out

with colleagues over lunch, as sources of anxiety or power, as marketing tools, or even as irrelevant to the real business of a company. Treating interviews as fieldwork does not just reduce the ethnographer’s anxiety about relying on them—it broadens her attention, turning the mundane mechanics of arranging and conducting conversations into material for analysis.

Parse corporate heteroglossia

While I was in the field in January 2014, a new music streaming service named Beats Music launched. An extended commercial featured a manifesto, which lauded human musicality and criticized algorithmic processing, read over scratchy, organic animations: silhouettes kissing, turntables spinning, a sailboat tossed on stormy water made of 1s and 0s.

What if you could always have the perfect music for each moment, effortlessly? Drives would be shorter. Kisses, deeper. Inspiration would flow, memories would flood. You’d fall in love every night. [...] And to do that you’ll need more inside your skull than a circuit board. [...] We’ve created an elegant, fun solution that integrates the best technology with friendly, trustworthy humanity—that understands music is emotion, and joy, culture... and life.

The scavenging ethnographer will at some point encounter a document like this—an advertisement or press release or blog post from a company executive, which, in spite of claiming an author, seems certainly written by committee. Beats’ manifesto evinces what Mikhail Bakhtin called “heteroglossia,” the quality of a text that speaks with many voices at once (1982). In the short extract above, at least two voices are evident: the flowery evocation of kisses, inspiration, memories, and love and the business language of “elegant, fun solutions.” The ad was a paean to the human curators Beats claimed distinguished it from competitors, a jeremiad against algorithms from a software company, and an awkward corporate effort to integrate technology and humanity.

Corporate speech is often heteroglot, but for Bakhtin and the linguistic anthropologists who follow him, heteroglossia is not just a consequence of corporate authorship; it is an ordinary feature of language: “In the reality of everyday life [...] the speech of any one person is filled by many different *voices* or linguistically constructed personae” (Duranti, 1997: 75). Identifying heteroglossia requires long-term familiarity—without familiarity, people tend to assume that voices are necessarily singular and that variation is evidence of incoherence and contradiction rather than multiplicity (Smith, 2004).

Linguistic anthropologists have made this case for people, but for corporations its necessity is even clearer: outsiders often attribute singular agency and voice to corporations composed of hundreds or thousands of employees, working in scores of internal groups. Thus, we hear that “Facebook” has claimed or done something or that “Spotify” has a particular point of view. But while managers may try to coordinate their work, nothing intrinsically binds an engineering team to a social media intern or a company founder. Especially in young companies or those in transformation, the institutionalizing forces that work to align these various voices are weak, and obvious heteroglossia in public statements is one notable consequence.

As one of my interlocutors—an engineer with another company—put it on social media, Beat’s manifesto was “bullshit”: while it aired, Beats was advertising for algorithm engineering positions, to work on the system that would recommend its curators’ playlists to users. At a conference the previous year, I had even met one of those engineers, who bragged about the company’s technical sophistication. Speaking through advertisements, job postings, and its engineers, the company said many things at once. Across these various channels, and between the many voices within them, “algorithms” were different things: precious intellectual property, incompetent calculators, or the heralds of a new age of technical sophistication.

Heteroglossia is a resource and a hazard for the ethnographer: catching corporate messages as they move in and out of phase with each other can reveal the interplay of practices within the corporation; it is not merely evidence of corporate dissimulation. The ethnographer needs to take care to resist interpretations that cast corporations as singular actors with plain intentions expressed in public statements. Relying on only one channel, or trying to find a presumed latent coherence in it, oversimplifies corporate action. Some incoherence is to be expected.

Beware irony

If careful parsing is important for making sense of corporate speech, it is doubly important for interpreting the speech of computer programmers. As ethnographers of computing cultures have noted (e.g. Coleman, 2015), programmers are especially inclined toward irony and jokes, making the ability to parse layered meanings crucial for understanding what they say. Recall that the central purpose of Clifford Geertz’s “thick description” was to detect irony—the difference between a blink, a wink, “fake-winking, burlesque-fake-winking, rehearsed-burlesque-fake-winking” and the combinatorial elaboration of layered meanings

which subtend activities which, on the surface, may appear to be the same (1973: 6–7). Only through deep engagement and richly contextual description could the ethnographer distinguish such variety—or, in other words, be in on the joke. Superficial accounts risk taking ironic statements literally or missing the conflicted experience of programmers negotiating between different sets of values.

In my own fieldwork, I met many commercially employed programmers who were deeply ambivalent about their own work or their industry: some had previously been academics or musicians and felt like they had sold out; others felt a moral charge to pursue their own teams’ work but felt guilty about broader industry dynamics. This ambivalence often manifested in ambiguous claims or jokes about things like data, markets, or algorithms. One of my interlocutors often joked that data had “forced” him to make a design decision that was, in context, clearly a matter of personal preference. Out of context, his remarks were interpreted as evidence of what Kate Crawford has called “data fundamentalism”—“the notion that correlation always indicates causation, and that massive data sets and predictive analytics always reflect objective truth” (2013). In context, it seemed evidence more of parody or resigned irony than of enthusiastic belief.

The attribution of fundamentalisms—technological determinism, naive economism, or hyper-rationalism—to computer programmers may, in some cases, indicate more about critics’ inability to parse ironic speech than it does about technologists’ simplistic beliefs. My technical interlocutors read critical literature (I encountered the Crawford piece cited above shared by my interlocutors on social media), and they criticized thoughtless uses of algorithmic processing; but they also knew how to work in that language, either to persuade believers or to crack jokes at their expense. Describing their statements as “fundamentalism” fails to capture the complex ways that data is tactically used in practice, and it risks obscuring local critiques. As Judith Nagata has argued, “The *fundamentalist* epithet is often a form of verbal ammunition against ideological and political enemies and ‘Others,’ recalling old orientalisms, and usually imposed unilaterally, whether by academics, popular opinion, or the media” (2001: 495). Given programmers’ tendency to irony, long-term engagement is crucial for ethnographers “to understand, not only the substance and content of beliefs, but also their context, source, and application” (Nagata, 2001: 481). Algorithmic systems are not necessarily populated by data fundamentalists, but rather by diverse and ambivalent characters, working in contexts and with meanings that cannot be simply read or guessed at, but which must be

found empirically. It is too easy (and too common) to try reading programmers' motivations off of algorithmic systems and to conclude that the programmers themselves must be algorithmic—limited by naive and rigid assumptions about human life. Ironically, this mistake echoes a common humanistic critique of Big Data: that it reduces people to decontextualized formalisms. As Clifford Geertz put it 45 years ago, both of these approaches suffer from trying “to understand [people] without knowing them” (1973: 30). Pace Dourish, I would argue that avoiding such readings is a serious matter “of ethnographic responsibility and practical politics,” allowing us to grasp the social dynamics within algorithmic systems and to communicate with the people there about those systems' consequences (Dourish, 2016: 2).

Conclusion

I have argued for the merits of understanding algorithms as intrinsically cultural—as enacted by diverse practices, including those of “outside” researchers. Approaching algorithms ethnographically enacts them as part of culture, constituted not only by rational procedures, but by institutions, people, intersecting contexts, and the rough-and-ready sensemaking that obtains in ordinary cultural life. This enactment differs from canonical expert enactments, which hold algorithms to be essentially abstract procedures, and it differs from other cultural approaches to algorithms that try to locate them as forces on culture's boundaries. Ethnography helps us to attend to empirical situations which are not necessarily stable or coherent.

Ethnography provides a useful orientation for entering and understanding worlds of meaning-laden practice, but conventional understandings of algorithms as defined by secret procedure suggest that ethnographic approaches are infeasible without a level of access that cannot realistically be obtained. The tactics I have laid out here are techniques for routing around that challenge; they work to enact algorithms not as inaccessible black boxes, but as heterogeneous and diffuse socio-technical systems, with entanglements beyond the boundaries of proprietary software.

While I insist on imagining alternatives to visions of algorithms as essentially secret, this style of ethnographic enactment does not answer all the questions that people might want to ask of them. Questions about the particular workings of particular algorithms at particular moments in time remain broadly unanswerable so long as corporations are able to hide behind legal and technical secrecy. Nonetheless, a sense of the algorithm as multiple, and of ethnography as a practice for producing and participating in plural enactments of algorithms, offers fruitful avenues for

producing actionable knowledge in spite of such secrecy.

Acknowledgments

I am grateful to the many colleagues and audiences who provided advice, feedback, and support as I developed the argument in this article, including: Bill Maurer, Paul Dourish, Malte Ziewitz, Stuart Geiger, Guilherme Sanches de Oliveira, Rachel Bergman, Tarleton Gillespie, Mary Gray, Nancy Baym, Lana Swartz, Kevin Driscoll, Sarah Brayne, Andrea Alarcón Sojet, Moon Duchin, Riccardo Strobino, the editors of this Special Issue, and the anonymous peer reviewers. I would also like to thank my anonymous ethnographic interlocutors.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was funded in part by National Science Foundation (Doctoral Dissertation Research Improvement Grant 1323834), the Wenner-Gren Foundation (Dissertation Fieldwork Grant 8797), and the Intel Science and Technology Center for Social Computing at the University of California, Irvine. I am also grateful to the Department of Anthropology at the University of California, Irvine for seed research funding, to the Algorithms in Culture project at the University of California, Berkeley for funding to attend the workshop where this article was developed, and to the Social Media Collective at Microsoft Research, New England for financial support during the first drafting of this argument.

Notes

1. This is a paraphrase from memory.
2. See the reading list compiled by Gillespie and Seaver (2015) here: <https://socialmediacollective.org/reading-lists/critical-algorithm-studies/>
3. Repeatedly step through a list, comparing adjacent items and swapping them if they are out of order, until nothing remains to be swapped.

References

- Abu-Lughod L (1991) Writing against culture. In: Fox RG (ed.) *Recapturing Anthropology*. Santa Fe, New Mexico: School of American Research Press, pp. 137–162.
- Aha DW (2017) IJCAI 2017 Workshop on Explainable Artificial Intelligence (XAI). Available at: <http://home.earthlink.net/~dwaha/research/meetings/ijcai17-xai/> (accessed 10 October 2017).
- Ananny M and Crawford K (2016) Seeing without Knowing: Limitations of the Transparency Ideal and Its Application to Algorithmic Accountability. *New Media & Society*. Online before print, December.

- Bakhtin M (1982) In: Holquist M (ed.) *The Dialogic Imagination: Four Essays* (Transl. Caryl Emerson). Austin: University of Texas Press.
- Barocas S, Hood S and Ziewitz M (2013) Governing algorithms: A provocation piece. Available at: <http://governinalgorithms.org/resources/provocation-piece/> (accessed 10 October 2017).
- Becker HS (1998) *Tricks of the trade: How to think about your research while you're doing it*. Chicago: University of Chicago Press.
- Bourdieu P (1972) *Outline of a Theory of Practice*. Cambridge: Cambridge University Press.
- Burrell J (2009) The field site as a network: A strategy for locating ethnographic research. *Field Methods* 21(2): 181–199.
- Burrell J (2016) How the Machine ‘Thinks:’ Understanding Opacity in Machine Learning Algorithms. *Big Data & Society* 3(1).
- Coleman G (2015) The anthropological trickster. *HAU: Journal of Ethnographic Theory* 5(2): 399–407.
- Crawford K (2013) The hidden biases in Big Data. *Harvard Business Review*. 1 April. Available at: <https://hbr.org/2013/04/the-hidden-biases-in-big-data> (accessed 10 October 2017).
- de Certeau M (1984) *The Practice of Everyday Life*. Berkeley: University of California Press.
- Devendorf L and Goodman E (2014) *The Algorithm Multiple, the Algorithm Material*. Contours of Algorithmic Life, UC Davis, May.
- Diakopoulos N (2013) Algorithmic Accountability Reporting: On the Investigation of Black Boxes. *A Tow/Knight Brief*. New York: Columbia Journalism School, Tow Center for Digital Journalism.
- Dourish P (2016) Algorithms and their others: Algorithmic culture in context. *Big Data & Society* 3(2): 1–11.
- Duranti A (1997) *Linguistic Anthropology*. Cambridge, UK: Cambridge University Press.
- Forsey MG (2010) Ethnography as participant listening. *Ethnography* 11(4): 558–572.
- Fuller S (1991) Disciplinary boundaries and the rhetoric of the social sciences. *Poetics Today* 12(2): 301–325.
- Gad C, Jensen CB and Winthereik BR (2015) Practical Ontology: Worlds in STS and Anthropology. *NatureCulture* 3: 67–86.
- Gal S and Irvine J (1995) The boundaries of languages and disciplines: How ideologies construct difference. *Social Research* 62(4): 967–1001.
- Geertz C (1973) *The Interpretation of Cultures*. New York, NY: Basic Books.
- Gieryn T (1983) Boundary-work and the demarcation of science from non-science: Strains and interests in professional interests of scientists. *American Sociological Review* 48: 781–795.
- Gillespie T (2016) Algorithm. In: Peters B (ed.) *Digital Keywords: A Vocabulary of Information Society and Culture*. Princeton, NJ: Princeton University Press.
- Gillespie T and Seaver N (2015) Critical algorithm studies: A reading list. Available at: <https://socialmediacollective.org/reading-lists/critical-algorithm-studies/> (accessed 10 October 2017).
- Gusterson H (1996) *Nuclear Rites*. Berkeley: University of California Press.
- Gusterson H (1997) Studying up revisited. *PoLAR: Political and Legal Anthropology* 20(1): 114–119.
- Gusterson H (2004) *People of the Bomb*. Minneapolis: University of Minnesota Press.
- Hallinan B and Striplas T (2014) Recommended for You: The Netflix Prize and the Production of Algorithmic Culture. *New Media & Society* 18(1): 117–137.
- Hannerz U (2003) Being there... and there... and there! *Ethnography* 4(2): 201–216.
- Helmreich S (2001) After culture: Reflections on the apparition of anthropology in artificial life, a science of simulation. *Cultural Anthropology* 16(4): 612–627.
- Hockey J (2002) Interviews as ethnography? Disembodied social interaction in Britain. In: Rapport N (ed.) *British Subjects: An Anthropology of Britain*. Oxford: Berg, pp. 209–222.
- Jensen CB (2010) Asymmetries of knowledge: Mediated ethnography and ICT for development. *Methodological Innovations Online* 5(1): 72–85.
- Jones GM (2014) Secrecy. *Annual Review of Anthropology* 43(1): 53–69.
- Malinowski B (1922) *Argonauts of the Western Pacific*. London: Routledge & Kegan Paul, Ltd.
- Marcus G (1995) Ethnography in/of the World System: the Emergence of Multi-Sited Ethnography. *Annual Review of Anthropology* 24: 95–117.
- Mol A (2002) *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press.
- Nader L (1969) Up the anthropologist: Perspectives gained from studying up. In: Hymes D (ed.) *Reinventing Anthropology*. New York, NY: Vintage Books.
- Nagata J (2001) Beyond theology: Toward an anthropology of ‘Fundamentalism.’ *American Anthropologist* 103(2): 481–498.
- Neyland D (2016) Bearing account-able witness to the ethical algorithmic system. *Science, Technology & Human Values* 41(1): 50–76.
- Ortner S (1984) Theory in anthropology since the sixties. *Comparative Studies in Society and History* 26(1): 126–166.
- Pasquale F (2015) *The Black Box Society: The Secret Algorithms that Control Money and Information*. Cambridge, MA: Harvard University Press.
- Sandvig C, Kevin H, Karrie K, et al. (2014) An Algorithm Audit. In: Seeta Peña Gangadharan (ed.) *Data and Discrimination: Collected Essays*. Washington, DC: New America Foundation, pp. 6–10.
- Seaver N (2013) Knowing algorithms. Paper presented at Media in Transition 8, Cambridge, MA. Available at: <http://nickseaver.net/papers/seaverMiT8.pdf> (accessed 10 October 2017).
- Skinner J (ed.) (2012) *The Interview: An Ethnographic Approach*. London: Bloomsbury Academic.
- Simmel G (1906) The Sociology of Secrecy and of Secret Societies. *The American Journal of Sociology* 11(4): 441–498.
- Smith AL (2004) Heteroglossia, ‘common sense,’ and social memory. *American Ethnologist* 31(2): 251–269.

- Star SL (1999) The Ethnography of Infrastructure. *American Behavioral Scientist* 43(3): 377–391.
- Strathern M (1995) The nice thing about culture is that everyone has it. In: Strathern M (ed.) *Shifting Contexts: Transformations in Anthropological Knowledge*. London: Routledge.
- Strathern M (2000) *Audit Cultures: Anthropological Studies in Accountability, Ethics and the Academy*. New York: Routledge.
- Striphas T (2015) Algorithmic culture. *European Journal of Cultural Studies* 18(4–5): 395–412.
- Titlow JP (2013) Screw algorithms! The new music service from beats uses celebrity curators to show you new music. *Fast Company*. Available at: <https://www.fastcompany.com/3019830/screw-algorithms-the-new-music-service-from-beats-uses-celebrity-curators-to-show-you-new-mu> (accessed 10 October 2017).
- Totaro P and Domenico N (2014) The Concept of Algorithm as an Interpretative Key of Modern Rationality. *Theory, Culture & Society* 31(4): 29–49.
- Welker M (2014) *Enacting the Corporation: An American Mining Firm in Post-Authoritarian Indonesia*. Berkeley: University of California Press.
- Ziewitz M (2015) Governing algorithms: Myth, mess, and methods. *Science, Technology & Human Values* 41(4): 3–16.

PAPER MACHINE

Jacques Derrida

Translated by Rachel Bowlby

STANFORD UNIVERSITY PRESS

STANFORD, CALIFORNIA



The Word Processor

LA QUINZAINE LITTÉRAIRE: We're going to begin with "Heidegger's Hand."¹ You explain how in Heidegger manual work, *Handwerk*, is a noble employment because it is not, "like other professions, organized in relation to public usefulness or making a profit," and that this employment "will also be that of the thinker or the teacher who teaches thinking." In addition, this employment is always "in danger," particularly of being downgraded by the machine. Heidegger is obviously thinking of the typewriter. But what does this machine do in the story, then, this machine that is no longer an obstacle, that makes the text too readable, too easy, too clear for the one who lends an ear to it—since you have also spoken at length of "Heidegger's Ear"?²

JACQUES DERRIDA: If only to move away from it, Heidegger's posture or postulation had to be analyzed at the outset. It belongs to a major interpretation of technology that calls forth numerous questions—calls them forth, really, where they are not so easy to hear as we would sometimes like to think . . .

To narrow things down to writing, I wanted to point out in what way Heidegger's reaction was at once intelligible, traditional, and normative. The tradition of these norms is often respectable, and its reserve considerable when it remains vigilant in the face of technological mutations. But it also gives rise, sometimes in its least naive form, to a confident dogmatism, an assurance that we have to interrogate. For instance, Heidegger deplores the fact that even personal letters are now typewritten and that the

singular trace of the signatory is no longer recognizable through the shapes of the letters and the movements of the hand. But when we write “by hand” we are not in the time before technology; there is already instrumentality, regular reproduction, mechanical iterability. So it is not legitimate to contrast writing by hand and “mechanical” writing, like a pretechnological craft as opposed to technology. And then on the other side what we call “typed” writing is also “manual.”

You would like me to speak about my own experiences. Well, yes, like so many other people I have gone through this history, or I have let it come my way. I began by writing with a pen, and I remained faithful to pens for a long time (faith is the right word here), only transcribing “final versions” on the machine, at the point of separating from them. The machine remains a signal of separation, of severance, the official sign of emancipation and departure for the public sphere. For the texts that mattered to me, the ones I had the slightly religious feeling of “writing,” I even banished the ordinary pen. I dipped into the ink a long pen holder whose point was gently curved with a special drawing quill, producing endless drafts and preliminary versions before putting a stop to them on my first little Olivetti, with its international keyboard, that I’d bought abroad. I still have it. My idea must have been that my artisanal writing really would break its way through into that space of resistance, as near as possible to that hand of thought or word evoked by the passage in Heidegger that I later tried to interpret in “Heidegger’s Hand.” As if that liturgy for a single hand was required, as if that figure of the human body gathered up, bent over, applying, and stretching itself toward an inked point were as necessary to the ritual of a thinking engraving as the white surface of the paper subjectile on the table as support. But I never concealed from myself the fact that, as in any ceremonial, there had to be repetition going on, and already a sort of mechanization. This theater of the prosthesis and the marking very quickly became a theme for me, in all its dimensions, more or less everywhere from “Freud and the Scene of Writing” to *Archive Fever*.³

Then, to go on with the story, I wrote more and more “straight onto” the machine: first the mechanical typewriter; then the electric typewriter, in 1979; then finally the computer, around 1986 or 1987. I can’t do without it any more now, this little Mac, especially when I’m working at home; I can’t even remember or understand how I was able to get on before without it. It’s a quite different kind of getting going, a quite different exercise of “getting to work.” I don’t know whether the electric typewriter or the

computer make the text “too readable” and “too clear” for us. The volume, the unfolding of the operation, obeys another organigram, another organology. I don’t feel the interposition of the machine as a sort of progress in transparency, univocity, or easiness. Rather, we are participating in a partly new plot. Heidegger points out that the work of thinking is a handiwork, a *Handlung*, an “action,” prior to any opposition between practice and theory. Thought, in this sense, would be a *Handlung*, a “maneuver,” a “manner,” if not a manipulation. But is that a reason for protesting against the machine? Having recourse to the typewriter or computer doesn’t bypass the hand. It engages another hand, another “command,” so to speak, another induction, another injunction from body to hand and from hand to writing. But it’s never at any moment, at least for the time being, a matter of handless writing, writing while keeping your hands in your pockets. Far from it. Handless writing is perhaps what we are doing now as we record our voices. But hands are not only in hands. Basically, the history I have just outlined is not marked by a breaking off of manual gestures or by the event of a hand being cut off; instead it would be another history of the hand, a history still maintained within the hand, a history of a hand-held writing,⁴ even if, of course, the hand’s destination is being slowly displaced, in a long-term history. Ultimately it’s the hand we’re talking about, and its relationship with the eye, with the rest of the body, and so on. We would instead have to think about other twists of manual labor, about virtually instant transitions, the time of the mutation, in a flash, by sleight-of-hand. Between the pen-tool and the pencil-tool on the one hand, and machines on the other, the difference is not the hand, because it is maintained and stays relevant, it’s also the fingers. With mechanical or electrical writing machines, with word processors, the fingers are still operating; more and more of them are at work. It is true that they go about it in a different way. You do it more with the fingers—and with two hands rather than one. All that goes down, for some time to come, in a history of digitality.

LA QUINZAINE LITTÉRAIRE: In the four-handed book you wrote with Geoffrey Bennington, there is a photograph showing the Bodleian Library miniature that is the subject of *The Post Card*, in which we see Plato planted behind Socrates, and Socrates writing with a quill and a stylet in his hands. In the photographed scene, the person holding the “quill” is you. Perhaps that’s about the invention of a new form of dialogue. A dia-

logue that would be as “serious” as dialogue because it is weighed down with all the heaviness of writing, and would equally be more playful because there’s a whole play aspect to the computer, the computer game. Wouldn’t this be a sort of advance?

DERRIDA: Can we speak of progress here? Certainly there is a transformation of the scene and, yes, a play aspect. The photograph itself, which wasn’t my idea, was a provocation I thought I should agree to. The point was to mime the scene, already a strange one, of an authoritarian Plato standing up, right behind a seated Socrates in the process of writing, “scratching”—relocating the scene in our modern time. The primary reason that we had the idea of this *tableau vivant* is that the long footnote that it was to accompany, namely *Circumfession*, was written on the computer, from the very beginning. Bennington also gave himself the task of setting up what he called, in relation to my work, a database or “Derridabase,” according to an IT model, if you like, enabling any reader, without there being any quotations, to find all the propositions and all the places in the corpus of texts, through a sort of ultraformalized index. So Bennington was himself playing with that machine. In *Circumfession* I also gave myself the somewhat random constraint of a software program that, when I got to the end of a paragraph of such and such a length, roughly twenty-five lines, told me: “The paragraph is going to be too long; you should press the Return button.” Like an order coming from I know not whom, from the depths of what time or what abyss, this slightly threatening warning would appear on the screen, and I decided to come quietly to the end of this long sequence, after the breathing space of a rhythmic sentence, which did have punctuation, as if rippling with commas, but was uninterrupted, punctuated without a period, if you like—so submitting the fifty-nine long sentences to an arbitrary rule made by a program I hadn’t chosen: to a slightly idiotic destiny. We both played with this machine that is the computer; we pretended to obey it even as we were exploiting it. As you know, the computer maintains the hallucination of an interlocutor (anonymous or otherwise), of another “subject” (spontaneous and autonomous, automatic) who can occupy more than one place and play plenty of roles: face to face for one, but also withdrawn; in front of us, for another, but also invisible and faceless behind its screen. Like a hidden god who’s half asleep, clever at hiding himself even when right opposite you.

I was very late in coming to this figure of “word processing.” I resisted for a long time. I thought I would never manage to submit to the rules

of a machine that basically I understand nothing about. I know how to make it work (more or less) but I don't know *how* it works. So I don't know, I know less than ever "who it is" who goes there. Not knowing, in this case, is a distinctive trait, one that does not apply with pens or with typewriters either. With pens and typewriters, you think you know *how* it works, how "it responds." Whereas with computers, even if people know how to use them up to a point, they rarely know, intuitively and without thinking—at any rate, *I* don't know—*how* the internal demon of the apparatus operates. What rules it obeys. This secret with no mystery frequently marks our dependence in relation to many instruments of modern technology. We know how to use them and what they are for, without knowing what goes on with them, in them, on their side; and this might give us plenty to think about with regard to our relationship with technology *today*—to the historical newness of this experience.

To come back to the computer. On the one hand it seems to restore a quasi immediacy of the text, a desubstantialized substance, more fluid, lighter, and so closer to speech, and even to so-called interior speech. This is also a question of speed and rhythm: it goes faster—faster than us; it surpasses us, but at the same time, because of our state of ignorance about what goes on in the night of the box, it surpasses understanding as well: you have the feeling that you are dealing with the soul—will, desire, plan—of a Demiurge-Other, as if already, good or evil genius, an invisible addressee, an omnipresent witness were listening to us in advance, capturing and sending us back the image of our speech *without delay*, face to face—with the image rendered objective and immediately stabilized and translated into the speech of the Other, a speech already appropriated by the other or coming from the other, a speech of the unconscious as well. Truth itself. As though the Other-Unconscious could make use of our speech at the point when it is so close to us, but as though it could just as well interrupt or destroy it. And we maintain a silent awareness of this; we are never safe from accidents, more common with the computer than with the typewriter or the pen. A mere power cut, or a careless or clumsy move, can wipe out hours of work in an instant. That increase in spontaneity, freedom, and fluidity would then be like the bonus to go with precariousness, with a screen display at risk, even calmly distressing; the reward for a sort of alienation. I understand this word neutrally: it would be to do with a "making strange," a mechanical Other-Unconscious sending us back our own speech from a quite different place. Love and hate: this new machine

might install another explanation of the body, the eye, and the hand—of the ear too, with the dictation of a foreign body, with the law, with the order of the Other-Unconscious.

LA QUINZAINE LITTÉRAIRE: When a writer writes a text, it goes through a whole series of intermediate stages. There used to be—there still are for many writers—writing by hand, then typing, then the proofs, first and second proofs, then the appearance of the book, and at each point, except at the end, it is possible to make changes, possible to make corrections, possible to come back to it. With “word processing” too it is possible to come back, but this possibility is immediate. It no longer happens in stages.

DERRIDA: It’s a different kind of timing, a different rhythm. First of all you correct faster and in a more or less indefinite way. Previously, after a certain number of versions (corrections, erasures, cutting and pasting, Tippex), everything came to a halt—that was enough. Not that you thought the text was perfect, but, after a certain period of metamorphosis, the process was interrupted. With the computer, everything is rapid and so easy; you get to thinking that you can go on revising forever. An interminable revision, an infinite analysis is already on the horizon, as though held in reserve behind the finite analysis of everything that makes a screen. At any rate it can be more intensely prolonged over the same time. During this same time you no longer retain the slightest visible or objective trace of corrections made the day before. Everything—the past and the present—everything can thus be locked, canceled, or encrypted forever. Previously, erasures and added words left a sort of scar on the paper or a visible image in the memory. There was a temporal resistance, a thickness in the duration of the erasure. But now everything negative is drowned, deleted; it evaporates immediately, sometimes from one instant to the next. It’s another kind of experience of what is called “immediate” memory and of the transition from memory to archive. Another provocation for “genetic criticism,” as it is called, which has developed around drafts, multiple versions, proofs, and the like.

All in all, it’s getting a bit too easy. Resistance—because ultimately, there’s always resistance—has changed in form. You have the feeling that now this resistance—meaning also the prompts and commands to change, to erase, to correct, to add, or to delete—is programmed or staged by a theater. The text is as if presented to us as a show, with no waiting. You see

it *coming up* on the screen in a form that is more objective and anonymous than on a handwritten page, a page which we ourselves *moved down*. So from bottom to top is how things go: this show happens almost above us, we see it seeing us, surveying us like the eye of the Other, or rather, simultaneously, it also happens under the eye of the nameless stranger, immediately calling forth his vigilance and his specter. It sends us back the objectivity of the text much faster, and so changes our experience of time and of the body, the arms and the hands, our embracing of the written thing at a distance. The written thing becomes both closer and more distant. In this there is another distancing or remoteness, *re-mote* here meaning a distancing of the removed, but also a distancing that abolishes the remote. So another distancing, and I assume that it *alters* every sign. That doesn't mean that it perverts or degrades the sign, but it renders *other* our old sorting out, our familiar altercation, our family scene, if I may call it that, when the written thing first appeared. I couldn't specify here in what way this hospitality changes. It occurs each time and differently for each one of us. People often ask me, "Has your writing changed since you have been writing on the computer?" I'm incapable of replying. I don't know what criteria to measure it by. There's certainly a change but I'm not sure that it affects what is written, even if it does modify the way of writing.

LA QUINZAINE LITTÉRAIRE: I've been reading you for a long time, and I don't see a violent change.

DERRIDA: Nor do I. But I'm aware of another dramaturgy, if I can put it like that. When I sit down at the table and switch on my computer, the scenario is different but I don't know if that translates into a change in what is written. It was well before computers that I risked the most refractory texts in relation to the norms of linear writings. It would be easier for me now to do this work of dislocation or typographical invention—of graftings, insertions, cuttings, and pastings—but I'm not very interested in that any more from that point of view and in that form. That was theorized and that was done—then. The path was broken experimentally for these new typographies long ago, and today it has become ordinary. So we must invent other "disorders," ones that are more discreet, less self-congratulatory and exhibitionist, and this time contemporary with the computer. What I was able to try to change in the matter of page formatting I did in the archaic age, if I can call it that, when I was still writing by hand or with the old typewriter. In 1979 I wrote *The Post Card* on an electric

typewriter (even though I'm already talking a lot in it about computers and software), but *Glas*—whose unusual page format also appeared as a short treatise on the organ, sketching a history of organology up to the present—was written on a little mechanical Olivetti.

LA QUINZAINE LITTÉRAIRE: We speak about "word processing," *traitement de texte* [literally, "text treatment"]. It's not altogether innocent to speak of "treatment" or "processing."

DERRIDA: The word *traitement* always comes to mind when I think of particular situations. For instance when I teach, since I prepare my seminars on the computer, it is much easier for me, with the help of the "cut and paste" facility, to reorder the seminar at the last minute, in a few seconds, and then at the beginning to read out a section that only came to seem necessary at the end, leaving it as though suspended above the scene; so I move a paragraph or a whole page by adjusting the arguments or articulating them together, economically. All that was possible before, I do know, but the same action was slow, heavy, and sometimes off-putting. The word processor saves us an amazing amount of time; we acquire a freedom that we perhaps wouldn't have acquired without it. But the transformation is economic, not structural. There are all these time-saving devices in the finishing off or polishing stages: playing with italics; separating paragraphs; intervening directly in lexical statistics, if I can call it that, by finding the number of occurrences of a given word. I've recently started using the mechanical spell-check. It's instructive, too: what are the words that are not regarded as normal or acceptable in French usage, and so remain censored, these days by the contemporary dictionary incorporated in the machine, as they would be by some other readership, some other media power for instance?

You said something about the time of proofreading. I do slightly miss the long time, the intervals, and the rhythm that then used to mark the history of a written text, all its comings and goings before publication. It was also the chemistry of a conscious or unconscious process of maturation, the chance of mutations in us, in our desire, in the bodily closeness with our text in the hands of the other. Today, as you know, we send a disk to the publisher at the same time as a manuscript: before all that goes off to the printer's, a new actor checks out the disk and makes copyediting suggestions. The proofing-improving is shared, on disk, with this invisible intermediary, but it is never written on a paper support in an exchange with the printer.

LA QUINZAINE LITTÉRAIRE: You are a teacher; you give lectures. You prepare each lecture on the computer, you write it and then you read it out. So then there is an echo of that lecture but the echo can merge with that of the machine.

DERRIDA: When you are preparing a seminar or a lecture, over a period of weeks, you see a body of letters in page form reappearing in front of you, at once objective, stable, independent, and yet floating, a bit fantasmatic—a body of letters that you no longer bear within you, and at any rate no longer completely within you like the more internal image of those old handwritten drafts. This display in fact returns the murmur of an echoing text that comes from out there, the ultrasound of oneself as another. This is the movement we were talking about a moment ago, this accelerated but suspended, fluid or aerial objectification. And I would point out parenthetically that some of my American colleagues come along to seminars or to lecture theaters with their little laptops. They don't print out; they read out directly, in public, from the screen. I saw it being done as well at the Pompidou Center [in Paris] a few days ago. A friend was giving a talk there on American photography. He had this little Macintosh laptop there where he could see it, like a prompter: he pressed a button to scroll down his text. This assumed a high degree of confidence in this strange whisperer. I'm not yet at that point, but it does happen.

LA QUINZAINE LITTÉRAIRE: We are coming to the complete abolition of the paper support. And even the complete abolition of the interlocutor. There is no longer anything except the text.

DERRIDA: The movement is apparently contradictory: more lucid and vigilant, but also more fantasmatic or dreamlike. The computer installs a new place: there one is more easily projected toward the exterior, toward the spectacle, and toward the aspect of writing that is thereby wrested away from the presumed intimacy of writing, via a trajectory of making alien. Inversely, because of the plastic fluidity of the forms, their continual flux, and their quasi immateriality, one is also increasingly sheltered in a sort of protective haven. No more outside. Or rather, in this new experience of specular reflection, there is more outside and there is no more outside. We see ourselves without seeing ourselves enveloped in the scroll or the sails of this inside/outside, led on by another revolving door of the unconscious, exposed to another coming of the other. And it can be sensed, differently, for the "Web," this W/W/W or World Wide Web that a network of computers weaves all about us, across the world, but also all about us, *in us*.

Think about the “addiction” of those who travel day and night in this WWW. They can no longer do without these world crossings, these voyages by sail [*à la voile*], or veil [*au voile*], crossing or cutting through them in its turn.

LA QUINZAINE LITTÉRAIRE: With the computer, word processing, and the immediacy of the screen, aren't we caught up in an endless, indefinite text? Whereas the book has the merit of cutting short, at one go.

DERRIDA: Yes, we don't know what tomorrow will be made of,⁵ but you feel that the publishing machine, the market for books, printing, and even libraries—in short the ancient world—still all play the role of a cut-off point. The book is both the apparatus and the expiration date that make us have to *cut off* the computer process, put an end to it. This stoppage dictates the end to us, the copy is snatched away from us—“Here, now you must make an end of it”—and there is a date, a limit, a law, a duty, and a debt. It *has* to be transferred to another kind of support. Printing has to happen. For the time being, the book is the moment of this stoppage, the pressure to switch off. The day is coming, will come, when the off-switch or cutoff point—the *interrupteur*—which will never disappear (it is essentially impossible), will no longer be the order of another kind of support, paper, but another audiovisual device, perhaps the CD-ROM. This will be like another arrangement of the cutoff points. The word *interrupteur*—cutoff point—doesn't have a negative meaning in my view. There have to be cutoffs, that's the condition of any form, the very formation of form.

For my own part, I can say that ultimately I accept mutations. And by the same token I accept a certain fetishism of the book that their increasing rarity will be bound to further. *Of Grammatology* named and analyzed the “end of the book,” but not at all in celebration of this.⁶ I believe in the value of the book, which keeps something irreplaceable, and in the necessity of fighting to secure its respect. Fortunately, or unfortunately—I don't know which to say—we will see what could be called, with a change of emphasis, a new religion of the book. Another bibliophilia will follow in the tracks of the book, everywhere that it will have to yield its place to other kinds of support.

LA QUINZAINE LITTÉRAIRE: Will there be the equivalent of bibliophilia in relation to CD-ROMs or floppy disks?

DERRIDA: Probably. Some particular draft that was prepared or printed on some particular software, or some particular disk that stores a stage of a work in progress—these are the kinds of things that will be fetishized in the future. I already know writers who keep the first versions of an essay or novel or poem on disk. Once these computer archives have been locked (because it will always be easier to use them without leaving any trace), they will have a very different kind of allure. You can feel that is on the way too. Even the computer belonging to the “great writer” or “great thinker” will be fetishized, like Nietzsche’s typewriter. No history of technology has wiped out that photograph of Nietzsche’s typewriter. On the contrary, it is becoming ever more precious and sublime, protected by a new aura, this time that of the means of “mechanical reproduction”; and that would not necessarily contradict the theory of mechanical reproduction put forward by Benjamin. Some computers will become museum pieces. The fetishizing drive has no limits, by definition; it will never let go.

As for those people who, nowadays, don’t themselves use either typewriters or computers, you can count them on the fingers of one hand. I do know some . . .

LA QUINZAINE LITTÉRAIRE: So do I. Our friend Pierre Vidal-Naquet . . .

DERRIDA: Hélène Cixous, Michel Deguy . . . When you give your work to be typed, you reconstitute a sort of “master-secretary” relationship, whether you like it or not. A dictation relationship—one thinks of Goethe, for instance. But there are many of us who do without a secretary. Structurally, the secretary is no more. Those who want to go on marking the authority of their position call on secretaries, even if they also know how to use a computer. I can’t imagine a French president, a high official or a minister, typing on their computers. In the old-fashioned way they correct by hand the speech prepared by someone else, and give it back to be made into a “clean” copy. So now, as it happened once upon a time through alphabetic writing, a kind of democratization is happening through the use of the machine (provided you can pay for the thing! the prices don’t go down that quickly . . .).

LA QUINZAINE LITTÉRAIRE: You can tell who’s the master—the one with no machine on the desk.

DERRIDA: It’s the old figure of the master—the political leader, the

thinker, the poet. No machine. No direct relationship with the machine. The relationship with the machine is secondary, auxiliary, mediated by the secretary-slave—too often, and it's not accidental, by the *woman* secretary. We should speak about the word processor, power, *and* sexual difference. Power has to be able to be mediated, if not delegated, in order to exist. At any rate—and this is not always different—to appear.

LA QUINZAINE LITTÉRAIRE: It could be said that the text that appears on the screen is a phantom text. There is no longer any matter, any ink. Now there is only light and shadows, whereas the book is a dense, material object.

DERRIDA: The figure of the text "processed" on a computer is like a phantom to the extent that it is less bodily, more "spiritual," more ethereal. There is something like a disincarnation of the text in this. But its spectral silhouette remains, and what's more, for most intellectuals and writers, the program, the "software" of machines, still conforms to the spectral model of the book. Everything that appears on the screen is arranged *with a view* to books: writing, lines, numbered pages, coded indications of forms (italics, bold, etc.), the differences of the traditional shapes and characters. There are some tele-writing machines that don't do this, but "ours" still respect the figure of the book—they serve it and mimic it, they are wedded to it in a way that is quasispiritual, "pneumatic," close to breathing: as if you had only to say the word and it would be printed.

LA QUINZAINE LITTÉRAIRE: This is perhaps taking us a bit far from word processing, even if, in one way, it is an extension of the problematic. The original subject was: "What does the word processor represent for you, a philosopher?" The contribution made by the writing machine, the typewriter, was not all that radical, as you have stressed yourself.

DERRIDA: As to knowing what word processing changes for philosophy, and not only (it hardly matters, in fact) for my work, I'm always wondering what would have happened to Plato, Descartes, Hegel, Nietzsche, and even to Heidegger (who really knew without knowing the computer), if they had encountered this "thing," not only as an available tool but also as a subject for reflection. From Pascal to Descartes to Leibniz to Heidegger, by way of Hegel, philosophers have certainly thought about calculating machines, thinking machines, translating machines, formalization in general, and so on. But how would they have interpreted a culture with the

tendency to be dominated, even in daily life, and across the entire universe, by these types of technological devices for writing and archiving? Because everything is involved here—the relationships of thinking to the “image,” to language, to ideas, to archiving, to the simulacrum, to representation. How would Plato have had to write what we call the “myth of the cave” so as to take account of these transformations? Would he only have had to change the rhetoric of his teaching, or would he have had to think quite differently about the ontological structure of the relationships between ideas, copies, simulacra, thought and language, and so on?

LA QUINZAINE LITTÉRAIRE: Until quite a recent period, which we could locate at the end of the Middle Ages, the transcription we have, the text, is never the author’s, from his hand to the quill. With the signed manuscript there appeared a new configuration that would last for a number of centuries and which we are now coming out of, to return to the point of departure, the separation of the powers of thought and writing.

DERRIDA: There is certainly a sort of parenthesis there, several centuries long. In Greece in the fifth and fourth century B.C.E., in Plato’s time, the manuscript was not an object of veneration. The signature did not yet figure; it only started to be fetishized much later on. This is not the end but we are probably moving to another regime of conservation, commemoration, reproduction, and celebration. A great age is coming to an end.

For us, that can be frightening. We have to mourn what has been our fetish. The compensations and the fetishistic substitutes confirm that the destruction is going on (you know, I don’t believe there are limits to fetishism, but that’s another story, if not another subject). We are frightened and rejoicing witnesses. We have experienced the transition from the pen to the typewriter, then to the electric typewriter, then to the computer, and all this in thirty years, in a single generation, the only one to have made the whole crossing. But the voyage continues . . .

LA QUINZAINE LITTÉRAIRE: Word processing doesn’t only raise problems about writing but also, in the shorter or longer term, problems about transmission.

DERRIDA: Yes, serious problems. Because of what we were saying just now, that the text is instantly objectified and transmissible, ready for publication, it is virtually public and “ready for printing” from the moment of its writing. We imagine, or we tend to believe or make people believe, that

everything recorded in this way then counts as a publication. What circulates on the internet, for instance, belongs to an automatic space of publication: the public/private distinction is increasingly being wiped out there, with the lawsuits, the allegations of rights and legitimation that proliferate from that, but also the movements toward the appropriation of the *res publica*. Today this is one of the big political issues—it *is* politics. For better and for worse, in a way that was justifiable in some cases, less justifiable in others, the barrier, the “cutoff,” the book’s stopping point, still protected a process of legitimation. A published book, however bad, remained a book evaluated by supposedly competent authorities: it seemed legitimate, and sometimes sacred, because it had been evaluated, selected, and consecrated. Today, everything can be launched in the public sphere and considered, at least by some people, as publishable, and so having the classic value, the virtually universal and even holy value of a public thing. That can give rise to all sorts of mystifications, and you can already see it, even though I have only very limited experience of what happens on the internet. Say about deconstruction, these international Web sites welcome and juxtapose extremely serious discussions, or ones that are publishable, and then chitchat that is not just dreary but also without any possible future. (It is true, and don’t let’s ever forget it, that that can also happen at conferences or in journals, academic and otherwise.) There are already learned journals on the internet. They reproduce all the conventional procedures for legitimation and publication; the only thing missing is the paper, so they save on printing and distribution costs. Inversely—and this is true of the media in general—as discussion is more open and anyone can have access to it, there is on the other hand some possibility of critique being encouraged and developed where sometimes those exercising the classical form of evaluation could play a censoring role: the choices of editors or publishing outfits are not always the best ones; there are repressions; things get marginalized or passed over in silence. A new freeing up of the flow can both let through anything at all, and also give air to critical possibilities that used to be limited or inhibited by the old mechanisms of legitimation—which are also, in their own way, word-processing mechanisms.

Digital Locks and the Automation of Virtue

Ian Kerr*

*“And what is good, Phaedrus,
And what is not good —
Need we ask anyone to tell us these things?”¹*

A. INTRODUCTION

Of all the “lock and key” narratives in the western cannon,² I think my favorite is the legend of the Gordian knot. Midas, the son of King Gordius,

* This chapter derives from two keynote addresses delivered in 2006 at New York University and the Banff Centre. I would like to thank Helen Nissenbaum, Michael Zimmer and Greg Hagen for those very special invitations. Thanks also to Niva Elkin-Koren and Abraham Drassinower for sharing their memorable insights following those lectures and to Dan Hunter, old bean, for making me promise to one day put the NYU keynote into writing (yes, I am slow to deliver). My work has — then and now — enjoyed tremendous support from the Social Sciences and Humanities Research Council and the Canada Research Chairs program and I am grateful for their generous contributions. Thanks also to Jennifer Barrigar, Michael Geist, David Matheson, Jason Millar, and the anonymous peer reviewers for their invaluable comments on an earlier draft. Special thanks to Golsa Ghamari, Sinziana Gutiu, and Kristen Thomasen for their brilliance, and for the high quality of research assistance that they so regularly and reliably provide. Saving the best for last, my extreme gratitude goes out on this one to Katie Szilagyi — engineer, law student *par excellence* and proud owner of these fine footnotes — for grace under pressure, her tireless enthusiasm, her ability to find anything under the sun, her insatiable intellectual curiosity, and her deep-seated disposition for *arête* . . . which she has not only cultivated for herself but, through collaboration, inspires in others.

1 Robert Pirsig, *Zen and the Art of Motorcycle Maintenance: An Inquiry into Values* (New York: Bantam, 1974) (epigraph).

2 For example, in the tale of Ali Baba and the Forty Thieves, the treasure chamber remained locked and inaccessible until the key — in this case the code words “Open

intricately tied the famous knot. It was initially fabricated as a physical lock. Woven in unfathomable complexity, the knot fastened his father's famous ox-cart³ to a wooden post. As the Greek historian Plutarch described it, Midas tethered the ox-cart, "fastened to its yoke by the bark of the cornel-tree . . . the fastenings so elaborately intertwined and coiled upon one another that their ends were hidden."⁴ Secured by the knot, Midas intended the cart to remain locked within the palace compound of the former kings of Phrygia at Gordium as an enduring legacy of his family's rule. However, due to a prophecy of the oracle of Telmissus, the knot became known not so much for what it prevented as for what it would one day permit. Indeed, the multitudes that sought to disentangle it over the years never intended to steal the cart. Rather, they hoped to fulfill the oracle's prophecy that, "was believed by all the barbarians, that the fates that decreed that the man who untied the knot was destined to become ruler of the whole world."⁵

Perhaps because of this rather strange divination, the Gordian knot became known in the region as a seemingly intractable puzzle, an intel-

Sesame!" — was uttered aloud. See Katie Daynes and Paddy Mounter, *Ali Baba and The Forty Thieves* (London: Usborne Publishing, 2007). In a famed fairy tale, heroine Rapunzel is locked in her tower with no way of entry, mandated to release her long hair as the golden stair/access key whenever the evil enchantress demands. When the enchantress discovers Rapunzel has been allowing a male suitor to also climb upon her hair, it is cut off — removing the key to the tower. Jacob Grimm, Wilhelm Grimm & Dorothee Duntze, *Rapunzel*, trans. by. Anthea Bell (New York: North-South Books, 2007). The Lion, The Witch and the Wardrobe, one of C.S. Lewis' most famous stories from "The Chronicles of Narnia" series, uses a wardrobe as the gateway to the magical land of Narnia. The children are transported to Narnia, forgetting their real home in the process. They remain locked in Narnia until a lamppost triggers their memories. Their memories are the key to unlocking the wardrobe, enabling them to arrive back home. See C.S. Lewis, *The Lion, The Witch and The Wardrobe* (London: Geoffrey Bles, 1950).

- 3 Midas and his father, Gordius, appeared in town on the fabled ox-cart at a particularly auspicious time. An oracle had foretold that the new king would be brought to the Phrygians upon an ordinary ox-cart and that the appearance of an eagle would signify future greatness. Gordius was proclaimed king, ending the civil war in the region, and beginning the Phrygian dynasty. See Graham Anderson, *Folktale as a Source of Graeco-Roman Fiction: The Origin of Popular Narrative* (Lewiston, NY: Edwin Meller Press, 2007) at 53. For the significance of the Gordian knot, see Lynn E. Roller, "Midas and the Gordian Knot" (1984) 3:2 *Classical Antiquity* at 256–71. For discussion of the legend of Midas more generally, see Lynn E. Roller, "The Legend of Midas" (1983) 2:2 *Classical Antiquity* at 299–313.
- 4 Plutarch, *The Age of Alexander: Nine Greek Lives By Plutarch*, trans. by Ian Scott-Kilvert (Harmondsworth: Penguin Books, 1973) at 271.
- 5 *Ibid.*

lectual lock requiring an intellectual key. According to the legend, numerous puzzlers visited the palace with the hope of unlocking the mystery of the knot and winning the kingdom. Many tried and failed over the years. Finally, in one version of the legend, Alexander the Great discovered a solution during his visit to the palace; he swiftly drew his sword, slicing through the knot rather than untying it by hand.

For the most part, history has declared Alexander the hero of the prophecy. His defiant, brute force solution of hacking the knot with his sword has become a metaphor not only for resolving difficult problems by unanticipated means, but “with a single dramatic stroke.”⁶ Having abstracted the problem as one of freeing the ox-cart from the post rather than seeing it merely as a problem of manually untying the knotted cord, the Alexandrian solution is a quintessential example of the gestalt shift,⁷ and of the idea that true problem solving often requires violating established conventions. The Alexandrian solution also reminds us that anything that can be built can be un-built, anything that can be locked, unlocked.

This chapter is about digital locks. Like the Gordian knot, digital locks are, in part, designed as a restraint on the use of property. Only, these newer technical protection measures (TPMs) employ cryptographic rather than physical entanglements with the aim of precluding people from using digital works in ways that the copyright owner does not wish. Digital locks can be wrapped around music, movies, books, newspapers and other digital content to prevent or limit access to those works, or to control the number of copies made. They can also be woven into the code of electronic devices such as computers, e-book readers, phones and other media players to restrict customers from using competitors’ applications and products. Like the Gordian knot, digital locks can be hacked. And, not unlike the

6 W. Russell Neuman, Lee McKnight, & Richard Jay Solomon, *The Gordian Knot: Political Gridlock on the Information Highway* (Cambridge: The MIT Press, 1997) at ix.

7 The gestalt shift refers to an abrupt, involuntary shift in perception that enables an observer to see something in a different manner. The object of the shift is unaltered; the only change is in the viewer’s perception of the object. The German word “gestalt” means “shape” or “form” in English. The sudden refocusing is said to take place suddenly and *in toto*. Celebrated examples include an image of a duck that can also be seen as a rabbit or an image of two women in profile facing one another that can also represent a vase. The shift from one to another takes place instantaneously and encompasses the totality of the image — it is not a matter of degrees. See Robert Wade, “Gestalt Shift: From ‘Miracle’ to ‘Cronyism’ in the Asian Crisis” (February 2002), London School of Economics and Political Science Development Studies Institute, www2.lse.ac.uk/internationalDevelopment/pdf/WP25.pdf. See also Robert Angelo, “Gestalt Shift,” www.roangelo.net/logwitt/gestalt-shift.html.

oracle of Telmissus, some digital lock-makers have even tendered challenges to would-be hackers to try to crack their codes, proffering rewards in exchange for details about how the lock might be defeated.⁸ Recognizing that all locks can be broken, many of those who employ digital locks have sought the further protection of law, lobbying lawmakers to make it illegal to circumvent digital locks.⁹

-
- 8 The Secure Digital Music Initiative (SDMI) was a project designed to prevent digital music sharing through the implementation of anti-piracy measures such as watermarking. To assist in the creation of a robust security system and aid in identifying possible holes in four potential technologies, SDMI issued a public challenge to researchers in the field. Over the course of three weeks in September 2000, researchers were invited to download the watermarked music files and attempt to remove the watermarks. A team of researchers from Princeton and Rice Universities, headed by computer scientist and security expert Edward Felten, successfully met the challenge, removing all four different watermarks without degrading the quality of the music files. They opted against signing a confidentiality agreement that would have made them eligible for the cash prize. Instead, the team wrote a paper detailing their findings, which they planned to present at a 2001 conference. The Recording Industry Association of America (RIAA) and SDMI threatened legal action under the *Digital Millennium Copyright Act* for circumventing an owner's copyright protections (despite having been previously invited to do exactly that), if the findings were made publicly available. Felten chose not to publish under this threat, instead initiating his own lawsuit against SDMI under freedom of expression. The lawsuit was later dismissed by the United States District Court of New Jersey for lack of standing, but it remains a key example to highlight differences in security policies. Felten's paper was not intended to be a "how-to" guide for the layperson, using technical language that would have been unintelligible to everyone but those who intimately understood the technology. From a full disclosure perspective, disclosing the weaknesses of a security system will aid its creators in identifying any loopholes and strengthening protection measures as quickly as possible. In contrast, a security from obscurity viewpoint, seemingly preferred by the RIAA and SDMI in this case, would favour keeping information about system weaknesses secret, hoping that no one will identify them. Felten commented on this issue in particular, stating that the weaknesses in the technology were clear and that interested parties would overcome them, regardless of whether or not his paper was published. See Electronic Frontier Foundation, "*Felten, et. al. v. RIAA, et. al.*" http://w2.eff.org/IP/DMCA/Felten_v_RIAA. See also Electronic Frontier Foundation, "Final Hearing Transcript, *Felten v. RIAA* (Nov. 28, 2001)" http://w2.eff.org/IP/DMCA/Felten_v_RIAA/20011128_hearing_transcript.html. See also Scarlet Pruitt, "Silenced Professor Sues SDMI, RIAA" *PCWorld* (6 June 2001), www.pcworld.com/article/52006/silenced_professor_sues_sdmi_riaa.html.
- 9 This letter from the US Motion Picture and Television Industry and Labour Organizations to USTR Ambassador Ron Kirk regarding ACTA Negotiations showcases the vested interests of entertainment industries in robust legislative copyright protections. Letter from Motion Picture Association of America *et al.* to Ambassador Ron Kirk (22 September 2009), www.mpaa.org/resources/ace3793e-cfaf-4749-96ae-385f38506268.pdf.

In this chapter, I investigate various potential uses of digital locks and the social consequences of creating laws that would make it illegal to circumvent them. I suggest that laws protecting an unimpeded use of digital locks — such as the one recently tabled in Canada¹⁰ — are Gordian in the sense of the oracle's prophecy. That is, these laws will ultimately cause digital locks to become better known for what they permit than for what they preclude. This, I claim, is because digital locks are the key technology underlying a relatively new and extremely powerful form of social control: *the automation of permissions*.¹¹

While the policy debate about digital locks has to date focused almost exclusively on their narrow role in copyright reform,¹² I will argue that

In the Canadian context, while a new Conservative cabinet was being sworn in on 6 February 2006, a lobbyist for the Canadian Recording Industry Association named David Dyer emailed the Director General of Canadian Heritage's Copyright Policy Branch recommending organizing an event about copyright reform. See Michael Geist, "CRIA's Lobby Effort: The Untold Story" (11 June 2006), www.michaelgeist.ca/index.php?option=com_content&task=view&id=1293.

- 10 Bill C-32 is the third bill designed to amend Canada's *Copyright Act* in recent years. Its predecessors, Bill C-60 and Bill C-61, both died on the order paper due to dissolution of Parliament. Bill C-32, *An Act to amend the Copyright Act*, 3d Sess., 40th Parl., 2010, www2.parl.gc.ca/HousePublications/Publication.aspx?Docid=4580265&file=4 [Bill C-32]. Bill C-61, *An Act to amend the Copyright Act*, 2d Sess., 39th Parl., 2008, www2.parl.gc.ca/HousePublications/redirector.aspx?RefererUrl=Publication.aspx%3fDocid=3570473%26file%3d4. Bill C-60, *An Act to amend the Copyright Act*, 1st Sess., 38th Parl., 2005, www2.parl.gc.ca/HousePublications/redirector.aspx?RefererUrl=Publication.aspx%3fDocid=2334015%26file%3d4.

- 11 Though not labeled as such, what I am calling the "automation of permissions" is a key strategy in the development of what Professor Lawrence Lessig refers to as a "permission culture"; see Lawrence Lessig, *Free Culture: How Big Media Uses Technology and the Law to Lock Down Culture and Control Creativity* (New York: The Penguin Press, 2004), www.free-culture.cc/freecontent at xiv, 8, 173, 192–93. I will elaborate on both of these concepts below.

- 12 Andrew A. Adams & Ian Brown, "Keep Looking: The Answer to the Machine is Elsewhere" (2009) 19 *Computers & L.* 32 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1329703; Nika Aldrich, "A System of Logo-Based Disclosure of DRM on Download Products" (29 April, 2007), www.ssrn.com/abstract=983551; Stefan Bechtold, "Digital Rights Management in the United States and Europe" (2004) 52 *Am. J. Comp. L.* 323, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=732825; Dan L. Burk & Tarleton L. Gillespie, "Autonomy and Morality in DRM and Anti-Circumvention Law" (2006) 4 *Triple C: Cognition, Communication, Cooperation* 239, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1146448; Lee A. Bygrave, "Digital Rights Management and Privacy — Legal Aspects in the European Union" in Eberhard Becker *et al.*, eds. *Digital Rights Management: Technological, Economic, Legal and Political Aspects* (New York: Springer, 2003) 418, http://folk.uio.no/lee/publications/DRM_privacy.pdf; Julie E. Cohen, "DRM & Privacy" (2003) 18

digital locks are of even greater social significance when properly understood in light of their role in larger digital rights management (DRM) systems that are employed well beyond the copyright context. I will argue that the broader automation of permissions through DRM is the enabler

Berkeley L. & Tech J. 575, www.law.berkeley.edu/journals/btlj/articles/vol18/CohenStripped.pdf; Carys J. Craig, "Digital Locks and the Fate of Fair Dealing in Canada: In Pursuit of 'Prescriptive Parallelism'" (2010) 13 J. World Intellectual Property 503, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1599610; Jeremy F. DeBeer, "Locks & Levies" (2006) 84 Denv U.L. Rev. 143, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=952128; Peter Drahos, *A Philosophy of Intellectual Property* (Sudbury MA: Dartmouth Publishing Group, 1996), <http://epublications.bond.edu.au/blr/vol8/iss2/7/>; Edward Felten, "A Skeptical View of DRM and Fair Use" (2003) 46 Communications of the ACM 4 at 57-59, <http://cacm.acm.org/magazines/2003/4/6849-a-skeptical-view-of-drm-and-fair-use/fulltext>; Daniel J. Gervais, "The Purpose of Copyright Law in Canada" (2006) 2 UOLTJ 2 at 315, http://works.bepress.com/daniel_gervais/10; Kamiel J. Koelman, "The Levitation of Copyright: An Economic View of Digital Home Copying, Levies and DRM" (2005) 4 Ent. L. Rev. 75, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=682163; Niva Elkin-Koren, "Making Room for Consumers Under the DMCA" (2007) 22 Berkeley Tech. L.J. 1119, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1024566; Michael Geist, "Anti-Circumvention Legislation and Competition Policy: Defining a Canadian Way?" in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 211, www.irwinlaw.com/pages/content-commons/anti-circumvention-legislation-and-competition-policy--defining-a-canadian-way---michael-geist; Tarleton L. Gillespie, "Designed to 'Effectively Frustrate': Copyright, Technology, and the Agency of Users" (2006) 8 New Media & Society 651, <http://nms.sagepub.com/content/8/4/651.abstract>; Graham Greenleaf, "Unlocking IP to Stimulate Australian Innovation: An Issues Paper" (2008) 44 University of New South Wales Faculty of Law Research Series, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1398604; Lawrence Lessig, *Code: Version 2.0* (New York: Basic Books, 2006), <http://codev2.cc/>; Mark Perry, "Rights Management Information" in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 251, www.irwinlaw.com/pages/content-commons/rights-management-information---mark-perry; Matthew Rimmer, *Digital Copyright and the Consumer Revolution: Hands off my iPod* (Cheltenham: Edward Elgar Publishing, 2007), http://works.bepress.com/matthew_rimmer/1; Pamela Samuelson & Jason Schultz, "Regulating Digital Rights Management Technologies: Should Copyright Owners Have to Give Notice About DRM Restrictions?" (2007) J. Telecomm. & High Tech. L. <http://people.ischool.berkeley.edu/~pam/papers/notice%20of%20DRM-701.pdf>; Pamela Samuelson, "Digital Rights Management {and, or, vs.} the Law" (2003) 46 Communications of the AC 4, <http://portal.acm.org/citation.cfm?id=641205.641229> at 41; Kimberlee G. Weatherall, "On Technology Locks and the Proper Scope of Digital Copyright Laws — Sony in the High Court" (2004) 26 Sydney L. Rev. 613 <http://works.bepress.com/kimweatherall/2>; Peter K. Yu, "Anticircumvention and Anti-anticircumvention" (2006) 84 Denv. U.L. Rev. 13 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=931899.

and catalyst of a potentially debilitating world, in which technology can be used to shift social defaults from inclusion to exclusion by disabling human action across a wide range of activities for all those who do not have prior permission from those controlling the DRM. While a well-established body of literature has very thoughtfully and carefully investigated the risks that excessive legal protection of digital locks can pose to access to information,¹³ freedom of expression,¹⁴ privacy,¹⁵ encryption research,¹⁶

-
- 13 Bernt Hugenholtz, "Copyright, Contract and Code: What Will Remain of the Public Domain," (2000) 26 Brook. J. Int'l L. 77; Michael Geist, "Canada Rejects One-Sided Approach to Copyright Reform" *The Toronto Star* (28 March 2005), www.michaelgeist.ca/resc/html_bkup/mar282005.html.
 - 14 Ian R. Kerr & Jane Bailey, "The Implications of Digital Rights Management for Privacy and Freedom of Expression" (2004) 2 Info. Comm. & Ethics in Society 87; Mark Perry and Casey Chisick, "Copyright and Anti-circumvention: Growing Pains in a Digital Millennium," (2000) New Zealand Int. Prop. J. 261, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1622851; Kamiel J. Koelman, "The protection of technological measures vs. the copyright limitations," ALAI Congress 2001, www.ivir.nl/publications/koelman/alaiNY.html; David Nimmer, "A Riff on Fair Use in the Digital Millennium Copyright Act," (2000) 148 U. Pa.L.Rev. 673.
 - 15 Julie E. Cohen, "DRM & Privacy" (2003) 18 Berkeley L. & Tech J. 575, www.law.berkeley.edu/journals/btlj/articles/vol18/Cohen.stripped.pdf; Lee A. Bygrave, "The Technologisation of Copyright: Implications for Privacy and Related Interests" (2002) 24 European Intellectual Property Review 2 at 51; Ian Goldberg, "Privacy-enhancing technologies for the Internet, II: Five Years Later" (2002) Workshop on Privacy Enhancing Technologies, www.cypherpunks.ca/~iang/pubs/pet2.pdf at 1–2; Daniel J. Solove, *The Digital Person: Technology and Privacy in the Information Age* (New York: New York University Press, 2004).
 - 16 See *Amicus Curiae* Brief in Support of Appellants, *Universal v. Reimerdes* (26 Jan 2001), www.2600.com/dvd/docs/2001/0126-crypto-amicus.txt. ("The *amici curiae* are cryptographers, individuals whose work or hobby involves research, design, analysis, and testing of encryption technologies. *Amici* are concerned that Section 1201 of the *Digital Millennium Copyright Act* ("DMCA"), as construed by the District Court . . . would deprive cryptographers of the most effective language in which to communicate their research and its results, with the effect of weakening security systems and technological protection of data for the public."); Severine Dusollier, "Electrifying the Fence: The Legal Protection of Technological Protection Measures for Protecting Copyright" (1999) 21 Eur. Int. Prop. R. 285, www.crid.be/pdf/public/4138.pdf; Yochai Benkler, "Free as the Air to Common Use: First Amendment Constraints on Enclosure of the Public Domain" (1999) 74 N.Y.U. L. Rev. 354 at 419; Lawrence Lessig, *Code: Version 2.0* (New York: Basic Books, 2006), <http://codev2.cc/>; Edward Felten *et al.*, "Lest We Remember: Cold-Boot Attacks on Encryption Keys" (2009) 52 Communications of the ACM 5 at 91, <http://citp.princeton.edu/pub/cold-boot.pdf>.

freedom to tinker,¹⁷ education,¹⁸ and copyright's delicate balance between owner and user rights,¹⁹ my aim in this chapter is to make a more fundamental — perhaps foundational — claim.

I argue that a generalized and unimpeded use of digital locks, further protected by the force of law, threatens not merely the above enumerated legal rights and freedoms but also threatens to significantly impair our moral development. In particular, I express deep concern that digital locks

-
- 17 According to Ed Felten, the freedom to tinker “is your freedom to understand, discuss, repair and modify the technological devices you own.” See Ed Felten, “My Experiment with ‘Digital Drugs’” *Ed Felten’s Blog*, www.freedom-to-tinker.com/blog/felten.
- 18 Samuel E. Trosow, “The Changing Landscape of Academic Libraries and Copyright Policy: Interlibrary Loans, Electronic Reserves, and Distance Education,” in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 375, www.irwinlaw.com/pages/content-commons/the-changing-landscape-of-academic-libraries-and-copyright-policy--interlibrary-loans-electronic-reserves-and-distance-learning---samuel-trosow; C. Risher, “Technological protection measures (anti-circumvention devices) and their relation to exceptions to copyright in the Electronic environment” (Paper presented to the IPA Copyright Forum Frankfurt Book Fair, 20 October 2000) [unpublished]; Neil Postman, *The End of Education: Redefining the Value of School* (New York: Alfred A. Knopf, 1996) at 192; Dan L. Burk & Julie E. Cohen, “Fair Use Infrastructure for Copyright Management Systems” (2001) 15 Harv. J.L. & Tech. 41 at 63, www.law.georgetown.edu/Faculty/jec/fairuseinfra.pdf.
- 19 Abraham Drassinower, “Taking User Rights Seriously” in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 479, www.irwinlaw.com/pages/content-commons/taking-user-rights-seriously---abraham-drassinower; Jane Bailey, “Deflating the Michelin Man: Protecting Users’ Rights in the Canadian Copyright Reform Process” in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 125, www.irwinlaw.com/pages/content-commons/deflating-the-michelin-man--protecting-users-rights-in-the-canadian-copyright-reform-process---jane-bailey; Jeffrey P. Cunard, “Technological Protection of Copyrighted Works and Copyrighted Management Systems: A Brief Survey of the Landscape” *ALAI Congress 2001*, www.alai-usa.org/2001_conference/pres_cunard.doc at 2; Michael Geist, “TPMs: A perfect storm for consumers” *The Toronto Star* (31 Jan 2005), www.michaelgeist.ca/resc/html_bkup/jan312005.html; Canadian Internet Policy and Public Interest Clinic, Media Release, “CIPPIC Questions Unbalanced Copyright Bill” (20 June 2005), www.cippic.ca/documents/Media_Release_-_Copyright_Bill_-_20_June_05_Final.pdf; Charles Clark, “The Answer to the Machine is in the Machine,” in Bernt Hugenholtz, ed., *The Future of Copyright in a Digital Environment: Proceedings of the Royal Academy Colloquium* (The Hague: Kluwer Law International, 1996); Garry L. Founds, “Shrink-wrap and Clickwrap Agreements: 2B or Not 2B?” (1999) 52 Fed. Comm. L.J. 99; Daniel B. Ravicher, “Facilitating Collaborative Software Development: The Enforceability of Mass-Market Public Software Licenses” (2000) 5 Va. J.L. & Tech. 11.

could be used in a systematic attempt to “automate human virtue” — programming people to “do the right thing” by constraining and in some cases altogether eliminating moral behaviour through technology rather than ethics or law. Originally introduced to improve the human condition, digital locks and other automation technologies could, ironically, be used to control our virtual and physical environments in unprecedented ways, to eliminate the possibility for moral deliberation about certain kinds of action otherwise possible in these spaces by disabling the world in a way that ultimately disables the people who populate it. Not by eliminating their choices but by automating them — by removing people from the realm of moral action altogether, thereby impairing their future moral development.

I begin in Section B with a series of historical and cultural vignettes investigating the nature, purpose and symbolic significance of locks. Recognizing that keys are in fact “the key” to a proper understanding of locking systems, I go on in Section C to examine digital locks and the power afforded to keyholders to control others through the automation of permissions, in effect enabling or disabling the world we live in by setting the terms and conditions for its use. Section D is where I illustrate this through a connected series of anecdotes from my own personal experience. Here, I sketch the potential progression of a widespread digital lock strategy through a series of developments in “carting” technologies and indicate what this might mean. In Section E, I ask how all of this might affect us as moral actors who desire to do good things. Examining Aristotle’s account of virtue ethics, I demonstrate that a state sanctioned, unimpeded and widespread digital lock strategy would impair our moral development by impeding our ability and desire to cultivate the practical wisdom necessary for the acquisition of morally virtuous dispositions. Finally, in Section F, I briefly investigate Bill C-32, Canada’s proposal for sanctioning the use of digital locks and prohibiting their circumvention. Arguing that the flaws in Bill C-32 are symptomatic of the larger digital lock strategy, I conclude that the proposed legislative solution is inelegant — a brute force formula that fails to achieve a balanced copyright framework. I suggest that those who use digital locks might sometimes owe a positive obligation to provide a key whenever someone else has a right to access or use the thing that has been locked-up. I further suggest that the laws protecting digital locks, like the digital and mechanical locks themselves, must be understood as something more than instruments of exclusion since a series of ubiquitous locks designed to keep people honest will in fact impair the development of a deep-seated disposition necessary for honesty.

B. LOCK AND KEY

Prior to the invention of locks, people, like animals, often buried their valuables, or hid them in caves or the trunks of trees.²⁰ This rather imperfect means of securing their belongings eventually gave way to innovation. As is evident from the legend of the Gordian knot, cords and ropes were initially used to tie things down. The strength and complexity of the Gordian knot, for instance, was used to physically hamper theft of the king's ox-cart by tethering it to a post firmly rooted in the ground. It was not long before it was discovered that knots could be used in other ways. For example, the "thief knot,"²¹ was employed not to hamper but to monitor possible intruders by detecting whether property had been tampered with. This early technology was simple but ingenious.²² The design of the thief knot very closely resembled the popular maritime "reef knot."²³ A sailor using this technique would "secure" his belongings in a ditty bag using the thief knot, often with the ends hidden.²⁴ If another sailor untied the knot and rifled through the bag—even if he took nothing—it was likely that he would re-tie the bag using the more common reef knot, revealing to the owner that the bag had been tampered with.²⁵

While techniques such as these offered some measure of security, it was the advent of mechanical locks that truly changed the game. It is thought that the earliest locks were constructed approximately 4,000 years ago.²⁶ However, the first archaeological discovery of a wooden lock—now known as the "Egyptian door lock"—dates back to the reign of Sargon II, who is believed to have used this technology to secure his palace in Khorsabad, near Nineveh, where he reigned from 722 to 705 B.C.²⁷ Its basic mechanism was a large wooden bolt used to secure a door, which had a slot with

20 Access Key and Lock, "A Brief History of Locks," (2010) www.keyandlocksupplies.co.uk/80665/info.php?p=15 [Access Lock].

21 Colin Jarman, *Top Knots*, (London: Quintet Publishing, 2001) at 32–33. See also Lindsey Philpott, *Pocket Guide to Knots*, (Singapore: New Holland Publishers Ltd., 2006) at 158–59.

22 The underlying strategy of the thief knot is utilized to this day in modern cryptographic techniques.

23 Jarman, above note 21 at 32; Philpott, above note 21 at 158.

24 Jarman, *ibid.* at 40; Philpott, *ibid.* at 160.

25 This is because the thief knot unties itself if the lines are pulled when the same action would seize a reef knot.

26 The Keyless Lock Store, "Ancient Roman Key Gallery and a Brief History Lesson" (2010), www.nokey.com/ankeymus.html [Keyless Lock Store].

27 "Schlage's History of Locks!" Dafor OY, www.locks.ru/germ/informat/schlagehistory.htm [Schlage].

several holes in its upper surface. The holes were filled with wooden pegs that prevented the bolt from being opened.²⁸ The design enjoyed significant longevity and is in fact the forerunner to modern pin tumbler locking systems used today.²⁹

The remainder of the lengthy but extremely interesting history of locks—from pin tumblers to warded locks to levers and double-acting levers to tubular locks to digital encryption³⁰—can for present purposes be understood as a series of innovations spurred to some degree by the monetary incentives of the patent system but, for the most part, by the ever-escalating arms race between lock-makers and lock-breakers.³¹ It is probably fair to say that, throughout the centuries, there are really only two basic means of securing mechanical locks. The first is “by means of fixed obstructions to prevent wrong keys from entering or turning in the locks. The other, which is superior, employs one or more movable detainers, which must be arranged in pre-selected positions by the key before the bolt will move.”³²

There is an old Irish proverb that says, “A lock is better than suspicion.”³³ Locks offer an ability to exclude others. They seek to prevent others from exercising control over us, and our possessions. As the proverb suggests, locks are a reassuring alternative to the insecurity we can feel when our possessions remain vulnerable to the incursions of others. For this reason,

28 *Ibid.*

29 Lock and Key—History, (2010), <http://science.jrank.org/pages/3989/Lock-Key-History.html>.

30 The following websites provide similar accounts of the timeline of the development of locks: Keyless Lock Store, above note 26; Schlage, above note 27; Brian Morland, “The History of Locks Museum” *History of Locks*, www.historyoflocks.com [Lock Timeline].

31 There is a growing competitive movement called “locksport” that involves learning the theory of locks, analyzing the devices and figuring out ways to quickly defeat the systems without destroying them. These lockpickers thrive on the intellectual thrill of beating all sorts of locks, but oppose attempts to use the skill for mischievous purposes. “Competitive Lockpicking Growing in US Popularity” NPR (28 July, 2010), www.npr.org/templates/story/story.php?storyId=128815821. To learn more about the history of lock picking, please refer generally to “Secrets of Lock Picking” by Steven Hampton, as a great example of providing accessible information to anyone who is looking to learn how to pick locks. Steven Hampton, *Secrets of Lockpicking* (Boulder: Paladin Press, 1987).

32 Access Lock, above note 20.

33 In Irish Gaelic, the expression is: “*Is fearr glas ná amhras.*” See Island Ireland, “Irish Proverbs with English Translations,” <http://islandireland.com/Pages/folk/sets/proverbs.html>.

locks are historically and culturally understood to be a crucial and indispensable technological development in the protection of private property. Locks have a long and rich history of use in the attempt to prevent theft and destruction.³⁴ Not surprisingly, the popular understanding of the proper function of a lock is exclusion. Locks keep intruders out. Locks protect private property. Locks prevent wrongdoing.

Then again, there is an even older Yiddish expression that, “A lock is good only for an honest man.”³⁵ In other words, a thief looks at a lock as an inconvenience but not necessarily as a form of prevention. A lock is unlikely to dissuade an unwavering lock-picker who has significant resources, skill, knowledge and time.³⁶ Especially if s/he believes that there is a legal right to defeat the lock. Locks have *never* been perfect technologies of exclusion. All locks can be defeated. Today, the Internet operates as a force multiplier in this respect by making it easy to share the means of defeating locks *en masse*.³⁷ Even though there are many custom-made locks, safes and security systems that are in fact quite difficult to defeat, considerations of efficiency, cost and convenience usually undermine the security that locks are meant to provide. As one expert in the field recently put it:

there is a basic conflict between security and convenience in the lock field. For example, the use of high-security locks has been resisted by American car-makers because of the difficulties drivers would encounter in finding rare blanks and the machines to cut the keys. Most people talk security, but they really want convenience.³⁸

Consequently, it is fair to say that our everyday use of mass market locks is part of a broader “security theatre” — the adoption of *apparent* security

34 Lock Timeline, above note 30.

35 See Kehillat Israel Reconstructionist Synagogue, “Yiddish Sayings, Proverbs, Phrases, Aphorisms, Curses, and Insults,” http://kehillatisrael.net/docs/yiddish/yiddish_pr.htm.

36 Although, even a standard lock can hamper a lesser intruder, and the disturbance generated in circumventing a decent lock (e.g., breaking windows) will deter many would-be thieves, shifting their attacks to weaker targets.

37 One could spend days browsing tens of thousands of techniques on websites ranging from answer.com to YouTube. See, e.g., “Lock Pick Guide, How to Pick a Lock,” www.lockpickguide.com; Lock Picking 101, “Lockpicking, Locksmithing, Locksport, Locks and Picks,” [/www.lockpicking101.com](http://www.lockpicking101.com); Howcast, “How to Pick Any Padlock or Combination Lock,” www.youtube.com/watch?v=rRcBNJMoFlw.

38 Quote attributed to Richard Berry, product development manager for Sargent Manufacturing Co. in New Haven, Conn. Quoted in Steven Ashley, “Under lock and key,” (1993) 115 *Mechanical Engineering* 62 at 67.

measures in order to provide *the feeling* of improved security while doing considerably less than might be supposed to improve actual security.³⁹ In this sense, historical and present day use of standard locks can to some extent be understood as a kind of convention or ritual, a leap of faith in which we place unfounded trust in the mysterious mechanism of lock and key. Whether the lock is mechanical or conceptual, digital or analog, “we religiously follow this ritual, often many times each day, [though] few are fully aware of what mechanical forces have been activated, but we have fulfilled a very fundamental psychological need.”⁴⁰ “Locking-up” allows us to go out into the world and carry out our daily routines with the *belief* that our homes and possessions are safe. In this respect, we are not unlike the ancients, who believed the iron used to make locks was *apotropeic*—counteracting the forces of evil and all malevolent spirits that tried to enter people’s homes, churches, and storage areas through keyholes and other openings.⁴¹

The ritualistic aspect of “locking-up” is illustrated by a 700-year-old ceremony that still takes place every single night⁴² in England at the Tower of London:

Every night, at exactly seven minutes to 10 o’clock, the Chief Yeoman Warder of the Tower emerges from the Byward Tower wearing

39 The term security theatre has been used to describe the implementation of security initiatives that are palliative in nature. Such procedures are designed to reassure users that measures have been taken for their protection, often in response to a crisis or tragedy. Bruce Schneier describes security theatre as “countermeasures [that] provide the feeling of security instead of the reality.” His examples include placing unarmed guards in airports following the 9/11 terrorist attacks and introducing tamper resistant packaging following the random Tylenol poisonings of 1982. Air travelers were comforted by the presence of guards and consumers were set at ease by the addition of a thin seal. The fact that either measure could be easily overcome was irrelevant; as Schneier explains, “[m]ost people are comforted by action, whether good or bad.” See Bruce Schneier, *Beyond Fear: Thinking Sensibly About Security in an Uncertain World* (New York: Copernicus Books, 2003) at 38–40.

40 Lock Timeline, above note 30.

41 “Protective Iron,” History of Locks (22 January 2008), www.historicallocks.com/en/site/hl/Articles/Locks-and-keys-in-folklore/Protective-iron.

42 The single exception occurred during WWII during an air raid on London on 16 April 1941. After a number of incendiary bombs fell on the old Victorian guardroom just as the Chief Yeoman Warder came through the Bloody Tower archway, he stood up, dusted himself off and carried on. It is said that The Tower holds a letter from the Officer of the Guard apologizing to King George VI for the delay in the ceremony, along with a reply from the King which says that the Officer is not to be punished as the delay was due to enemy action. See Colonel E.H. Carkeet-James O.B.E., M.C., *His Majesty’s Tower of London* (London: Staples Press Limited, 1950) at 48. See also “Ceremony of the Keys,” www.trooping-the-colour.co.uk/keys/index.htm.

his long red coat and Tudor bonnet. He carries in one hand a candle lantern and in the other hand the Queens Keys. With solemn tread he moves along Water Lane, to Traitor's Gate where his escort, provided by one of the duty regiments of Foot Guards, awaits him. He hands the lantern to an escorting soldier and the party moves to the outer gate. On the way, all guards and sentries salute the Queen's Keys. After locking the outer gate the Chief Yeoman Warder and escort retrace their steps. The great oak gates of the Middle and Byward Towers are locked in turn. They now return along Water lane towards Traitor's Gate where, in the shadows of the Bloody Tower archway, a sentry awaits.

"Halt, who comes there?" the sentry barks.

"The Keys!" answers the Chief Yeoman Warder.

"Whose Keys?"

"Queen Elizabeth's Keys"

"Pass Queen Elizabeth's Keys" replies the sentry, "and all's well"

The party then proceeds through the Bloody Tower archway and up towards the broadwalk steps where the main guard is drawn up. The Chief Yeoman Warder and escort halt at the foot of the steps and the officer in charge gives the command to the Guard and Escort to present arms. The Chief Yeoman Warder moves two paces forward, raises his Tudor bonnet high in the air and calls "God preserve Queen Elizabeth." The guard answers "Amen" exactly as the clock chimes ten and 'The Duty Drummer' sounds The Last Post on his bugle. The Chief Yeoman Warder takes the keys to the Queen's House and the guard is dismissed.⁴³

Although there are several accounts of the origin of the key ceremony, the one offered on tours at the Tower of London explains that it was initiated by Richard II in response to mob violence during the Peasant Revolt of 1381, reminding us of the kind of devastation that can take place when our homes (and castles) are not adequately locked.⁴⁴ Indirectly, it also reminds us of the power afforded to the key-holder. Indeed, lock technolo-

43 *His Majesty's Tower of London*, *ibid.* at 48.

44 While several competing origin stories can be found on the Internet, anecdotal experience suggests that this is the origin story favoured by the Yeoman Guards at the Tower of London. See Marilyn Doore, "The Ceremony of the Keys at the Tower" *Suite 101* (28 December 2009), www.suite101.com/content/the-ceremony-of-the-keys-at-the-tower-a156218.

gies are not properly or adequately understood without simultaneously examining the role and significance of keys.

Technically speaking, a key is a piece of metal mechanically fashioned through the shape of its bit to match the pins, wards or levers in the locking apparatus. However, throughout history, keys have been regarded as much more than just a mechanism. Ancient Greek and Roman keys — like well-crafted statues or carvings — were elegant and artistic.⁴⁵ Often ornate and cast in bronze, keys were status symbols indicating that their possessor had property worth protecting.⁴⁶ In ancient times, the number of keys a person owned was a measure of his importance as the head of a household.⁴⁷ Keys were large and cumbersome and slaves were often needed to carry them all. Having several key bearers indicated a person of great wealth and distinction.⁴⁸

Of course, the symbolism of keys transcends wealth and stature. Conceptually, it is crucial to remember that keys not only lock — they unlock. Keys are therefore a “symbol of all forces that open and close, bind and release.”⁴⁹ From this perspective it is wrongheaded to understand lock technologies merely as instruments of private property. The power of the key includes the power to exclude. But, surely, it is much more than that. *Keys give us the power to open or close, to turn on or turn off, to grant or deny, to allow or forbid.*

These broader social powers are represented across various cultural domains. For example, several classical paintings portray Christ handing Peter the keys to the kingdom of heaven.⁵⁰ Catholic teachings have inter-

45 World cultures have afforded considerable clout to locks and keys throughout the ages. For example, in China, miniature padlocks were traditionally given to newborn babies as a talisman. Animal-shaped padlocks would be used to convey messages. A fish padlock is always on guard, since fish sleep with their eyes open; an elephant padlock connotes strength. Ceremonial padlocks were also placed around the waists of expectant mothers, with a knotted cord being placed around a pregnant woman, which would remain until another ceremony in the ninth month. See “Ancient Style Padlocks,” *History of Locks*, www.historyoflocks.com/padloo2.html#secret.

46 “History of Keys” *Historical Locks* (23 November 2007), www.historicallocks.com/en/site/hl/Articles/HistoryAboutLocks/History-of-keys.

47 *Schlage*, above note 27. Gender specific language is, unfortunately, intentional.

48 *Ibid.*

49 “Definition of keys,” *Historical Locks*, (12 January 2008), www.historicallocks.com/en/site/hl/AboutHistoricalLocks/Definition-of-keys/.

50 This often-used illustration comes from bible verse Matthew 16:18–20: “I tell you that you are Peter, and on this rock I will build my church, and the gates of Hell will not overcome it. I will give you the keys of the kingdom of heaven; whatever

preted this to mean not that St. Peter would act as gatekeeper of heaven, but instead as his clout over the church on Earth. Indeed, the succession of the papacy has been referred to as the “passing of the keys,”⁵¹ as the ruling Pope assumes Peter’s authority to serve as interpreter of the word of God, for “whatever Peter ‘binds’ as a legal obligation on Earth is bound in heaven; whatever he looses in loosed in heaven.”⁵² The “power of the keys,” in this context, has been interpreted to include the very real and highly political power to admit or exclude from church membership, to set church policy and teachings, to render binding interpretations of sacred scripture, and to bind and loose sins.⁵³

Heavenly destinations aside, keys to the gates of a city also carried significant symbolic power through until at least the 18th century.⁵⁴ By keeping unwanted strangers out, the keys to the city represented its inhabitants’ right to security and self-determination.⁵⁵ The surrender of a city to an attacking army was historically symbolized by turning over

you bind on earth will be bound in heaven, and whatever you loose on earth will be loosed in heaven.” Famous depictions include the fresco “Christ Giving the Keys to St. Peter” in the Sistine Chapel by Pietro Perugino and “The Delivery of the Keys to St. Peter” by Bernardo Strozzi. See Peter Perugino, “Frescoes on the side walls of the Sistine Chapel” *Web Gallery of Art*, www.wga.hu/frames-e.html?/html/p/perugino/sistina/index.html; “European: 1600–1800” *Chazen Museum of Art* (2005), http://chazen.wisc.edu/collection/paintings/euro_pt2.htm#.

51 See generally Francis A. Burkley-Young, *Passing the Keys: Modern Cardinals, Conclaves, and the Election of the Next Pope* (Oxford: Madison Books, 1999).

52 Richard P. McBrien, *The HarperCollins Encyclopedia of Catholicism*, (New York: HarperCollins Publishers Inc., 1995) s.v. “keys, power of the” at 735.

53 *New Catholic Encyclopedia*, Vol. 8, (Washington: The Catholic University of America, 1967) s.v. “Keys, Power Of” at 172.

54 Indeed “key to the city” ceremonies take place to this day as a way of honouring individuals for significant accomplishments. For example, Harry Winkler, better known to television audiences as Arthur “The Fonz” Fonzearelli of television’s hit 70s TV show *Happy Days* currently holds the keys to the cities of Dallas, New Orleans, and Winnipeg. According to news reports, Winkler grew up with undiagnosed dyslexia and has since gained recognition as a children’s author, a source of inspiration for those with learning disabilities. Winnipeg mayor Sam Katz admits that bestowing this honour upon Winkler was spurred by most young men in the 1970s who wanted to wake up to be as cool as “The Fonz.” See “Fonzie gets key to the city” *CBC News Canada* (26 March 2010), www.cbc.ca/canada/manitoba/story/2010/03/26/mb-winkler-fonz-key-winnipeg.html. See also “Actor who played The Fonz on ‘Happy Days’ receives key to Winnipeg city” *CTV Edmonton* (29 March 2010) http://edmonton.ctv.ca/servlet/an/local/CTVNews/20100329/100329_happydays/20100329/?hub=CP24Entertainment.

55 “The Keys to the City” *Historical Locks* (22 January 2008), www.historicallocks.com/en/site/hl/Articles/Locks-and-keys-in-art/The-keys-to-the-city.

its keys to the conquerors. In one classic example, the Bayeux tapestry portrays the Duke Conan ensnared within the tower of the city and despairingly handing over the keys to the castle of Dinan to William the Conqueror.⁵⁶ Similarly, the Spanish painter Velázquez's famous portrait of "The Surrender of Breda (1625)" celebrates the Dutch governor of Breda meekly handing over the key to the city to Spanish general Ambrosio de Spinola.⁵⁷ Ironically, Spanish culture did not always have a great deal of trust in locks and keys. At a later point in its history, householders would hire a watchman to invigilate their neighbourhood, who would carry at once the keys to all of the dwellings in that neighbourhood. To enter or leave a house, residents would clap to summon the watchman, such that all comings and goings became a matter of public record.⁵⁸ In this context, locks enabled personal privacy, while control of the keys by a trusted third party offered accountability.⁵⁹

While this last example suggests that in the broader security context lock and key are flipsides of the same coin, most historical and technological accounts tend to focus on the lock alone. This is potentially problematic when the ultimate goal is to develop law and policies about locks. The narrower focus on locks creates a misperception in most lay people — *including those responsible for drafting the so-called "digital lock" provisions in Canada's copyright reform bill* (Bill C-32) — who come to think of locks, narrowly, as mere instruments of exclusion used to protect private property.

While locks can and do perform this function, our brief consideration of the significance of keys suggests a richer understanding of the nature and function of locking technologies. This more robust understanding of locking mechanisms recognizes symbolic and actual power stemming not from the fact that these mechanisms can be locked but, rather, that they

56 On plate 26 of the tapestry, the defenders of the castle of Dinan are pictured resisting the invading Norman troops, while the Normans set fire to the castle. Then Conan surrenders, and transfers the keys of the castle from his lance to William's. See Sir Frank Stenton, ed., *The Bayeux Tapestry: A Comprehensive Survey* (London: Phaidon Press, 1957).

57 Pedro Marrades, *Velázquez Y Su Siglo* (Madrid: Espasa-Calpe, S.A., 1953) at 347. See also Robert Harvard, *The Spanish Eye Painters and Poets of Spain* (Woodbridge: Tamesis, 2007) at 33.

58 Schlage, above note 27.

59 Not much has changed in the digital realm, where trusted third parties are used in public key infrastructures (PKI) to authenticate transactions through the creation, management, distribution, use, storage, and revocation of digital certificates. See Carlisle Adams & Steve Lloyd, *Understanding PKI: Concepts, Standards, and Deployment Considerations*, 2d ed. (Boston: Pearson Education, Inc., 2003).

can be unlocked. The fact that locks are *made* to be unlocked suggests that, unlike other security barriers, the essence of their design is not simple or systematic exclusion, but something else. From the perspective of the intended key-holder, locks provide an access-control device that is premised on the notion of appropriate or authorized permission.

Although this point is not commonly acknowledged in typical discussions of locks, it is certainly well known by those working in the security field. Here is how security expert, Bruce Schneier, articulates this point in his leading text, *Beyond Fear*:

The problem with securing assets and their functionality is that, by definition, you don't want to protect them from everybody. It makes no sense to protect assets from their owner, or from other authorized individuals (including the trusted personnel who maintain the security system). In effect, then, all security systems need to allow people in, even as they keep people out. Designing a security system that accurately identifies, authenticates, and authorizes trusted individuals is highly complex and filled with nuance, but critical to security.

It's not sufficient to protect a valuable asset by encasing it in stone or steel, or by sending it to outer space, or by posting armed guards around it. With a very few exceptions, all security barriers need to be penetrated—under authorized circumstances by trusted people. The barrier needs a system that facilitates penetration, and additional systems to determine who is trusted. Buildings and safes have doors and keys or combinations so authorized people can open them. A casino slot machine has a locked door that lets maintenance personnel repair and refill the machine; it also has an opening through which players can collect their winnings—another avenue of penetration, for the user who has been temporarily “authorized” by a winning spin.

The additional security requirements needed to make a barrier conditionally penetrable necessitate an enormous effort of planning, design, and execution: What was once a simple system becomes a complex one. A barrier is designed to keep attackers out; but since we need to allow people in, we must make a barrier that can be penetrated in authorized circumstances and can't be penetrated under any other circumstances. We need to punch a hole in the barrier and then control access to that hole. Our intentionally created holes—windows and doors, for example—are far and away the most frequent avenues for unauthorized entry. The holes we intentionally put in a

barrier are very often the weakest link, since they make the security of the barrier depend on the security of the hole and its own systems: identifying the trusted people who are allowed in, the circumstances under which they are to be allowed in, and what privileges they are to have once inside. These ancillary systems of identification, authentication, and authorization are far more complex and subtle than they seem. Understanding the security of barriers means understanding the security of these systems.⁶⁰

As Schneier's lengthy passages reveal, locks are as much technologies of permission as they are technologies of exclusion. The best locking systems not only prevent access to interlopers but also grant access to those who have or ought to have permission. This cannot easily be achieved with a typical mechanical lock since it is difficult to ensure that its key-holder always has permission.⁶¹ This is where digital locks are thought to come into play. Whereas the point of a mechanical lock is to guarantee the key-holder automatic entry, the more sophisticated digital locks automate the actual permission with stunning precision. As will be discussed in the section that follows, digital locks can be used in conjunction with automated identification and authentication systems to ensure that the key-holder is, or ought to be, authorized to do whatever the lock would otherwise preclude. But, as we shall also see, digital locks can do much more than that.

C. DIGITAL LOCKS

Not surprisingly, the invention of digital locks coincided with the advent of digital property. Digital locks are Gordian knots for content owners, a digital antidote to Stewart Brand's famous revelation that "information wants to be free":

Information wants to be free. Information also wants to be expensive. Information wants to be free because it has become so cheap to distribute, copy, and recombine — too cheap to meter. It wants to be expensive because it can be immeasurably valuable to the recipient. That tension will not go away. It leads to endless wrenching debate about price, copyright, "intellectual property," the moral rightness

60 Schneier, above note 39 at 181.

61 Since keys can be taken by force, forged, found or can be shared without permission.

of casual distribution, because each round of new devices makes the tension worse, not better.⁶²

Digital locks are the newest round of devices, and the tension Brand refers to is not only the escalating technological arms race between digital lock-maker and lock-breaker but also the legal clash between those who would seek further protection of digital locks through legislation and those concerned about the broader social consequences of doing so. Disentangling the technological from the legal is difficult and to some extent artificial, especially in light of the World Intellectual Property Organization's (WIPO) global imperative to provide legal protection to digital locks⁶³ and the new role that digital locks sometimes play in hybrid techno-legal systems discussed below, known as DRM. Because many others⁶⁴ and I⁶⁵ have

62 Stewart Brand, *The Media Lab: Inventing the Future at MIT* (New York: Viking Penguin Inc., 1987) at 202.

63 Both of the 1996 World Intellectual Property Organization (WIPO) treaties, and the forthcoming Anti-Counterfeiting Trade Agreement (ACTA), include provisions that enhance digital locks through guaranteeing legal protections. In particular, conforming to the requirements of the WIPO treaties is often cited as rationale for increasing domestic protection for technological protection measures. The relevant provisions are Article 11 in the *WIPO Copyright Treaty* and Article 18 in the *WIPO Performances and Phonograms Treaty*. See *WIPO Copyright Treaty*, 20 December 1996, (1997) 36 I.L.M. 65 (entered into force 6 March 2002), www.wipo.int/treaties/en/ip/wct/trtdocs_wo033.html, art. 11 [WCT]; Article 18, *WIPO Performances and Phonograms Treaty*, 20 December 1996, (1997) 36 I.L.M. 76, (entered into force 20 May 2002), www.wipo.int/treaties/en/ip/wppt/trtdocs_wo034.html, art. 18 [WPPT].

64 Above note 12 and accompanying text.

65 Ian Kerr, "If Left To Their Own Devices: How DRM and Anti-circumvention Laws Can Be Used to Hack Privacy" in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 167 www.irwinlaw.com/store/product/120/in-the-public-interest--the-future-of-canadian-copyright-law [If Left To Their Own Devices]; Ian Kerr & Jane Bailey, "The Implications of Digital Rights Management for Privacy and Freedom of Expression" (2004) 2:1 Information, Communication & Ethics in Society 87; Ian Kerr, Alana Maurushat, & Chris Tacit, "Technical Protection Measures: Tilting at Copyright's Windmill" (2002) 34:7 *Ottawa L. Rev.* 13; Ian Kerr, Alana Maurushat, & Chris Tacit, "Technological Protection Measures: Part I — Trends in Technical Protection Measures and Circumvention Technologies" (2004) Department of Canadian Heritage, Copyright Policy Branch, <http://ssrn.com/abstract=705003> [Heritage Report Part I]; Ian Kerr, Alana Maurushat, & Chris Tacit, "Technical Protection Measures: Part II — The Legal Protection of TPMs" (2004) Department of Canadian Heritage, Copyright Policy Branch, <http://ssrn.com/abstract=705081> [Heritage Report Part II]; Ian Kerr, "To OBSERVE AND PROTECT? How Digital Rights Management Systems Threaten Privacy and What Policy Makers Should Do About It" in Peter Yu, ed., *Intellectual Property and Information Wealth: Copyright and Related Rights*, vol. 1 (Westport: Praeger Publishers, 2007).

already written extensively on these broader subjects, my aim in this section⁶⁶ is limited to a brief description of digital locks and DRM, with a particular focus on their role in what I call “the automation of permissions.”

Although digital lock technologies offer an imponderable number of powerful applications across various domains,⁶⁷ their early and current use has been driven primarily by the copyright industries. In the copyright context, digital locks are often encoded within software, films, music, books, games and other digital media. The “digital lock” metaphor is colloquial and provocative no matter what side of the “copyfight” fence you sit on. Not long after this and other phrases entered the public lexicon, WIPO and other like-minded stakeholders sought a more neutral linguistic terrain. Through their efforts⁶⁸ the term “technological protection measure”⁶⁹ or, TPM, has been adopted as the global signifier for the technique of locking-up a digital work.

In its simplest form, a TPM is a technical method employed to control access to work subject to copyright, or to control its subsequent use.⁷⁰ While at first blush this might seem similar in effect to the proverbial lock on the cupboard, TPMs enable an incredibly nuanced level of access control as well as a fine-grained ability to monitor and manage the way that

66 Portions of this section are adapted from my own previous writing on the subject, including my co-authored studies for the Department of Canadian Heritage: Ian Kerr, Alana Maurushat, & Chris Tacit, “Technological Protection Measures: Part I — Trends in Technical Protection Measures and Circumvention Technologies” (2004) Department of Canadian Heritage, Copyright Policy Branch, <http://ssrn.com/abstract=705003>; Ian Kerr, Alana Maurushat, & Chris Tacit, “Technical Protection Measures: Part II — The Legal Protection of TPMs” (2004) Department of Canadian Heritage, Copyright Policy Branch, <http://ssrn.com/abstract=705081>; and a book chapter written for Michael Geist’s previous study of copyright reform in Canada: Ian Kerr, “If Left To Their Own Devices: How DRM and Anti-circumvention Laws Can Be Used to Hack Privacy” in Michael Geist, ed., *In The Public Interest: The Future of Canadian Copyright Law* (Toronto: Irwin Law, 2005) 167, www.irwinlaw.com/content/assets/content-commons/120/Two_03_Kerr.pdf.

67 I shall provide some stark examples in the following sections.

68 WCT above note 60; WPPT above note 60.

69 They are sometimes also referred to as “technical protection measures.”

70 This includes: copying, distribution, performance, and display. See Perry, above note 12. Canada’s recently proposed Bill C-32 defines a TPM as “any effective technology, device or component that, in the ordinary course of its operation, (a) controls access to a work, to a performer’s performance fixed in a sound recording or to a sound recording and whose use is authorized by the copyright owner; or (b) restricts the doing — with respect to a work, to a performer’s performance fixed in a sound recording or to a sound recording — of any act referred to in section 3, 15 or 18 and any act for which remuneration is payable under section 19.” See Bill C-32, above note 10.

digital property is used. For example, techniques have been developed in the field of cryptography to link encrypted files to devices or players comprised of hardware or software so that an encrypted message can only be decrypted using that particular device or player.⁷¹ This is what allows companies like Apple to control the kinds of applications that can operate on their devices⁷² and, to some extent, the kind of content.⁷³ It also allows digital content to be tethered to a particular device or player for a particular period of time.

Perhaps the best current example of this is the e-book, the increasingly widespread use of which has constituted a so-called “revolution.”⁷⁴ More and more, consumers are attracted to this modern spin on an age-old pastime. There is something compelling in the advertising campaign for the

-
- 71 C. Risher, “Technological protection measures (anti-circumvention devices) and their relation to exceptions to copyright in the Electronic environment” (paper presented to the IPA Copyright Forum Frankfurt Book Fair, 20 October 2000) [unpublished].
 - 72 Despite its business model of allowing developers to design and customize applications for the iPhone, Apple retains the ability to remove an application. Jonathan Zittrain has described this practice as “tethering,” raising concerns about external control and autonomy. See Jonathan Zittrain, “The iPhone Kill Switch” *The Future of the Internet and How to Stop It*, (14 August 2008), <http://futureoftheinternet.org/the-iphone-kill-switch>; see also Brad Stone, “Amazon Faces a Fight Over Its E-Books” *The New York Times Online* (26 July 2009), www.nytimes.com/2009/07/27/technology/companies/27amazon.html.
 - 73 For example, Apple CEO Steve Jobs has decreed that Apple products such as the iPad and iPhone will not run Flash-based applications. The official rationale for this decree includes concerns about reliability, prolonging battery life on mobile devices, and most importantly, reliance on cross-platform development tools hindering the creation of Apple-specific products. Another reason for this decision, revealed in an email debate with Gawker.com writer Ryan Tate, is that eliminating Flash offers users “freedom from porn,” since most web-based pornographic videos use the Flash platform. For Apple’s official stance on Adobe Flash, see Steve Jobs, “Thoughts on Flash” *Apple.com* (April 2010), www.apple.com/hotnews/thoughts-on-flash/. For the origin of the phrase “freedom from porn,” see Ryan Tate, “Steve Jobs Offers World Freedom From Porn” *ValleyWag* (15 May 2010), <http://gawker.com/5539717/steve-jobs-offers-world-freedom-from-porn>.
 - 74 For use of the phrase “eBook revolution,” see Mike Elgan, “Here comes the e-book revolution” *Computerworld* (7 February 2009), www.computerworld.com/s/article/9127538/Elgan_Here_comes_the_e_book_revolution. See also John Anderson, “The Ebook Revolution is Irreversible: Digitization is Replacing Physical Publishing” *Suite 101* (24 February 2010), <http://bookpublishing.suite101.com/article.cfm/the-ebook-revolution-is-irreversible>.

Kindle: "Think of a book and start reading it in 60 seconds."⁷⁵ It doesn't hurt that you can also carry around 3,500 e-books all at once. Despite Steve Jobs' (since repressed) assertion that no one reads anymore,⁷⁶ e-books have become the format of choice for many and are stretching the boundaries of the written word. Convenience, economic incentives, aggressive online marketing campaigns, and environmental concerns tied to saving paper have all been given as reasons to embrace e-books.⁷⁷ Younger consumers who have grown up in the digital age and may have felt disenfranchised by old-fashioned books are embracing this new medium with fervor. And the revolution is not only in form but also in substance. E-books have the potential to change not only the way consumers view their books, but also the content of the books themselves. As electronic formats are adopted, it is likely that books will be adapted to better suit these new formats: shorter, timelier, more culturally relevant.⁷⁸ For example, in Japan and South Korea, where cell phone use is ubiquitous, so is the cell phone novella.⁷⁹

With an increasing consumption of literary and artistic works in a digitized form comes the spectre of external control through TPMs. Here, Jonathan Zittrain's description of Apple's products as "tethered appliances" rings true.⁸⁰ As we shall see, this raises questions about what it means to say that a consumer has 'purchased' a book, a song or a movie.

Consider the evolving business model for renting movies. Under the older system of going to a store to rent plastic discs, though it would be inconvenient for the average customer to make illegal copies of those disks, the customer was at liberty to play the movie wherever⁸¹ and as often and

75 Jeff Bezos, "Amazon Debuts a 3G Kindle, and That's Only Half of Jeff's News," [*e-reads*], (29 July 2010) <http://ereads.com/2010/07/amazon-debuts-gen-3-kindle-and-thats-only-half-of-jeffs-news.html>.

76 Well, he said it! This was his first response to the launch of Amazon's Kindle (his second response being the e-book app for his iPad). See John Markoff, "The Passion of Steve Jobs" *The New York Times* (15 January 2008), <http://bits.blogs.nytimes.com/2008/01/15/the-passion-of-steve-jobs/>; see also Michael Wolf, "iPad Fueling Enhanced E-Book Revolution" *Gigaom* (21 July 2010), <http://gigaom.com/2010/07/21/ipad-fueling-enhanced-e-book-revolution/>.

77 Mike Elgan, "Here comes the e-book revolution" *Computerworld* (7 February 2009), www.computerworld.com/s/article/9127538/Elgan_Here_comes_the_e_book_revolution.

78 *Ibid.*

79 *Ibid.* See also William Patry, *Moral Panics and the Copyright Wars* (New York: Oxford University Press, 2009) at 195.

80 Zittrain, above note 72.

81 Subject to regional coding. See e.g., "DVD Regions," www.amazon.co.uk/gp/help/customer/display.html?nodeId=502554. See also "DVD Regions" *Home Theatre Info*, www.hometheaterinfo.com/dvd3.htm.

for as long as she or he wishes, subject to late penalties at the store. Customers not only had the freedom to consume the product however they wished during the rental period but also to share it with others. Using TPMs such as the encryption techniques described above, the movie rental, now downloaded from an online v-tailer, can be limited to the machine used for downloading and can also be programmed to be deleted from that machine at a specified time or, in some cases, at the content owner's whim. Unlike the simple binary (open/close) nature of the analog lock on the neighbourhood video store's door, the level of control afforded by the digital lock puts the content owner/provider, rather than the customer, in the driver's seat. Continuing with the above example, if you did not have a chance to watch the movie you rented before its preset expiry date, or if you wished to keep it a day longer to show it to your roommate the next night,⁸² you no longer have the option of simply keeping it and paying late fees. The movie is automatically disabled (or deleted) and can no longer be viewed by your player.

What this example reveals is that TPMs are in fact much more than a lock in digital clothing. The metaphor of the lock is not nearly strong enough to convey the full power of TPMs. This is one of the reasons why proposals to give digital locks further legal protection is so controversial. TPMs already afford copyright owners protection beyond that which would have been guaranteed by copyright law alone. As Professor Carys Craig has recently described it:

Activities such as reading, listening, and viewing have always been perfectly lawful — and of course desirable from a cultural policy perspective — in the analogue world. *Nothing in the law of copyright would prohibit* someone from flipping through a magazine in a doctor's office, borrowing a novel from a friend, listening to a roommate's music collection, or watching a movie on a home video machine.⁸³

82 But not until she finished her work slavishly formatting footnotes for her professor! I am grateful to Katie Szilagyi and Shea Loewen for sharing their painful experience of this with me, even though good fortune would have it that the movie in question didn't quite live up to the book upon which it was based. (Alas, a different kind of copyright problem . . .)

83 Carys J. Craig, "Digital Locks and the Fate of Fair Dealing in Canada: In Pursuit of Prescriptive Parallelism" (2010) 13 J. World Intellectual Property 503 at 9 [emphasis added].

Professor Craig's point is important to any legitimate attempt at balanced copyright.⁸⁴ But what I like most about the above passage is that its subtle phrasing ("nothing in the law of copyright would prohibit. . .") hints at a far more significant point that has not been carefully articulated in the current literature on digital locks. For starters, TPMs — unlike copyright law — would prohibit, in a digital context, activities that we consider commonplace in the analog world, such as "flipping through a magazine in a doctor's office, borrowing a novel from a friend, listening to a roommate's music collection, or watching a movie on a home video machine."⁸⁵

But, here is the crucial point: by prohibiting these things, TPMs have the ability to radically shift copyright's defaults by automating its system of permissions. Prior to the advent of TPMs, the default for intellectual consumption might have been explained to lay persons through the heuristic of an old adage — "sometimes, it is better to beg for forgiveness than to ask for permission." While obviously hyperbolic and totally inaccurate as an actual statement of the law of intellectual property, in terms of copyright's underlying intellectual consumption defaults, the adage does illustrate the fact that citizens, as consumers, are generally at liberty to consume intellectual products as they think is fair, except to the extent that a content owner subsequently asserts that such consumption is in breach of its copyrights. Citizens are not generally required⁸⁶ to ask content owners or anyone else for *prior permission* every time that they wish to gain access to, read, share or otherwise use someone else's intellectual work (especially those that they have already purchased). This kind of copyright clearance *en masse* would not only fly in the face of fair-

84 As she goes on to say at page 13: "This is the challenge that now presents itself to policy-makers and the Canadian copyright system: how can copyright's delicate balancing act continue to be performed in any meaningful way when the technological environment is increasingly one of absolutes — absolute freedom versus absolute control." *Ibid.*

85 *Ibid.*

86 Although the above is still generally true, there is an expanding resistance by content owners aimed at thwarting a creative process known as "remixing" (the attempt to integrate, change, improve upon or in some other way remake a work that is subject to copyright). According to Professor Lessig, the response by copyright industries seeks to promote what he calls a *permission culture*: "The opposite of a free culture is a 'permission culture' — a culture in which creators get to create only with the permission of the powerful, or of creators from the past." Lessig, above at note 11 at xiv. Digital locks, he thinks, help to ensure that "we are less and less a free culture, more and more a permission culture." Lessig, above at note 11 at 8; See also, Lawrence Lessig, *Remix: Making Art and Commerce Thrive In The Hybrid Economy* (New York: The Penguin Press, 2008).

dealing principles and other user rights, it would cripple most systems of distribution currently in place. That said, in cases where people exceed their rights as users and forgiveness is *not* forthcoming, content owners obviously have the right to seek remedies for copyright infringement by way of legal action.

The digital lock strategy effectively seeks to reverse these intellectual consumption defaults through its automation of permissions. In the case of digital locks it is no longer better to ask for forgiveness (or pay the penalty) since there is no longer anything to forgive or to be penalized for. Returning once again to the movie rental example from above, deliberation over a decision (not) to keep the movie for an extra day is no longer an option. With digital locks, your ability to wait until later to watch the movie that you already rented and paid for is only available by *prior permission*.

Recall, now, my argument in the previous section — that locks are as much technologies of permission as they are technologies of exclusion. Shown in their very best light, TPMs can be used to ensure appropriate or authorized permission. However, as the above examples (and others that will follow) suggest, TPMs can go well beyond appropriate or authorized permission. In fact, TPMs can be employed in even more sophisticated DRMs to automate *all* permissions, shutting down any and every possible course of action except for those pre-selected by the party employing the digital lock. While TPMs might be thought of as the building blocks used to restrict access or use, DRMs are designed to manage an entire array of related activities by using various automation and surveillance technologies to identify digital property and those seeking to use it, in order to technologically enforce certain licensing conditions. In so doing, DRM can be used to automate permission systematically.

In the copyright context, these systems can be used to track royalties or run accounting systems that monitor usage and payment. They enable business models that go beyond sales and subscriptions, including licensing arrangements with variable terms and conditions. But the DRM strategy extends well beyond copyright. More generally, DRM can refer to any “technology systems facilitating the trusted and dynamic management of rights in any kind of digital information, throughout its life cycle, irrespective of how and where the digital information is distributed.”⁸⁷

87 Nic Garnett, “Outline of Presentation of Nic Garnett, representing InterTrust Technologies” (paper presented to the ALAI Congress 2001, June 2001) [unpublished], www.alai-usa.org/2001_conference/pres_garnett.doc at 1. This is a fairly broad definition of DRMs for, as the author notes, “the term DRM has now come to be applied

Typically, a DRM consists of two components. The first component is a set of technologies that could include encryption, authentication, access control, digital watermarking, tamper-resistant hardware and software, and risk management architectures. In the copyright context, such technologies are used to enforce corporate copyright policies and pricing schemes through a registration process that requires purchasers to hand over certain bits of personal information. The second component is a licensing arrangement. This set of legal permissions establishes the terms of use for the digital property by way of contract.⁸⁸

If a TPM is a virtual fence, then a DRM is a virtual surveillance system. The technological components of most full-blown DRMs are linked to a database, which enables the automated collection and exchange of various kinds of information among rights owners and distributors, about the particular people who use their products. This includes users' identities, their habits, and their particular uses of the digital material subject to copyright. The information collected can be employed in a number of ways that go well beyond ensuring access and use that is authorized by copyright laws. As we have seen, DRM-enabled movie players can limit the ability to copy the digital work, restrict its transmission to other users, prevent or limit its transfer to machines other than the one on which it is registered to run, and even set limits on the number of times that the work can be accessed.⁸⁹ In the course of its normal operation, a DRM can even be used to track and record the various uses of works. Consequently, and perhaps most importantly, DRM can be used not only to enforce the rights accorded to content owners pursuant to copyright statutes but can also be used to set entirely new ground rules, giving even more rights to property owners in accordance with the rules that they have set for themselves in the terms and conditions of the licensing arrangement accompanying the DRM, usually on a take-it-or-leave-it basis.⁹⁰

to a variety of different technologies, most of which relate to the control of access to information or to its copying."

88 Gervais, above note 12. Hugenholtz has defined a DRM similarly as a contract, typically a licensing agreement, coupled with technology, typically a technological protection measure such as encryption. See Hugenholtz, above note 12.

89 For a complete overview of the attributes of DRMs, see Gervais, above note 12.

90 Jeffrey P. Cunard, "Technological Protection of Copyrighted Works and Copyrighted Management Systems: A Brief Survey of the Landscape" (paper presented to the ALAI Congress, June 2001) [unpublished], www.alai-usa.org/2001_conference/pres_cunard.doc at 2.

The ability to change the ground rules in this way affords tremendous power to those in a position to employ DRM. Purchasers of Amazon's e-book reader, the Kindle, experienced this power first hand in the summer of 2009 after many law-abiding readers who had legally purchased from Amazon copies of George Orwell's *1984* and *Animal Farm* had those titles auto-deleted from their devices without their consent. According to news reports, Amazon mistook a "no" for a "yes" regarding a publisher's decision to extend its permission to publish Orwell's works in e-book format. Fearing serious sanction from the copyright owners after already having sold many e-copies, Amazon capitulated. Using the power of DRM to change the ground rules, Amazon was able to enter the private digital libraries of their many Kindle customers, to scan all of the titles on each and every active Kindle, and electronically seize the two Orwell books from all those who possessed them. Ironically, it was a classic Orwellian moment. Without a formal recall and without having to make a plea to customers to delete the book, with just a simple mouse click, "The Ministry of Truth" expunged the offending material without notice or permission, rectifying what it perceived as a mistaken past by replacing it with a perfected present.

Other than the irony of deleting Orwell's books without consent and contrary to the licensing agreement, Amazon's DRM is not unusual. As is true in most DRM-enabled distribution systems, the ongoing exchange of personal usage information between user-owned devices and content owner/provider servers takes place in an invisible "handshake" occurring in the software layer. This allows for the transmission of personal usage information from the devices that we own back to the content owner/provider — something Professor Graham Greenleaf cleverly and famously characterized as "IP phone home."⁹¹ The surveillance features associated with the database are crucial to the technological enforcement of the licensing component of the DRM. It is through the collection and storage of personal usage information that DRMs are able to "authorize use" in accordance with the terms of the licensing agreement thereby "managing copyrights." In the Amazon case, "authorizing use" is presumably what allowed Amazon to mistakenly sell those e-books to its customers for profit. "Managing copyright," on the other hand, seemed to include the powers necessary to rectify that mistake, such as snooping customers' book-

91 Graham Greenleaf, "IP, Phone Home: The Uneasy Relationship between Copyright and Privacy, Illustrated in the Laws of Hong Kong and Australia" (2002) 32 Hong Kong Law Journal 35 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=884329.

shelves and auto-deleting digital property that they legally purchased at the content owner's whim.⁹²

Although debacles of this sort rightly tempt critics to focus on DRM's potential for egregious breaches of privacy, access to information, personal autonomy and so forth, my current aim is to demonstrate that there is something much more fundamental at stake. I say this not because the digital locks on DVDs or the Kindle are primitive prototypes of what is likely to come. I say it because these are rather insignificant one-off examples compared to the potential social consequences of a more generalized strategy that uses digital locks to automate permissions writ large. In the next section, I will try to paint a picture of the gradual evolution of a widespread digital lock strategy and what it might mean.

D. CARTING

My concern is not with one kind digital lock technology versus another. Nor is my goal to shock-and-awe by portraying some dystopic digital lockdown. My aim is more straightforward. Through a reflection of my own anecdotal experiences, I want to try to imagine what would happen if we were to generalize copyright's digital lock strategy across other property-based domains. What affect would this have on fundamental legal institutions? And, how might it affect us as moral actors?

In thinking our way through moral problems the great philosopher, Immanuel Kant, famously suggested that we adopt a "categorical imperative" so that we "act only in accordance with that maxim through which you can at the same time will that it become a universal law."⁹³ In our current context we ask: what would it mean to will a universal adoption of a state sanctioned, unimpeded use of digital locks across all property-based domains? To set the stage for answering this question, I have very purposely chosen a low-tech, fairly simple form of property — the cart. In tracking a mere snapshot of its evolution, the carting example is offered as a heuristic

92 During all of this, Jeff Bezos, CEO of Amazon, groveled to his consumer base, admitting that its actions were "stupid, thoughtless, and painfully out of line with our principles." He promised that Amazon would "use the scar tissue from this painful mistake to help make better decisions going forward." What he didn't promise was to remove the DRM or rewrite its licensing conditions so that the auto-delete functionality is no longer possible. See Ian Kerr, "Robot law is taking over," *The Ottawa Citizen* (15 September 2009) <http://iankerr.ca/index.php?view=article&catid=1:latest&id=749:robot-law-is-taking-over&format=pdf>.

93 Immanuel Kant, *Foundations of the Metaphysics of Morals*, trans. by Lewis White Beck (Indianapolis: The Bobbs-Merrill Company, Inc., 1969) at 44.

for envisioning a world wherein the digital lock strategy is adopted much more broadly and then pondering its potential social implications.

Recall that it was King Gordius' famous ox-cart that inspired his son Midas to tie the Gordian knot. Other than its significance in terms of the prophecy of the oracle of Telmissus, one imagines this cart to have been fairly typical, a vehicle with wheels designed to transport items too heavy to carry. As described previously, the king's ox-cart was moored to a post within the palace grounds, preventing anyone unwilling or unable to untie it from moving it very far. Although carts are not always as valuable as the things they are meant to transport, the historic desire to control their use carries forward to present day.

Toy wagons aside, my own experience with carts probably began in my early childhood during a family vacation to Disneyland in the 1970s. Not ironically, this theme park, built in the 1950s and located about 45 minutes from Hollywood, was a key feature of Walt Disney's intellectual property strategy. My favorite part of the Magic Kingdom was unquestionably Tomorrowland. To the best of my recollection, I liked Tomorrowland for pretty much the same reasons that Walt was once said to have liked it:

Tomorrow can be a wonderful age. Our scientists today are opening the doors of the Space Age to achievements that will benefit our children and generations to come. The Tomorrowland attractions have been designed to give you an opportunity to participate in adventures that are a living blueprint of our future.⁹⁴

Tomorrowland was Walt Disney's utopia. My favorite of its many attractions was a go-cart ride cleverly named, "Autopia." Although it is difficult now to imagine, Autopia was initially constructed in 1955 during the early days of the developing freeway system in the United States. With little kids riding wee go-carts along miniature cloverleaves, overpasses and multilane straight-aways, Autopia was a hit from the beginning. It represented a time when the concept of free-flowing, limited-access highways remained an unrealized vision.⁹⁵ It was Walt's conception of the ideal high-

94 Kim Bellotto, Niki Mcneil & Katie Kubush, *In the Hands of a Child: Custom Designed Project Pack -- Disneyland* (Coloma, MI: Hands of a Child, 2007) at 13. See generally Gordon Morris Bakken, *Icons of the American West: From Cowgirls to Silicon Valley* (Santa Barbara: Greenwood Press, 2008).

95 Citizens were fascinated by the abiding dream of the consummate transportation system. At that time, in July 1955, the Santa Ana Freeway was new and legislation to finance the American interstate highway system was still months away from being signed by President Dwight Eisenhower. See Phil Patton, "In Disney's World, a Per-

way — one where the automobile as the icon of personal freedom now survives as a theme park diversion, defying, as one author put it, “the reality of the smog-generating traffic just outside the gates.”⁹⁶ Autopia remains a testament to the enduring quality of this dream; it is the only ride in all of Disneyland that remains today from the original 1955 plan of the park.

But, to those little kids, Autopia was something else. It was an enormous and amazing ride that wide-eyed seven-year-olds were permitted to go on by themselves, unaccompanied by an adult. This was made possible by virtue of the fact that the go-carts were secured by a railing affixed to the roadway. Although the child could speed up or slow down a little bit, the cart would automatically steer itself along the seemingly endless highway, banking on corners and holding steady down the straight-aways. With the usual magic of Disney, the technological infrastructure that made this possible went completely unnoticed by the kids on the ride; they believed that they were actually driving! Through the illusion of technology, Walt had figured out how to build the literal instantiation of Thoreau’s famous observation that, “we do not ride on the railroad; it rides upon us.”⁹⁷

I suggest that Disney’s Autopia is a much richer conceptual model for understanding the risks posed by digital locks than copy-protected DVDs or e-book readers. Rendered invisible, Autopia’s various technological constraints offer the appearance of freedom while in reality disabling the capacity to act through the design of the architecture.⁹⁸ Kids can assume the driver’s seat, veering a little left or right of centre, but the hidden rail always guides them back into the middle. Unlike training wheels on a bicycle, Autopia’s technological infrastructure does not train kids to learn how to drive. In fact it *un-trains* them. Although I had no idea of this as a seven year-old sitting behind the wheel, Autopia’s carts are impossible to crash. What I realized, years later, is that Autopia has passengers, not drivers. On Walt Disney’s highway, *mistakes are not permitted*.

fect Freeway” *The New York Times* (22 August 2005), www.nytimes.com/2005/08/22/automobiles/22CARS.html.

96 *Ibid.*

97 Henry David Thoreau, *The Annotated Walden: Walden; or, Life in the Woods, and Civil Disobedience*, ed. by Philip Van Doren Stern (New York: Clarkson N. Potter, 1970) at 223.

98 As Mark Weiser famously remarked upon coining the term ‘ubiquitous computing in 1991’: “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” Mark Weiser, “The Computer for the 21st Century,” *Scientific American* 94, (September 1991) http://wiki.daimi.au.dk/pca/_files/weiser-orig.pdf.

Then again, neither is good driving. Autopia automates essential aspects of the driving experience so as to ensure desirable outcomes for the property owner. In other words, *no* driving is permitted. Just like copyright's digital locks, the answer to the machine is, once again, in the machine⁹⁹ — which means that it is the property owner who, once again, sits in the driver's seat. All permissions — whether the rider may go north or south, turn east or west — are pre-programmed by the owner of the machine, automated to ensure no possible wrongdoing.

Autopia can be understood as a metaphor for my concern about a generalized digital lock strategy and the automation of permissions. I am concerned about a widespread use of technological constraints — whether in private or public spaces, whether owned or operated by a corporation, a government or an individual — imposed on citizens by property owners who seek total command of their environments. I am concerned because those environments are also our environments. These spaces are crucial to our well-being. They are the playgrounds of our moral development. Yet, digital locks and related techniques allow property owners to eliminate the possibility for moral deliberation about certain kinds of action otherwise possible in these spaces by disabling the world in a way that morally disables the people who populate it.¹⁰⁰ Not by restricting their choices but by automating them — by creating world-altering contrivances that remove people from the realm of moral action altogether, thereby impairing their future moral development.

Consider a second carting example that I experienced some thirty years later. There I was, shopping for groceries at my local Loblaws store, part of Canada's largest food distributor.¹⁰¹ The lot at the strip mall was rather busy that day, so I ended up parking further down, in front of another box store called Michael's Crafts.¹⁰² While trundling a rather large haul

99 Charles Clark, "The Answer to the Machine is in the Machine" in P. Bernt Hugenholtz, ed., *The Future of Copyright in a Digital Environment* (The Hague: Kluwer Law International, 1996) 139. See also Andrew A. Adams & Ian Brown, "Keep Looking: The Answer to the Machine is Elsewhere" (2009) 19 *Computers & L.* 32; Niklas Lundblad, "Is the Answer to the Machine Really in the Machine?" *Proceedings of the IFIP Conference on Towards The Knowledge Society: E-Commerce, E-Business, E-Government* (Deventer, The Netherlands: Kluwer, B.V., 2002) 733, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.101.5735&rep=rep1&type=pdf>.

100 As I argue below, a widespread digital lock strategy results in something I call "moral disability."

101 Loblaw Companies Limited, "ABOUT US: Company Profile" (2001), www.loblaw.com/en/abt_corprof.html.

102 Michaels (2010) www.michaels.com.

of groceries back to my car one winter's morning, my shopping cart came to a grunting halt. At first I thought it was caused by snow or a piece of ice stuck in the wheel. But when I investigated, I discovered the cart was *intentionally disabled*. One of its wheels contained a locking mechanism that had been triggered by an infrared sensor device detecting that my cart had crossed the store's property line.¹⁰³ In order to prevent shopping cart theft and to avoid paying employees to retrieve carts from the four corners of the vast suburban strip mall complex, Loblaws had installed digital locks on their carts to automate the permissions concerning their use. It turns out that my permission to use the Loblaws cart stopped precisely where the property line for Michael's Crafts began. Unfortunately for me, my car was parked a few hundred metres beyond that. There was no one from whom to seek further permission and no one to re-activate the cart. I had to leave the cart on the Loblaws' property, schlep whatever I could carry, and hope that no one stole the rest of the groceries before I could return for a second load.

While novel at the time, this is by now a wholly unremarkable event: something that happens thousands of times a day, everyday, at parking lots across Canada and the US. Except that, the day it happened to me was about one week after Hurricane Katrina rocked New Orleans. Alongside the usual depictions of devastation and ruin, I noticed significant media attention being paid to the imagery of shopping carts, thousands upon thousands of which littered the parking lot and the interior of the New Orleans Convention Center. This should not be surprising. Ever since 1937, when Sylvan Goldman first invented shopping cart technologies as a way to entice people to buy more than they could otherwise carry,¹⁰⁴ uses of the shopping cart have expanded beyond the archetypical shopping experience. Some uses are legal, others illegal. Some are tolerated, others less so. "They have been used as barbecue pits, go-carts, laundry trolleys and shelters. They wind up mostly in apartment complexes, low-income housing and bus stops. Or anywhere else where the person doing the grocery shopping is unlikely to own a car."¹⁰⁵ According to the Food Marketing

103 To learn more about what this looks like, see: Carrtronics LLC, "Carrtronics: Partnering Solutions to Curb Losses and Create Profits" (2009) www.carttronics.com/Resources/TechnologyinAction/tabid/68/Default.aspx.

104 See generally Terry P. Wilson, *The Cart That Changed The World: The Career of Sylvan N. Goldman* (Norman: University of Oklahoma Press, 1978).

105 Kelly Wilkinson, "Wheels of Fortune" *Metroactive News* (3 June 1999), www.metroactive.com/papers/metro/06.03.99/shoppingcarts-9922.html.

Institute in Washington, D.C., global losses total more than \$800 million annually.¹⁰⁶

While digital locks therefore make a lot of sense to grocery retailers,¹⁰⁷ those images of New Orleans gave me considerable pause. Would anyone, including grocery retailers, pass moral judgment on Katrina victims for using those carts as they did? It is difficult to imagine. Especially since the very foundation of our legal and moral institutions are clear that in times of necessity, the institution of property must give way to the preservation of life and other core values.¹⁰⁸ But I was further compelled to imagine: what would have happened had there actually been “effective technological measures”¹⁰⁹ on all shopping carts in New Orleans? What further devastation might have occurred for those thousands of unfortunate people using grocery retailers’ property out of necessity if it had been technologically disabled?¹¹⁰

Remember that the preemptive nature of digital locks leaves no room for forgiveness. Instead, digital locks simply disable the property so that it does not permit of any uses other than its pre-programmed use — which likely would not have contemplated and/or could not otherwise accommodate the range of uses that necessity so often demands. As pre-programmed, preemptive devices meant to automate permissions, digital locks are not law-abiding. To be sure, they can be programmed to comport

106 *Ibid.*

107 The alternative for those retailers would have been to employ shopping cart bounty hunters to “repo” the carts. See Susan Abram, “City Worker is a Wheel Man: Employee Hunts for Abandoned Grocery Carts” *Daily News of Los Angeles* (14 March 2007), www.thefreelibrary.com/CITY+WORKER+IS+A+WHEEL+MAN+EMPLOYEE+HUNTS+FOR+ABANDONED+GROCERY+CARTS...-a0160618096.

108 The principle of necessity generally allows a defendant who commits a private wrong in an effort to protect a person or property from imminent harm to be excused from liability that she would otherwise incur. See, e.g., *Sherrin v. Haggerty* (1953), Carswell Ont 391 (Co. Ct.); *Vincent v. Lake Erie Transp. Co.*, 109 Minn. 456, 124 N.W. 221 (1910). The same general principle applies in criminal law. As stated by Dickson J. in *Perka v. R.*, [1984] 2 S.C.R. 232 at para. 11, “[f]rom earliest times it has been maintained that in some situations the force of circumstances makes it unrealistic and unjust to attach criminal liability to actions which, on their face, violate the law.” The defence of necessity articulated in that case, “rests on a realistic assessment of human weakness, recognizing that a liberal and humane criminal law cannot hold people to the strict obedience of laws in emergency situations where normal human instincts, whether of self-preservation or of altruism, overwhelmingly impel disobedience” (*Perka* at para. 33).

109 To use the language of the WIPO Copyright Treaties, above at note 63.

110 Which is something we should perhaps also ask ourselves *every time* we see a homeless person with a shopping cart.

with simple legal rules to some extent.¹¹¹ And they can be re-programmed if those simple rules are amended. But, generally, these pre-set permissions are unsophisticated and non-negotiable. Lord Denning MR once remarked on this (though he didn't likely know he was talking about "digital locks") in a case involving an automated parking system that only permitted cars to exit the lot upon payment of a fee:

The customer pays his money and gets a ticket. He cannot refuse it. He cannot get his money back. He may protest at the machine, even swear at it; but it will remain unmoved.¹¹²

It is one thing to program a digital lock to accord with the terms of a contract.¹¹³ It is quite another to program digital locks that delicately balance public and private interests—which is precisely what both the necessity principle and, for that matter, the law of copyright would require. In the copyright context, none of the Canadian proposed anti-circumvention rules (i.e., rules that would prohibit breaking a digital lock), including those in Bill C-32, have ever contemplated imposing obligations on property owners requiring them to open digital locks in order to permit access that is appropriate or otherwise authorized by law. At best, the anti-circumvention rules permit self-help remedies (i.e., allowing locks to be hacked) for certain non-infringing purposes¹¹⁴ or as justified by one of the narrow exemptions set out in the legislation.¹¹⁵ Of course, breaking

111 And, even then, only to the extent that the rules are so clear that legal interpretation is unnecessary. In my experience, this is often not the case.

112 *Thornton v. Shoe Lane Parking Ltd.*, [1971] All E.R. 686 at 689, 2 Q.B. 163.

113 Which is the entire purpose of DRM.

114 Shockingly, Bill C-32 does not tie circumvention to an infringing purpose. These new anti-circumvention rules would therefore make it illegal to break a digital lock even in situations where no copyright violation ever occurred. As such, these rules have sometimes been referred to as "paracopyright." See Peter Jaszi, "Intellectual Property Legislative Update: Copyright, Paracopyright, and Pseudo-Copyright" (May 1998), www.arl.org/resources/pubs/mmproceedings/132mmjaszi. See also Ian Kerr, "To Observe and Protect? How Digital Rights Management Systems Threaten Privacy and What Policy Makers Should Do About It," in Peter Yu, ed., *Intellectual Property and Information Wealth: Copyright and Related Rights*, vol. 1 (Westport: Praeger Publishers, 2007).

115 Bill C-32 permits limited circumvention of TPMs for specific purposes: investigations related to the enforcement of laws; activities related to law enforcement and the protection of national security; making computer programs interoperable; encryption research; protection of personal information; access for persons with perceptual disabilities; broadcasting, or telecommunications service on a radio apparatus; and unlocking mobile devices. These provisions, created in s. 47 of the

the lock yourself requires resources and know-how. One can only imagine the further tragedies that would have been reported had Katrina victims been left to their own devices, trying against all odds to re-activate all of those disabled carts.

Consider now a third carting example that I experienced more recently, this time on the golf course. Although I have driven power carts since my dad first showed me how when I was around the age of twelve, I recently experienced “smart carts” while playing for the first time ever on a high-tech golf course. Global positioning systems¹¹⁶ (GPS) is the key technology, allowing golfers to determine the distance between golf ball and green, understand the layout of the course, track the location of their golf balls and chart their progress on a real-time map. They can also track the play of others, contact the snack cart for a beer or hot dog delivery and satisfy a host of other consumer desires. GPS also allows the club’s marshal to know exactly where all players are on the course and how fast or slow they are playing, ensuring an optimal pace of play. The same applications are used by the head greens keeper to monitor employees and valuable golf course assets such as trucks, cars generators, trailers, mowers, sprinklers and the like.¹¹⁷

What I learned that day was that smart carts also had digital locks. After a nice approach shot on the second hole, I was driving my cart toward the green when, all of a sudden, the cart was disabled. I had been driving the cart at a decent clip and it just shut right down. And yet, although it would no longer proceed in the forward direction, I was permitted to reverse the cart away from the green and then it turn in any other direction. I later learned that the cart had been deactivated by a GPS tracking system that used geo-fencing technology¹¹⁸ to immobilize carts that threatened to encroach upon the greens or course boundaries.¹¹⁹

While this may seem (virtually) identical to the shopping cart example just offered there is at least one important difference. Unlike shopping

amendment, would become ss. 41.11–41.18 in the existing *Canada Copyright Act*. See Bill C-32, above note 10 at cl. 47 [Anti-Circ].

116 See generally Ahmed El-Rabbany, *Introduction to GPS: The Global Positioning System*, 2nd ed., (Norwood: Artech House Inc., 2006). See also, Nel Samama, *Global Positioning Technologies and Performance* (Hoboken, NJ: John Wiley & Sons Inc. 2008).

117 For a more detailed descriptions of these features see RavTrack Complete Real-Time Tracking “Golf Course GPS Solutions” 2010, <http://ravtrack.com/Golf-Courses.html> [Ravtrack].

118 Wikipedia, “Geo-Fence,” <http://en.wikipedia.org/wiki/Geofence>.

119 Ravtrack, above note 117.

cart theft, driving toward the green of a golf course or too close to its boundary line is *not* illegal. So it took a while before I grasped the full significance of what had just happened. And, here is how I would describe it. During my previous thirty years of spotty play, golf was regulated by a quaint set of communal norms instilled in newer golfers by those who had truly come to understand and accept the game. “Golf etiquette” was the social instrument for ensuring safety, maintaining the condition of the course, improving the quality of play and showing care and consideration for other players.¹²⁰

To me, etiquette is something to be taken seriously by those who golf. The rules aren’t easily learned and their mastery requires significant trial and error. But there is much to be gained from learning how to behave on a golf course. Among other things, it makes one a member of the community of those who play by the rules. Not those who merely conform to the rules but rather those who follow them because they understand their importance and the reasons why those rules were put into place. This requires adopting what Oxford jurist H.L.A. Hart once called “an internal point of view” of the rules.¹²¹ Those who adopt an internal point of view of golf etiquette see themselves as governed by its rules and accept those rules as the reasons guiding their behaviour on the golf course.

This is precisely what was *not* taking place at the high-tech golf course. There, GPS-enabled digital locks automated an array of permissions that included not only when I could buy hot dogs and beer, where I was permitted to drive and how fast, but also whether I was permitted to breach the rule of etiquette about driving power carts too close to the green — one of a series of rules about taking proper care of the golf course. By disabling my ability to drive too close to the green, the property owners were attempting to automate golf’s social norms. Just like at Disneyland, I was once again being prevented from making mistakes. No longer would I have to pay careful attention to the rules of etiquette or thoughtfully weigh my actions against what I perceived as appropriate behaviour in light of a particular standard of conduct. Technology took care of all of this by proxy. To the property owners utilizing these machines, I was no longer a golfer; I was no longer a person being called upon to make right or wrong decisions about the appropriate standards of conduct on the golf course.

120 See generally Barbara Puett & Jim Apfelbaum, *Golf Etiquette* (New York: St. Martin’s Press, 2003).

121 H.L.A. Hart, *The Concept of Law* (Oxford: Oxford University Press, 1961) at 99.

I had become an autonomic extension of the golf machine, robotized by technology in order to ensure optimal efficiency on the golf course.

Consider, finally, a fourth carting example that I have yet to experience, though I may have the opportunity to do so at the end of my driving career. I say this not because the technology I am about to mention is thought to be such a long way off. I say that it will happen at the end of my driving career because the technology I am referring to is called the “driverless car.”¹²² While this sounds like pure science fiction — didn’t George Jetson have one of these? — it is quickly becoming science fact. General Motors’ VP of Research and Development, Larry Burns, claims “GM will begin testing driverless cars by 2015 and have them on the road by 2018.”¹²³

DARPA, the research agency that developed the precursor to the Internet, issued a competition that took place back in 2007 called “the urban challenge.”

This event required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections. This event was truly groundbreaking as the first time autonomous vehicles have interacted with both manned and unmanned vehicle traffic in an urban environment.¹²⁴

More recently, in 2010, a team of Italian engineers launched what has been billed as the longest-ever test drive of driverless vehicles — a 13,000 km, three-month road trip from Italy to China:

Two . . . vehicles, equipped with laser scanners and cameras that work in concert to detect and help avoid obstacles, are to brave the traffic of Moscow, the summer heat of Siberia and the bitter cold of the Gobi desert before the planned arrival in Shanghai at the end of October.¹²⁵

122 That is, once this technology is adopted, I am by definition no longer a driver. Walt Disney’s *Autopia*, it seems, was not so far off the mark.

123 Chuck Squatriglia, “GM Says Driverless Cars Could Be on the Road by 2018” *Wired* (7 January 2008), www.wired.com/autopia/2008/01/gm-says-driverl.

124 The winning team, Tartan Racing, was awarded \$20 million. See DARPA, “DARPA Urban Challenge,” www.darpa.mil/grandchallenge/index.asp.

125 The Associated Press, “Italy To China In Driverless Vehicles: Italian Team Embarks On 8,000-mile Journey To China Using Driverless Vehicles” *CBS News* (20 July 2010), www.cbsnews.com/stories/2010/07/20/tech/main6694854.shtml.

There are literally hundreds of public and privately funded research consortiums seeking to contribute the future of carting. Projects have included: the US Department of Transportation's "National Automated Highway System Consortium" (NAHS)¹²⁶ and, more recently, Europe's Intelligent Speed Adaption (ISA) — "a collective name for systems in which the speed of a vehicle is permanently monitored within a certain area. When the vehicle exceeds the speed limit, the speed is automatically adjusted."¹²⁷ ISA experiments have expanded to include broad European participation from countries including: Sweden, the Netherlands, Belgium, Denmark, Britain, Finland, Germany, France, Hungary and Spain.¹²⁸ "The standard system uses an in-vehicle digital road map onto which speed limits have been coded, combined with a positioning system."¹²⁹ Not unlike the smart golf carts discussed above, one variant of ISA research contemplates a GPS enabled system that "intervenes directly with the fuel supply. As a result it is impossible to exceed the speed limit."¹³⁰

From ox-carts to go-carts, shopping carts, and golf carts, to the driverless carts of tomorrow's Tomorrowland, we see that the potential for corporations, governments, and individuals to control behaviour by placing digital locks and related technological constraints on the devices we have so deeply come to rely upon in daily life is increasing in exponential fashion. This control now extends well beyond the electronic consumer goods that are of interest to the copyright industries. Indeed, one could easily offer detailed accounts along the lines of my carting example across numerous unexpected domains. To mention just a couple, there has been interesting scholarly work¹³¹ applying the digital lock concept to agricul-

126 National Automated Highway System Consortium, www.path.berkeley.edu/naahsc/pdf/NAHSC-Presentation_Docs.pdf; see also Richard Bishop, "Whatever Happened to Automated Highway Systems (AHS)?," *Traffic Technology International* (August–September 2001), <http://faculty.washington.edu/jbs/itrans/bishopahs.htm>.

127 The Netherlands, Ministry of Transport Transport Research Centre (AVV), "Intelligent Speed Adaptation (ISA): A Successful Test in the Netherlands" by Alex van Loon & Lies Duynstee, www.fatedu/~fdimc/laboratorijske_vaje/Intelligentni_transportni_sistemi/Teme_zastudente/Loon%20et%20al%20Intelligent%20Speed%20Adaptation.pdf at 2.

128 European Commission, "Intelligent Speed Adaptation," http://ec.europa.eu/transport/road_safety/specialist/knowledge/speed/new_technologies_new_opportunities/intelligent_speed_adaptation_isa.htm.

129 ISA-UK, "Project Summary" at 1, www.its.leeds.ac.uk/projects/isa/in_depth/project_summary2.pdf.

130 van Loon and Duynstee, above note 127 at 2.

131 Dan L. Burk, "DNA Rules: Legal and Conceptual Implications of Biological 'Lock-Out' Systems" (2004) 92 Cal. L. Rev. 1, http://papers.ssrn.com/sol3/papers.cfm?abstract_

tural biology, wherein “terminator seeds” have been used in “genetic use restriction technologies” to purposely cause second-generation seeds to be sterile.¹³² Some of my own ongoing research investigates the use of digital locks in human biotechnology, including human-implantable devices such as RFID chips being used to monitor and maintain biological function,¹³³ and cochlear implants, which now use digital locks to offer a menu of sound filters and hearing choices for hearing-impaired customer/patients.¹³⁴ A stunning array of new examples will emerge with increasing interest in artificial organs and, more generally, the merger of humans and machine systems.

The future is but a question mark. Although the looming uses and limits of digital locks across these broad domains remain uncertain, the examples in this section are meant to provoke and inspire deeper thinking about the potential ethical and legal implications of unimpeded and universal adoption of digital locks. Especially given the strategy of preemption adopted by the powerful entities that currently deploy them.

How might all of this affect us as moral actors who desire to do good things?

E. THE AUTOMATION OF VIRTUE

The question mark that punctuates the end of the previous section is meant as an important point of departure from the existing literature on digital locks and their social implications. As Professors Dan Burk and Tarleton Gillespie have correctly noted, “[t]o date the public debate over deployment of DRM, has been almost entirely dominated by utilitarian

id=692061; Jeremy DeBeer “Reconciling Property Rights In Plants” (2005) 8 *The Journal of World Intellectual Property* 5, <http://onlinelibrary.wiley.com/doi/10.1111/j.1747-1796.2005.tb00235.x/abstract>.

132 Thus ensuring Bill Gates’ famous “planned obsolescence” business model not only in our electronic consumer goods but now, also, for agricultural products used for human sustenance, see generally, Giles Slade, *Made to Break: technology and obsolescence in America* (Cambridge: Harvard University Press, 2006).

133 Ian Kerr, “Chapter 19: The Internet of People? Reflections on the Future Regulation of Human-Implantable Radio Frequency Identification” in Ian Kerr, Valerie Steeves, & Carole Lucock, eds., *Lessons From The Identity Trail: Anonymity, Privacy and Identity in a Networked Society* (New York: Oxford University Press, 2009), www.idtrail.org/content/view/799.

134 Ian Kerr, “The Components of Health,” www.iankerr.ca/publications-mainmenu-70/press-mainmenu-76/762-the-components-of-health.html.

arguments regarding the social costs and benefits of this technology.”¹³⁵ Indeed, so far as I know, there is only one published article in the entire literature on digital locks that focuses on autonomy and morality and its authors are Burk and Gillespie. Examining “the moral propriety of laws endorsing and encouraging the deployment of DRM,”¹³⁶ their excellent article offers a deontological analysis focusing on the moral autonomy of information users.

Like these notable scholars, I am interested in the moral repercussions of what they call a “state sanctioned deployment of DRM.”¹³⁷ However, the focus of my inquiry is neither utilitarian nor deontological in nature. I want to know how a state sanctioned, generalized deployment of digital locks (i.e., deployment beyond the copyright sphere) might affect us as moral actors. To this end, I turn instead to the third strand in the holy trinity of ethical theory: virtue ethics.

Ever since Elizabeth Anscombe penned her “complaint”¹³⁸ about modern moral philosophy in 1958, there has been renewed academic interest in the study of virtue ethics. Disenchanted by modern moral philosophy’s fixation with legalistic accounts of ethics and its reliance on utilitarian and deontological conceptions of rights and duties — Anscombe thought that these things generate an unrealistic and absolutist moral oughtism that is rigid and meaningless in a secular society — she pushed for a revitalization of Greek ethics and its questions about the nature of the good life. Like Anscombe, I am interested in these questions. In particular, I wish to consider whether — or how — moral character, virtue and human flourishing might be affected by a state sanctioned, widespread deployment of digital locks.

Although, to my knowledge, it has never previously been characterized in this way, a layperson might reasonably describe the digital lock strategy as an attempt to promulgate the “automation of virtue.” Something like this seems already to be a popular sentiment as is evident in this varia-

135 Dan L. Burk & Tarleton L. Gillespie, “Autonomy and Morality in DRM and Anti-Circumvention Law” (2006) 4:2 Triple C: Cognition, Communication, Cooperation 239, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1146448 at 239.

136 *Ibid.*

137 *Ibid.*

138 Anscombe was correct in characterizing her own work in its final sentence as a “complaint.” Consider, for example, the last line in her opening paragraph where she states her third thesis, namely: “that the differences between the well-known English writers on moral philosophy from Sidgwick to the present day are of little importance.” G.E.M. Anscombe, “Modern Moral Philosophy” (1958) 33 *Philosophy* at 1, www.philosophy.uncc.edu/mleldrid/cmt/mmp.html.

tion on the Yiddish proverb cited earlier — “a lock keeps an honest man honest.”¹³⁹

If something like this is the goal of the digital lock strategy, then my professional prognosis for its success is: negatory. This is because the very notion of automating virtue is an oxymoron. The preemption of wrongdoing does not a virtuous person make. A basic account of Aristotle’s virtue ethics illustrates not only why this is so but also lays the groundwork for demonstrating what is at stake in the attempt to carry out preemption of this sort. In this section, I will argue that a successful, state sanctioned, generalized deployment of digital locks actually impedes the development of moral character by impairing people’s ability to develop virtuous dispositions, thereby diminishing our well-being and ultimately undermining human flourishing. It creates something that I shall call a “moral disability.”

Virtue, in the Greek sense, stems from the word *arête*, which is perhaps best understood as “excellence.” For Aristotle, the achievement of excellences (there are many) is key to human flourishing. Well-being (*eudaimonia*) is something he understood in terms of the unique function of human beings.¹⁴⁰ What sets humans apart from other animals is the possession of reason. So the proper function of human beings is “activity of the soul in accordance with reason.”¹⁴¹ But to be a person of good moral character, one must not simply act in accordance with reason, one must “perform . . . well and finely, and each thing is completed well when it possesses its proper excellence.”¹⁴² Thus, “the human good turns out to be activity of soul in accordance with excellence.”¹⁴³

139 Wolfgang Mieder, Stewart A. Kingsbury, & Kelsie B. Harder, *A Dictionary of American Proverbs* (Oxford: Oxford University Press, 1992). Copyright owners have taken hold of this particular proverb, equating placing a lock on digital content with simply removing the temptation to break the law. In their paper, “Keep Looking, The Answer to the Machine is Elsewhere,” Adams and Brown use the example of a 2003 Congressional committee, in which the Motion Picture Association of America described TPMs as “designed to keep honest users honest.” Princeton University encryption expert Ed Felten quipped in response: “Nothing needs to be done to keep honest people honest, just as nothing needs to be done to keep tall people tall.” See Adams and Brown, above note 12 at 2.

140 Aristotle, *Nicomachean Ethics*, trans. by Sarah Broadie & Christopher Rowe (Oxford: Oxford University Press, 2002) at 1097b20–25. Note: all subsequent references to Aristotle’s *Nicomachean Ethics* will be cited in the classical style, denoted as *Nic. Ethics* followed by the pinpoint (Bekker number).

141 *Nic. Ethics* 1098a5.

142 *Nic. Ethics* 1098a10–15.

143 *Nic. Ethics* 1098a15.

With this we see that each achievement of virtue is an activity. Well-being “consists in the exercise (not the mere possession of) the virtues.”¹⁴⁴ That said, the virtuous character consists in a set of dispositions (*hexeis*)¹⁴⁵ deeply entrenched in the psyche. In good Aristotelian fashion, the development of virtuous dispositions requires both knowing and doing. Most famously, the acquisition of a virtuous disposition requires knowing how and then hitting the right mark (the ‘golden mean’):

excellence of character is an intermediate state . . . it is intermediate between two bad states, one relating to excess and the other to deficiency; and that it is such because it is effective at hitting upon the intermediate in affections and in actions¹⁴⁶

However, it is important to understand that a virtuous act is not determined by its outcome alone. It also depends upon certain facts about the person performing the act. As Professor David Matheson has characterized it, “[t]he particular kind of dispositions of which the virtues consist is brought about by a consideration of their connection to praiseworthy behaviour, which entails not merely doing the right thing but doing it in the right way.”¹⁴⁷ Aristotle sets out three conditions for this, stating that a person’s actions are virtuous,

first, if he does them knowingly, secondly if he decides to do them, and decides to do them for themselves, and thirdly if he does them from a firm and unchanging disposition.¹⁴⁸

As such, “[c]haracter virtue . . . turns out on Aristotle’s account to be deep-seated psychological dispositions to do the right thing (in the relevant context), based on a desire to do the right thing because it is known to be, i.e. recognized as, such.”¹⁴⁹

How, then, is all of this achieved? According to Aristotle, the ability to develop virtuous dispositions to do the right thing based in the desire to

144 Roger Crisp, “Virtue Ethics” in Roger Crisp and Michael Slote, eds., *Virtue Ethics* (Oxford: Oxford University Press, 1997) at 2, www.hrstud.hr/hrvatskistudiji/skripte/filozofija/tbracanovic/Etika1/Crisp-Virtue-Ethics.pdf.

145 Virtue is seen as a tendency or disposition, induced by our habits, to have appropriate feelings. See *Nic. Ethics* 1105b25–6.

146 *Nic. Ethics* 1109a20–24.

147 David Matheson, “Virtue and the Surveillance Society” (2007) 3 *International Journal of Technology, Knowledge, & Society* 133 at 135.

148 *Nic. Ethics* 1105a22–b12.

149 Matheson, above note 147 at 135.

do the right things *knowingly* requires, as a necessary precondition, the cultivation of practical wisdom (*phronesis*).¹⁵⁰ *Phronesis* is a special kind of skill, which requires not only an ability to decide how to achieve a certain end, but also the ability to reflect upon and determine that end. As Professor Roger Crisp has noted, *phronesis* is the skillful acquisition of “sensitivity to morally salient features of particular situations which goes beyond an ability to apply explicit rules.”¹⁵¹ Practical wisdom is therefore not something easily acquired and is the reason Aristotle insisted that one must be of a certain age before one can undertake the study of ethics and the development of virtuous dispositions.

Whereas young people become accomplished in geometry and mathematics, and wise within these limits, young people [endowed with practical wisdom] do not seem to be found. The reason is that *phronesis* is concerned with particulars as well as universals, and particulars become known from experience, but a young person lacks experience, since some length of time is needed to produce it.¹⁵²

Thus the moral attainment of virtue relies fundamentally on practicing, or developing, the virtues in real situations over the course of a lifetime. For, as Aristotle says, “the way we learn the things we should do, knowing how to do them, is by doing them. . . We become just by doing just things, moderate by doing moderate things, and courageous by doing courageous things.”¹⁵³ Grounded in practice, ethical decision-making of this sort insists that each situation be approached as unique, and considered in its completeness. When the virtuous person finds herself in a difficult situation, she will use all relevant knowledge of the virtues (and of human activity in general), according to the salient moral facts of the circumstances as a guide in making her ethical decision.

With even this rudimentary version of Aristotle’s model for understanding and acquiring character-virtue, it is not difficult to see how a universal digital lock strategy would undermine the project of achieving moral excellence.

Honesty, for example, is an intermediary state between an excess and a defect, between exaggeration and fraudulence. To fall short of the mark of honesty is to be dishonest; to exceed it is to be tactless. Among other

¹⁵⁰ *Nic. Ethics* 1144b14-17.

¹⁵¹ Crisp, above note 144 at 6.

¹⁵² *Nic. Ethics* 1142a.

¹⁵³ *Nic. Ethics* 1103a30-31.

things, honesty involves keeping one's promises. In a legal context, this might sometimes mean honouring the terms and conditions of a contract or licensing agreement. As we have seen, DRM is a souped-up contract — i.e., the terms of its licence can be enforced through the operations of digital locks rather than ethical norms. For instance, if the terms of the license accompanying my e-book are such that I undertake to print no more than ten pages of any books that I download from the service, what this really means, practically speaking, is that the device simply will not permit the printing of an eleventh page.¹⁵⁴

The e-book reader's lock "keeps an honest person honest" only insofar as someone like me, who has neither the inclination or know-how needed to circumvent it, will probably print ten pages or less. No breach of contract, no broken promises. And, yet, there is *nothing* approaching virtue in my conduct. Recall Aristotle's three conditions for virtuous action set out above. First, it requires being honest knowingly. But, I did *not* knowingly keep my promise. To the extent that the promise was unbroken (since it makes no sense to speak of it in this case as fulfilled), this was not because I knowingly omitted to print an excessive number of pages (heck, I probably didn't even read the terms and conditions of the license requiring such conduct). It was either a coincidence or a consequence of the operations of the software.

Second, according to Aristotle, it is only a virtuous act if my decision to limit myself to ten pages was made *because* it was the honest thing to do. In such case it may never be clear whether my conduct was virtuous. After all, I could have decided to print more than ten pages and yet this still would have made no difference to the outcome, since the digital lock would have complied with the licensing terms no matter what my intentions were. In any event, I probably did not limit myself to less than ten pages because it would be dishonest but rather because it would have been inconvenient to figure out how to do otherwise.

Third, the mere fact that the number of pages printed comported with the licence was not the result of my firm and unchanging disposition toward honesty in the face of temptation but rather because the e-book's robotic code made me do it. The answer to the machine was, as they say, in the machine. But this cannot in any meaningful way be understood as an automation of virtue. To the contrary, technologically compelling me to comply with the terms and conditions of the licence, if anything, pre-

154 In the spirit of Professor Lawrence Lessig's *Free Culture*, I will first borrow, and then later remix, his example found at page 151. See Lessig, above note 11.

vented me from acting in accordance with virtue, let alone acting from any deep-seated disposition towards honesty. Perhaps, eventually, I will reach a point where I simply do anything that the machine doesn't preempt me from doing. *Domo arigato, Mr. Roboto.*

This last point is critical. A series of ubiquitous locks designed to keep people honest would impair the development of a *hexis*, a deep-seated disposition for honesty. Recall the important role that practical wisdom plays in the cultivation of virtue. Virtuous conduct is impossible without *phronesis*—the ability to untie moral knots, to determine both what is good and how to achieve it. Practical wisdom, remember, is a special skill requiring special sensitivity to morally salient features of particular situations. Practical wisdom cannot be programmed. It cannot be cut and pasted. It requires exposure to an array of moral episodes and adventures—opportunities to explore the intricacies of moral deliberation.

Ironically, a ubiquitous digital lock strategy meant to “keep honest people honest” is a self-defeating goal since it impairs the development of *phronesis*, stunts moral maturity and thereby disables the cultivation of a deep-seated disposition for honesty. Woven into the fabric of everyday life, digital locks would ensure particular outcomes for property owners but would do so at the expense of the moral project of honesty.¹⁵⁵

The cultivation of honesty, like the cultivation of *phronesis*, is a skill. Here, I am reminded of the image of the child riding Walt Disney's Autopia. Recall that the ride permits children to assume the driver's seat, veering a little left or right of centre, but the hidden rail always guides them back into the middle. Just as this is no way to the way to learn how to drive, let alone how to drive well, it is also not how a moral actor achieves the golden mean. The technological procurement of right conduct is not the attainment of virtue.¹⁵⁶

Although his focus was on the concept of a permission culture rather than its affect on the good life and the attainment of moral excellence, Professor Lawrence Lessig hints at how digital locks might impair the development of *phronesis* and the cultivation of moral virtue:

The control comes instead from the code—from the technology within which the e-book “lives.” Though the e-book says that these

¹⁵⁵ And, I suspect, not *just* honesty. Other moral virtues are also at stake.

¹⁵⁶ Professor Matheson adopts a similar position, arguing that a “surveillance society risks undermining the ability of its citizens to develop virtue for the same sorts of reasons that overprotective parenting can impair the character development of children.” Matheson, above note 147 at 133.

are permissions, they are not the sort of “permissions” that most of us deal with. When a teenager gets “permission” to stay out till midnight, she knows (unless she’s Cinderella) that she can stay out till 2 A.M., but will suffer a punishment if she’s caught. But when the Adobe eBook Reader says I have the permission to make ten copies of the text into the computer’s memory, that means that after I’ve made ten copies, the computer will not make any more. The same with the printing restrictions: After ten pages, the eBook Reader will not print any more pages.¹⁵⁷

For a moment, let’s try to imagine a world where virtue-locks could ensure that the teenager is home by midnight. Maybe Cindy’s coach doesn’t turn into a pumpkin¹⁵⁸ but the evolution of the carting industry spawns the development of her FROG AGV 3.0.¹⁵⁹ Taking the lead from Walt Disney’s Tomorrowland, this driverless vehicle, complete, let’s imagine, with identification and authentication systems, manages a series of permissions pre-programmed by her over-protective parents, resulting in version 3.0 of the classic line, “I have to go now, my ride is here.” Only this time round, a series of technological locks prevent Cindy from doing anything other than coming home.

Though I am uncertain whether this thought experiment is fun, frivolous, or just plain frightening, the intended “moral” of the story is important, and is meant to be taken seriously. Professor Lessig’s original example implicitly acknowledges something important in Cindy’s moral development that comes with having to learn whether to adhere to the curfew rule. To name only a few, her deliberations (should she have any) might include: (1) an evaluation of the importance of the original curfew rule, (2) whether there are legitimate exceptions to it, (3) whether the likely penalty is worth whatever was to be gained from breaking the rule, and (4) the importance of other moral values in conflict with the curfew rule (e.g., staying late to help a friend in need), etc. Cindy’s moral deliberations might be epicurean, Kantian, consequentialist, existentialist, eudaimonic, hedonistic, egoistic, spiritualistic, nihilistic, stoic, or pragmatic but, regardless of which, she will be morally knee-capped if technology is permitted to systematically deny her the ability to act upon those deliberations.

157 Lessig, above note 11 at 151.

158 Although I imagine this to be the sort of DRM that Tim Burton might like.

159 AGV is the acronym for “Automated Guided Vehicle” systems, the enabling technology for driverless vehicles. See generally Frog AGV Systems, “Over Frog AGV Systems” (2008) www.frog.nl/About_Frog_AGV_Systems/index.php.

To be clear, the critique here is not about her freedom to do as she pleases. It is about the moral disability that she will suffer from not being able to do so. Reiterating from above, the moral attainment of virtue relies fundamentally on practicing the virtues in real situations over the course of a lifetime. À la Aristotle: “we become honest by doing honest things.” If locks of various sorts prevent Cindy from making mistakes, from negotiating with herself about what honesty entails or from deciding what *she* will morally permit *herself* to do, her ability and desire to cultivate practical wisdom and the achievement of moral excellence will be impaired. She will become morally disabled.

F. ALEXANDRIAN SOLUTIONS

On Wednesday, 2 June 2010, in the Montreal office of US video-game software developer Electronic Arts, Heritage Minister, James Moore, and Industry Minister, Tony Clement, announced that the Government of Canada would take its third crack at unraveling the Gordian knot of “balanced copyright.”¹⁶⁰ In front of a room filled with puzzlers and lock-makers, Minister Clement drew his sword and, with a single dramatic stroke, proclaimed:

For those companies that choose to use digital locks as part of their business model, they will have the protection of the law.¹⁶¹

To anyone paying attention to copyright reform in Canada over the last decade, it shouldn’t take a rocket scientist¹⁶² to realize that the anti-circumvention laws¹⁶³ to which Minister Clement was referring are a kind of legal lock — promised by Bill C-32 to copyright owners to further secure

¹⁶⁰ It is an unfortunate coincidence that this phrase has been officially adopted by both the Government of Canada and “Balanced Copyright for Canada,” an industry-based coalition funded primarily by the Canadian Recording Industry Association: <http://balancedcopyrightforcanada.ca>.

¹⁶¹ Government of Canada, “Speaking Points — Minister of Industry” *Balanced Copyright* (2 June 2010), www.ic.gc.ca/eic/site/crp-prda.nsf/eng/rp01191.html.

¹⁶² Although, at least one did. Marc Garneau, former Canadian astronaut and MP for Westmount-Ville-Marie identified digital locks as “the major issue that stands out in the bill” and went on to say that, “the bill seems to be missing an exception that would allow people to break digital locks if it was for private, non-commercial use, but added that his party will have to study it further.” See Peter Nowak, “Copyright bill would ban breaking digital locks” *CBC News: Technology & Science* (3 June 2010), www.cbc.ca/technology/story/2010/06/02/copyright-bill-clement-montreal.html#ixzzowllnKJbl.

¹⁶³ For details on the anti-circumvention provisions, see *Anti-Circ*, above note 115.

the digital lock strategy that industry stakeholders have been lobbying for. As Minister Moore recently noted at a luncheon on “Intellectual Property, Innovation, Economic Growth, and Jobs” in Toronto:

Copyright owners told that us that their online and digital business models depend on strong protections for digital locks. And they’re right. With Bill C-32, we are proposing protections for digital locks. The Bill gives creators stronger legal tools for protecting technological measures including ‘digital locks’ and other methods. . .¹⁶⁴

Indeed it does. With all the brute force of an Alexandrian solution, Bill C-32’s approach adds a fourth layer of protection¹⁶⁵ to copyright owners through a series of strongly worded prohibitions against: (1) circumventing TPMs that control access to a work;¹⁶⁶ (2) offering services to the public to circumvent TPMs;¹⁶⁷ and (3) manufacturing, importing, distributing, or selling technologies that can be used to circumvent TPMs.¹⁶⁸

In my view, there are three fundamental flaws with Bill C-32’s Alexandrian solution that, operating in conjunction with one another undermines the very possibility of balanced copyright.

First, Bill C-32’s anti-circumvention provisions are not tied to copyright infringement, thereby expanding the law of copyright to include acts that have nothing to do with copying. Second, the few exceptions wherein circumvention is permitted¹⁶⁹ are, by many accounts, deficient in scope. Third, Bill C-32 provides what in this chapter, following Burk and Gillespie, I have been calling an “unimpeded state sanction” of digital locks. The first two flaws have been thoroughly canvassed by others in this book and I will not address them here.¹⁷⁰ Instead, I will focus on the third funda-

164 Canadian Heritage, “Minister Moore’s Speech at Luncheon on Intellectual Property, Innovation, Economic Growth, and Jobs Toronto, Ontario June 22, 2010,” www.pch.gc.ca/pc-ch/minstr/moore/disc-spch/index-eng.cfm?action=doc&DocIDCd=SJM100603.

165 Legal protection begins with the law of copyright and its sanctions against infringement. The second layer of protection, used with increasing frequency, is contract law, where the terms of end user licence agreements (EULAs) are used to override existing copyright limitations. As a third layer of protection, many copyright owners have taken it upon themselves to use digital locks.

166 Bill C-32, above note 10 at cl. 47.

167 *Ibid.*

168 *Ibid.*

169 For details on the anti-circumvention provisions, see *Anti-Circ*, above note 115.

170 My view on the first two flaws has been articulated in *Heritage Report Part I*, above note 65; *Heritage Report Part II*, above note 65; *If Left To Their Own Devices*, above note 65.

mental flaw — which is crucial not only to balanced copyright but also to my concerns about the broader use of digital locks set out in this chapter.

In my co-authored two-part study on digital locks commissioned by Canadian Heritage,¹⁷¹ I enumerated a few observations crucial to the proper scope of protection for digital locks as well as the broader mandate of balanced copyright and then remarked on their policy implications. One such observation was that

the exercise of any of the exceptions enumerated . . . is premised on the ability to gain access to the work in question.¹⁷²

Consequently, I went on to suggest that any proposed digital lock provisions must therefore

include a positive obligation on the copyright holder to ensure that alternative means of obtaining access to a work remain available — a “copy-duty” . . .¹⁷³

In other words, those who use digital locks might in certain circumstances be obliged to provide a key or at least open the lock whenever someone else has a right to access or use the thing that has been locked-up.

This point is hardly revolutionary. In the ten years since stating it in my second Canadian Heritage study, it has been adopted in one form or other in various countries around the world. For example, the WIPO Standing Committee on Copyright and Related Rights issued a report in June 2010 describing that national laws in at least nineteen Member States provide mechanisms to make sure that prohibition of circumvention of TPMs does not prevent beneficiaries of copyright limitations and exceptions from exercising them.¹⁷⁴ Norway, for example, has established a Ministerial Board, which is empowered to order rightholders to allow access to protected works. Likewise,

If the rightholder fails to provide access to protected work, many Member States grant beneficiaries of limitations and exceptions a recourse

¹⁷¹ To be fair to Minister Moore, these studies were written nearly 10 years ago, back when he was a very junior Member of Parliament and before he was professionally acquainted with copyright reform.

¹⁷² *Heritage Report Part II*, above note 65 at 66.

¹⁷³ *Ibid.* See also Lessig, *Code: Version 2.0* above note 12 at 190.

¹⁷⁴ World Intellectual Property Organization, Standing Committee on Copyright and Related Rights, “Report on the Questionnaire on Limitations and Exceptions,” SCCR/20/7, Twentieth Session, Geneva, 21–24 June 2010 at 12 www.wipo.int/meetings/en/doc_details.jsp?doc_id=134432.

to some form of judicial review (e.g. Ireland), arbitration (e.g. Finland), mediation (e.g. Greece) or administrative proceedings (e.g. Estonia).¹⁷⁵

Poland goes even further, “limiting the application of TPMs only to acts which are not covered by any exception or limitation.”¹⁷⁶ In other words, Poland recognizes that there are uses of digital locks that should be outright prohibited (in a way that mere exemptions will not do). In sum, by limiting or prohibiting the use of some digital locks altogether, or requiring the rightholder to open the lock, these Member States have recognized that an absolutist über-protection of digital locks thwarts the possibility of balanced copyright¹⁷⁷ and creates even greater risks outside of copyright’s vast empire.

Ten years and three copyright bills later, the Government of Canada has once again tabled a bill that exclusively provides “strong protections for digital locks.” For the third time running, it has done so without imposing appropriate balancing counter-measures for circumstances in which some measure of public interest might require strong protection from digital locks. Bill C-32 contains no countervailing provisions that would set limits or impose obligations concerning the use of locks, and certainly no provisions that prohibit particular uses of them or require them to be unlocked. *In other words, Bill C-32’s legal locks provide a total lock on locks.* Those who have them can use them however they so choose with total impunity.¹⁷⁸

¹⁷⁵ *Ibid.*

¹⁷⁶ *Ibid.*

¹⁷⁷ Thanks to Michael Geist for useful discussions on this point, including reference to the following excellent article: Urs Gasser and Silke Ernst, *EUCD Best Practice Guide: Implementing the EU Copyright Directive in the Digital Age*, University of St. Gallen Law School: Law and Economics Research Paper Series Working Paper No. 2007-01, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=952561.

¹⁷⁸ In fact, if you read the government’s speeches, FAQs and talking points, you will notice the language surrounding digital locks is peppered with soundbytes employing “freedom” and “choice” for the property owner. The section of the government’s ‘Balanced Copyright’ website identifying key provisions of Bill C-32 includes this quote: “Businesses that choose to use digital locks as part of their business models will have the protection of the law.” See Government of Canada, “What the New Copyright Modernization Act says about Digital Locks (8 June 2010), www.ic.gc.ca/eic/site/crp-prda.nsf/eng/rp01189.html. Another part of the website articulates what Bill C-32 will mean for copyright owners, artists and creators. With reference to the digital lock protections required by the WIPO Internet Treaties, the following is stated: “Protecting digital locks gives copyright industries the certainty they need to roll out new products and services, such as online subscription services, software and video games, if they choose to use digital locks. Not only will this promote investment and growth in Canada’s digital economy, it will also encourage

The reasons for my broader concerns about this unimpeded, state sanctioned digital lock strategy should by now be clear in light of my analysis in Sections B and C of this chapter. The “permission” that Bill C-32 would give to property owners to make unimpeded use of digital locks is premised on a misconception of the function of locks as mere instruments of exclusion used to protect private property. In its bold Alexandrian reaction to digital copyright’s Gordian knot, Bill C-32 fails to acknowledge the fact that locks properly understood are access-control devices premised not only on authorized permission by the copyright owner but, also, *permission authorized by the law*.

The fatal flaw is this: Bill C-32 refuses to recognize that foundational legal rules or principles might sometimes require property owners to open digital locks in order to permit justified access or use. As I stated in my second Canadian Heritage study, this is not merely the passing fancy of wishful academics—or, dare I now say, “radical extremists.”¹⁷⁹ It has its basis in Canadian constitutional law, and is already supported in principle in the copyright context by the Supreme Court of Canada in the following passage from *Haig v. Canada*:

... a situation may arise in which, in order to make a fundamental freedom meaningful, a posture of restraint would not be enough, and positive governmental action might be required. This might, for example, take the form of legislative intervention aimed at preventing certain conditions which muzzle expression, or ensuring public access to certain kinds of information.¹⁸⁰

It is absolutely essential to note that a legal duty requiring property owners to open digital locks in order to permit justified access or use is totally separate and distinct from self-help remedies indirectly available through the exceptions contemplated within the anti-circumvention prohibitions. For example, to say that I have a right to circumvent a lock in

the introduction of innovative online services that offer access to content.” (21 June 2010) www.ic.gc.ca/eic/site/crp-prda.nsf/eng/rp01189.html.

179 While addressing the International Chamber of Commerce in Toronto on Tuesday, 22 June 2010, Minister Moore advanced the claim that any people opposed to the new legislative provisions prescribed by Bill C-32 belonged to two groups of ‘radical extremists’. For news reporting on this event, see Peter Nowak, “Copyright debate turns ugly: Heritage minister stirs hornet’s nest with ‘radical extremist’ comments,” *CBC News* (24 June 2010), www.cbc.ca/technology/story/2010/06/23/copyright-heritage-minister-moore.html.

180 *Haig v. Canada* [1993] 2 S.C.R 995, <http://csc.lexum.umontreal.ca/en/1993/1993scr2-995/1993scr2-995.html> at para. 79.

order to protect my personal information pursuant to the exceptions set out in Bill C-32 is *certainly not* the same thing as having a law wherein the state requires a party that collects, uses or discloses information about an identifiable individual to open the lock under circumstances where data protection law would demand it. The same argument could be made in the context of copyright laws where user rights might demand something more than the exception set out in Bill C-32. I further suspect that the principle I am articulating here is of general application. As I tried to make clear in my analysis of digital locks in the case of shopping carts, laws that would authorize, justify or excuse the circumvention of a lock — or, for that matter, impose upon the property owner a duty to open it — will often fall outside of the private ordering rules that are created and controlled in their entirety by property owners. Believe it or not, they could also fall outside of the ambit of law of copyright. ;)

While it is hard to imagine a foundational principle like the law of necessity actually creeping into a copyright infringement case, there are a myriad of legal rules and principles that could do so from both inside and outside of copyright law. The *Haig* case, mentioned above, is one such example. The problem with Bill C-32 is that its bold, unimpeded, absolutist Alexandrian protection of digital locks misunderstands the purpose and function of a lock which, at least in the case of more sophisticated access-control systems, not only hinders unauthorized access but also provides a mechanism for situations where the property owner has not contemplated a need for access but one later arises. The best security systems not only prevent access to interlopers but also grant access to those who have or ought to have permission.

The protection afforded to digital locks in Bill C-32 would, in situations such as the ones we are imagining, allow the property owner to trump the public interest for no other reason than being the *de facto* keyholder. Without a legal mechanism that imposes a duty on a property owner to open or remove the lock when the law would otherwise authorize doing so but the property owner would not, private ordering through the use of digital locks will become the rule and property owners the rule-makers. Balanced copyright doesn't stand a chance.

In witnessing this decade long Sisyphean error, I am tempted to understand the Alexandrian solution¹⁸¹ offered by Ministers Clement and Moore

181 My use of several historical versions of the Alexandrian myth throughout this chapter is offered as a richer illustration of the difference between brute force and elegant solutions. The methodology of using classical mythology as a framework

not in accordance with the popular version of the legend wherein Alexander the Great is the solver of the knot's puzzle and the hero of the prophesy. Perhaps it seems more in line with a less popular account of the legend. In this alternative version,

an exasperated Alexander is unsuccessful in every legitimate attempt.

his whole body
drenched in sweat
while I
sat nearby
quietly
watching

(Ba. 620-2) — Euripides' *Bacchae*

for understanding contemporary problems is well established. For instance, "[t]wo of our oldest metaphors tell us that all life is a battle and that all life is a journey; whether the *Iliad* and the *Odyssey* drew on this knowledge or whether this knowledge was drawn from the *Iliad* and the *Odyssey* is, in the final count, unimportant, since a book and its readers are both mirrors that reflect one another endlessly." See Alberto Manguel, *Homer's The Iliad and The Odyssey: A Biography* (Vancouver: Douglas & McIntyre, 2007) at 2. James Joyce's *Ulysses* also evokes classic Greek literature. In the despair and unrest that was the shattered modern world post-WWI, Joyce uses the familiar journey of Odysseus to inject a sense of order that will resonate with readers. In a famous review of *Ulysses*, T.S. Eliot makes a similar point: "[i]n using the myth, in manipulating a continuous parallel between contemporaneity and antiquity, Mr. Joyce is pursuing a method which others must pursue after him . . . It is simply a way of controlling, of ordering, of giving a shape and a significance to the immense panorama of futility and anarchy which is contemporary history." See Michael Bell, *Literature, modernism and myth: belief and responsibility in the twentieth century* (Cambridge: Cambridge University Press, 1997) at 122. Joyce calls himself only "a shy guest at the feast of the world's culture," but nonetheless succeeds at characterizing modern life through the veil of antiquity. This technique of using myth to understand modern culture has been seen in countless stories. See Gilbert Highet, *The classical tradition: Greek and Roman influences on western literature* (Oxford: Oxford University Press, 1949) at 518. Another popular mythological figure, Hercules, has "embodied or endorsed" a wide range of ideas or opinions. Such an example has broad cultural appeal, due to the various myths emanating from this fascinating figure. As biographer Alastair Blanchard has written "Biography attempts to make the world understandable. It is our response to chaos." By using these tales as a framework, we are empowered to think critically about our own culture through the eyes of an ancient persona. Alastair Blanchard, *Hercules: A heroic life* (London: Granta Books, 2005) at xix.

Faced with the specter of conspicuous failure, Alexander slashes the knot in two with his sword.¹⁸²

As one biographer described this outcome, “Alexander was a man incapable of shrugging his shoulders and walking away from an unsuccessful effort. If, as a result of several futile attempts, he was frustrated and angry, he might very well have decided that a sudden stroke of the sword would rescue him from public embarrassment.”¹⁸³

However, my goal here is not so much to critique Bill C-32 or its proponents as it is to inspire deeper thinking about the potential ethical and legal implications of an unimpeded and universal adoption of digital locks, especially given the strategy of preemption adopted by the powerful entities that current deploy them. In the spirit of doing so, I offer yet a third account of the legend of the Gordian knot, known mostly by historians and scholars in the field of classical studies.

[Alexander] saw the celebrated chariot which was fastened to its yoke by the bark of the cornel-tree . . . According to most writers the fastenings were so elaborately intertwined and coiled upon one another that their ends were hidden: in consequence Alexander did not know what to do, and in the end loosened the know by cutting through it with his sword, whereupon the many ends sprang into view. *But according to Aristobulus he unfastened it quite easily by removing the pin which secured the yoke to the pole of the chariot, and then pulling out the yoke itself.*¹⁸⁴

Like our protagonist in Aristobulus’ account, I prefer elegance to brute force. And, yet, elegant solutions are not always the stuff of political expedience. I know that there are many senior government lawyers, policy advisors and bureaucrats working on the digital copyright file who understand these arguments as well—better, actually—than the academics seeking to contribute to their improvement. The flaws in Bill C-32 are symptomatic of the larger digital lock strategy upon which they are modeled. As I have suggested in this chapter, the legal locks, just like the digital locks, just like the mechanical locks, must be understood as something more than instruments of exclusion to be used at the whim of those who hold them in their hands. One must remember that the preemptive nature

182 John Maxwell O’Brien, *Alexander the Great: The Invisible Enemy, A biography* (London: Routledge, 1992) at 70–73.

183 *Ibid.*

184 Plutarch, above note 4 at 271 [emphasis added].

of digital locks leave no room for forgiveness. Instead, digital locks simply disable the property so that it does not permit any uses other than its pre-programmed use. Perhaps more significantly, moving to the moral sphere, I have also suggested that a series of ubiquitous locks designed to keep people honest would impair the development of a *hexis*, a deep-seated disposition for honesty, by discouraging or preventing the development of practical wisdom.

My argument in this chapter has been cast through the lens of virtue, the ancient Greek idea that the good life is to be lived through the attainment of moral excellence. From this point of view, practical wisdom cannot be uploaded or downloaded. It requires a broad variety of life experiences — opportunities to navigate the messy, complex world of moral decision-making. It also requires making mistakes. How could we possibly live well, let alone flourish, in environments that increasingly seek to control our behaviour with fine-tuned granularity, by the flick of a switch permitting or forbidding various courses of conduct not proscribed by law but by lock-makers? How are we to cultivate a moral compass, a sense of right and wrong, good and bad, if we are locked on a course that leads us only from here to there with no opportunity for moral journey, deliberation or error? And what, other than some form of robotic habituation, would make us think that those endowed with the power to use digital locks in this way should have a monopoly on right conduct in the first place, or that they are always justified in using the locks as they do?

As Elizabeth Anscombe has noted, the attainment of virtue is foreign to the law's language of rights and duties. Perhaps the unity of these distinct discourses finds expression in the words of the philosopher, Joseph Raz, whose thoughts on the relationship between the morality of freedom and copyright law's concept of authorship are worthy of citation:

All too often moralists tend to regard a person's moral life as the story of how he proves himself in the face of moral demands imposed on him by chance and circumstance. Crucial as this aspect is, it is but one side of a person's moral history. The other side of the story evolves around the person not as the object of demands imposed from the outside, but as the creator of such demands addressed to himself. We are all to a considerable degree the authors of our moral world.¹⁸⁵

...

185 Joseph Raz, *The Morality of Freedom* (New York: Oxford University Press, 1986) at 86.

Autonomy requires that self-creation must proceed, in part, through choice among an adequate range of options; that the agent must be aware of his options and of the meaning of his choices; and that he must be independent of coercion and manipulation by others. Personal autonomy is the ideal of free and conscious self-creation.¹⁸⁶

If we are to remain, to a considerable degree, the *authors* of our *moral world*, we must maintain the ability to access it and make use of it. While the law of copyright affords protection to the creators of original works, a balanced copyright scheme must not, in the process, diminish the very possibility of self-creation. Excessive protection of digital locks places coercive limits on moral actors, preventing them from acquiring access to an adequate range of life's options. What would be the point in developing entire systems to protect creative works or other forms of property if the means by which this is achieved ultimately undermines *moral authorship* and the project of *conscious self-creation*?

¹⁸⁶ *Ibid* at 390.