1 Intermediation

Textuality and the Regime of Computation

Language and Code

Unnoticed by most, new languages are springing into existence, proliferating across the globe, mutating into new forms, and fading into obsolescence. Invented by humans, these languages are intended for the intelligent machines called computers. Programming languages and the code in which they are written complicate the linguistic situation as it has been theorized for "natural" language, for code and language operate in significantly different ways.[1] Among the differences are the multiple addressees of code (which include intelligent machines as well as humans), the development of code by relatively small groups of technical specialists, and the tight integration of code into commercial product cycles and, consequently, into capitalist economics. Although virtually everyone would agree that language has been decisive in determining the specificity of human cultures and, indeed, of the human species, the range, extent, and importance of code remain controversial. Many people would argue that natural languages are much more broadly based than programming languages, a stance that relegates code to the relatively small niche of artificial languages intended for intelligent machines. Recently, however, strong claims have been made for digital algorithms as the language of nature itself. If, as Stephen Wolfram, Edward Fredkin, and Harold Morowitz maintain, the universe is fundamentally computational, code is elevated to the lingua franca not only of computers but of all physical reality.

Given these complexities, it has become an urgent task to understand in nuanced and theoretically sophisticated ways interactions between code and language. The scholarship on human languages is, of course, immense, and a smaller but still enormous quantity of research exists on programming languages. To date, however, criticism exploring feedback loops that connect the two kinds of language has been minimal.[2] At issue are the semiotically and materially distinct ways in which code and language operate, as well as the different contexts in which they emerge and develop. The task of understanding these differences is impeded by the diversity of the expert communities attending to them, comprising humanists and linguists on the one hand and computer programmers and software engineers on the other. Despite the general lack of communication between these communities, programming code and language interact continually in millions of encounters every day. The trading zones in which these negotiations occur are global in scope, penetrating deep into nearly every aspect of environments that rely on computers to carry out everyday tasks. Language alone is no longer the distinctive characteristic of technologically developed societies; rather, it is language plus code.

This project aspires to contribute to our understanding of these complexities by creating a theoretical framework in which language and code (in both its narrow and broader senses) can be systematically thought together. In addition, it explores through a series of case studies implications of the interactions of language and code for creative, technological, and artistic practice. The case studies focus on a range of issues, including the relation of print to electronic textuality, the constitution of subjectivity through bits as well as words, and the (mis)understandings through which humans interact with analog patterns functioning as metaphors for digital processes.

In the next chapter, I consider the three principal discourse systems of *speech, writing,* and *digital computer code.* To focus my discussion, I choose as representative of speech the semiotic theories of Ferdinand de Saussure,[3] and of writing, the early texts of Jacques Derrida, especially *Of Grammatology, Positions, Writing and Difference,* and *Margins of Philosophy,* works where he discusses the language system as theorized by Saussure and contrasts it with his theory of grammatology. My remarks on code are drawn from a number of sources; particularly important is the work of Stephen Wolfram, Edward Fredkin, Harold Morowitz, Ellen Ullman, Matthew Fuller, Matthew Kirschenbaum, and Bruce Eckel.[4] Further, I claim that theories about speech, writing, and code as represented by these sources are fraught with presuppositions, premises, and implications, in effect constituting what, for lack of a better term, I call "worldviews." The worldviews of speech, writing, and code are inextricably entwined with the technological conditions enveloping the theorists that developed these ideas, the philosophical, linguistic, and scientific traditions in which they claimed lineage, and the purposes toward which they wanted their work to contribute. From the comparison of these worldviews emerges a series of tensions and problematics that will form the basis for the arenas of interaction—*making, storing,* and *transmitting*—central to contemporary creative practices in scientific simulations, digital arts, electronic literature, and print literature.

The Regime of Computation

To facilitate the comparison of speech, writing, and code, I want to explore the larger context in which code as performative practice is located. For this inquiry, let us backtrack for a moment to consider the relation of computation (and hence of code, the language in which computation is carried out) to preexisting models for understanding truth statements, especially classical metaphysics. Perhaps no philosopher in the last century has been more successful than Jacques Derrida in exposing the impossible yearning at the heart of metaphysics for the "transcendental signified," the manifestation of Being so potent it needs no signifier to verify its authenticity. Yet Derrida repeatedly remarks that we cannot simply leave metaphysics behind.[5] He frequently asserts that metaphysics is so woven into the structure of Western philosophy, science, and social structures that it continually imposes itself on language and, indeed, on thought itself, creeping back in at the very moment it seems to have been exorcised. In this sense, classical metaphysics plays the role of the hegemonic influence that makes Derrida's resistant writing necessary and meaningful as a cultural practice. Derrida's discourse, as he himself remarks, is "entirely taken up with the reading of [others'] texts" and in this sense can be considered parasitic.[6] In his early writings, this preoccupation focuses specifically on texts that reinscribe the metaphysical yearning for presence that he devotes himself to deconstructing. To paraphrase a notorious remark, if metaphysics did not exist, Derrida would have been forced to invent it.

The worldview of computation also offers new answers to metaphysical questions, although in a very different way than Derridean grammatology. "Computation" in the sense it is used here connotes far more than the digital computer, which is only one of many platforms on which computational operations can run. Computation can take place in a variety of milieu and with almost any kind of material substrate. Leonard M. Adelman has pioneered the use of solutions of DNA as computational platforms for solving certain topological problems; Daniel Hillis recounts that as a child he made a computer out of Tinkertoys; John von Neumann, brooding over the birth of the digital computer, envisioned computation taking place with giant iron I beams adjacent to a factory that could assemble them into patterns representing binary code.[7]

If computation is not limited to digital manipulations, binary code, or silicon, what is it? Alan Turing gave a formalist definition of computation in his famous 1936 article describing an abstract computer known as the Turing machine, the most general version of which is called the Universal Turing machine. The Universal Turing machine, as its name implies, can perform any computation that any computer can do, including computing the algorithm that constitutes itself.[8] The computational regime continues in the tradition of Turing's work by considering computation to be a process that starts with a parsimonious set of elements and a relatively small set of logical operations. Instantiated into some kind of platform, these components can be structured so as to build up increasing levels of complexity, eventually arriving at complexity so deep, multilayered, and extensive as to simulate the most complex phenomena on earth, from turbulent flow and multiagent social systems to reasoning processes one might legitimately call thinking.

The wide-reaching claims made for the Regime of Computation are displayed in Stephen Wolfram's *A New Kind of Science.* The ambition of this book is breathtaking, especially considering the modesty with which scientists have traditionally put forth their claims. The book makes a fascinating contribution to the Regime of Computation, demonstrating through Wolfram's twenty years of research into cellular automata that simple rules can indeed generate complexity through computational means. Cellular automata have been around for decades. John von Neumann experimented with them, learning from Stanislaw Ulam how they could be reduced to a grid of two-dimensional cells;[9] Konrad Zuse in the 1950s suggested that they could form the basis for the physical universe;[10] in the 1990s researchers at the Santa Fe Institute, particularly Christopher Langton and his colleagues, explored the conditions under which cellular automata create, modify, and transmit information;[11] and John Conway showed that they could give the impression of living systems in his famous *Game of Life.*[12]

The basic idea is disarmingly simple, illustrated through this typical configuration.[13] Imagine a square grid, with each square representing a cell that can be either "on" or "off"; further suppose that we represent these states by black or white. An initial state is defined for each cell, as well as a set of rules telling each cell how to update its state. For example, a cell might have a rule specifying that it is "on" if two or more of its four neighbors are "on"; otherwise it is "off." Each cell in parallel then canvases the state of its neighbors and updates its state accordingly, while all of the other cells do the same. This update results in a new state for the system, which transforms in yet another iteration during which all the cells again canvas their neighbors and update their states accordingly. With contemporary computing power, it is possible to run through hundreds or thousands of iterations in a relatively short time. Through extensive research into various categories of cellular automata with simple rules, Wolfram shows that these conceptually simple systems are nevertheless capable of emergent behaviors in which astonishingly complex patterns appear. In particular, he discovered that the one-dimensional cellular automata described by Rule 110 yielded a Universal Turing machine, previously thought possible only in complex cellular automata of high dimensions.[14] That it should prove possible to create a Universal Turing machine in a system this simple is indeed a remarkable discovery.

Wolfram is not slow to draw sweeping implications from his work. He summarizes them in the Principle of Computational Equivalence, explored at length in chapter 12 of *A New Kind of Science.* In one of its formulations, the principle states, "Whenever one sees behavior that is not obviously simple—in essentially any system—it can be thought of as corresponding to a computation of equivalent sophistication" (5). The principle, as I read it, has three interlocking claims. The first is that all complex behavior can be simulated computationally, up to and including human thought and action (at least in principle). The second claim is that complex systems are "computationally irreducible" (6). Although the computations may be generated through simple rules (as are the cellular automata Wolfram discusses), there is no way to shorten the labor of computing the system's behavior (for example, by reducing it to mathematical equations). Simulating the behavior of these complex systems requires roughly the same amount of computation as the system itself puts forth to generate its actions, which implies a redistribution of intellectual labor. In a classical system susceptible to explicit solution, the equations may be difficult to solve but, once solved, serve to explain a wide variety of disparate behavior. For the cellular automata Wolfram discusses, the rules are extremely simple, but the labor of computing the behavior is intensive, requiring hundreds (or thousands or more) of iterations. The third claim, often not stated explicitly, is implied by the sweeping consequences Wolfram envisions for his research. This is the strong claim that computation does not merely *simulate* the behavior of complex systems; computation is envisioned as the process that actually *generates* behavior in everything from biological organisms to human social systems.

Wolfram's slide from regarding his simulations as models to thinking of them as computations that actually generate reality can be tracked at several places in his massive text. For example, he comments that "countless times I have been asked how models based on simple programs can possibly be correct, since even though they may successfully reproduce the behavior of some system, one can plainly see that the system itself does not, for example, actually consist of discrete cells that, say, follow the rules of a cellular automaton" (366). He answers this objection by claiming that "there is no reason that the model should actually operate like the system itself" (366). Elsewhere, however, he equivocates:

> My approach in investigating issues like the Second Law is in effect to use simple programs as metaphors for physical systems. But can such programs in fact be more than that? And for example is it conceivable that at some level physical systems actually operate directly according to the rules of a simple program? . . . At first the laws might seem much too complicated to correspond to any simple program. But one of the crucial discoveries of this book is that even programs with very simple underlying rules can yield great complexity. . . . And so it could be with fundamental physics. Underneath the laws of physics as we know them today it could be that there lies a very simple program from which all the known laws—and ultimately all the complexity we see in the universe—emerges. (434)

In this passage and in similar ones, Wolfram introduces a crucial ambiguity into his claims for the Computational Universe. At issue is whether computation should be understood as a metaphor pervasive in our culture and therefore indicative of a certain "climate of opinion" (in Raymond Williams's phrase) at the turn of the millennium, or whether it has ontological status as the mechanism generating the complexities of physical reality. Rather than attempting to argue one side or the other of this controversial issue, I explore the implications of what it means to be situated at a cultural moment when the question remains undecidable—a moment, that is, when computation as means and as metaphor are inextricably entwined as a generative cultural dynamic. As we shall see, this entanglement has extensive implications for the positioning of humans in relation to intelligent machines and the broader landscape of the Computational Universe.

What does it mean to say that the Computational Universe functions simultaneously as metaphor and means? One way to understand their entanglement is through feedback loops that connect culturally potent metaphors with social constructions of reality, resulting in formulations that imaginatively invest computation with world-making power, even if it does not properly possess this power in itself. In *The Second Self* and *Life on the Screen*, Sherry Turkle shows compellingly that such feedback loops can dramatically influence how people perceive themselves and others. This influence extends even to the interactions of young children with intelligent toys. One of my favorite examples comes when one of her respondents, a shy and socially inept young man, comments, "Reality is not my best window."

A second kind of feedback loop emerges when belief in the Computational Universe is linked with an imagined future through which anticipation cycles to affect the present. A striking example of the Regime of Computation's ability to have real effects in the world, whatever its status in relation to the underlying physics, is the initiative to reorganize the U.S. military to pursue "network-centric warfare." Presupposing the ontology of code, military strategists argue that information has become a key military asset and that the U.S. military must be reorganized to take full advantage of it. They aim to abandon a centralized command/control structure in favor of a highly mobile and flexible force, a transformation that involves moving from platform-based strategies (based on tanks, airplanes, ships, etc.) to "network-centric" structures in which units are seen not as independent actors but as "part of a continuously adapting ecosystem."[15] Vice Admiral Arthur K. Cebrowski of the U.S. Navy and his collaborator, John J. Garstak, writing for the *Naval Institute Proceedings Magazine*, proclaim, "We are in the midst of a revolution in military affairs (RMA) unlike any seen since the Napoleonic Age." They quote Chief of Naval Operations Admiral Jay Johnston to the effect that network-centric warfare marks a "fundamental shift" in military thinking (1).

A principal advantage of network-centric warfare is the presumed ability to create "lock-out" effects through superior flexibility and speed. (The textbook example of lock-out occurred when video producers made the decision to produce for VHS equipment instead of Beta, thus converting a slight numerical advantage in the marketplace into interrelated equipment-content-consumption networks that decisively locked out Beta, despite the fact that in some ways it was technically superior to VHS). Cebrowski argues that lock-out can happen even faster in warfare and be even more decisive. Creating lock-out in military terms means acting fast and flexibly enough so that the opponent's very ability to plan strategically is disrupted. Cebrowski argues that such action demands a high-performance information grid combined with interoperable sensor and engagement grids. Moreover, it also requires the ability to achieve "self-synchronization" in which the commander's intentions, instead of filtering from the top slowly down the chain of command, are activated through the bottom-up organization of flexible units called "swarms," which can continually reorganize and restructure themselves (the nomenclature is no doubt indebted to the artificial-life software called "Swarm," designed to create self-organization and emergent behaviors).

Anticipating a future in which code (a synecdoche for information) has become so fundamental that it may be regarded as ontological, these transformations take the computational vision and feed it back into the present to reorganize resources, institutional structures, and military capabilities. Even if code is not originally ontological, it becomes so through these recursive feedback loops. In *Wetwares*, Richard Doyle makes a similar observation about the belief that we will someday be able to upload our consciousness into computers and thereby effectively achieve immortality. Doyle comments, "'Uploading,' the desire to be wetware, makes possible a new technology of the self, one fractured by the exteriority of the future. . . . Uploading seems to install discursive, material, and social mechanism for the anticipation of an *externalized* self, a techno-social mutation that is perhaps best characterized as a new capacity to be affected by, addicted to, the future" (133).

We will return to the entanglement of means and metaphor in chapter 9 through an analysis of Greg Egan's "subjective cosmology" trilogy: *Quarantine*, *Permutation City*, and *Distress*. An enormously inventive writer, Egan is arguably the most admired and influential novelist associated with the Regime of Computation. In the trilogy, feedback cycles between human cognition and the Computational Universe function to construct the nature of both reality and human beings. The novels will be contrasted with Slavoj Žižek's analysis of the symptom, which presupposes that such phantasmatic imaginations function as symptoms pointing toward repressed trauma and underlying psychopathologies. Thus in the final chapter we return to the issues raised here through a sharp contrast between a view that sees the Computational Universe as metaphoric and symptomatic, and one that sees the Computational Universe as physically real and deeply bound up with human thought. Through the encounter staged in chapter 9 between Egan and Žižek, the book cycles back to the beginning, although from the changed perspective articulated in the epilogue.

I am, however, getting ahead of my story. The third way in which the Computational Universe functions indeterminably as means and metaphor is through its current status as a provocative hypothesis that has neither won wide consensus nor been definitively disproved. Although many physicists remain skeptical of Wolfram's claims and of the Computational Universe generally, the idea of the Computational Universe has also attracted considerable attention and speculation. To understand the controversy in more detail, let us return to explore the different levels at which the Computational Universe has been postulated to run. To this end, it will be useful to summarize where we are at this point by indicating how the Regime of Computation positions itself in relation to classical metaphysics.

The regime reduces ontological requirements to a bare minimum. Rather than an initial premise (such as God, an originary Logos, or the axioms of

Euclidean geometry) out of which multiple entailments spin, computation requires only an elementary distinction between something and nothing (one and zero) and a small set of logical operations.[16] The emphasis falls not on working out the logical entailments of the initial premises but on unpredictable surprises created by the simulation as it is computed. The consequences of a simulation are not logically entailed by the starting point, which is why there is no shortcut to the computational work of running the simulation, and why the behaviors of complex systems cannot be compressed into more economical expression such as mathematical equations. Consequently, the Regime of Computation provides no foundations for truth and requires none, other than the minimalist ontological assumptions necessary to set the system running. Far from presuming the "transcendental signified" that Derrida identifies as intrinsic to classical metaphysics, computation privileges the emergence of complexity from simple elements and rules. Underscoring the point, Wolfram comments that "throughout most of history it has been taken almost for granted that such complexity—being so vastly greater than in the works of humans—could only be the work of a supernatural being" (3). Now complexity is understood as emerging from the computational processes that constitute the universe, and that changes everything. "The crucial idea that has allowed me to build a unified framework," Wolfram summarizes, ". . . is that just as the rules for any system can be viewed as corresponding to a program, so also its behavior can be viewed as a computation" (5).

Thinking along similar lines, Edward Fredkin has proposed a worldview that he calls "digital philosophy," a term that, like Wolfram's remarks, implicitly positions itself as providing answers to metaphysical questions. Fredkin argues that the discrete nature of elementary particles indicates that the universe is discrete rather than continuous, digital rather than analog. Electrons, protons, and neutrons always have charges represented by a small integer (–1, +1, 0); atomic nuclei are composed of neutrons and protons that are always (relatively) small integers; other qualities like spin and charm are either integers or halves of integers. These observations are consistent with Fredkin's major thesis: that the universe is digital all the way down and, moreover, can be understood as software running on an unfathomable universal digital computer. "Digital Philosophy carries atomism to an extreme in that we assume that everything is based on some very simple discrete process, with space, time, and state all being discrete."[17] Moreover, the discreteness he takes as axiomatic implies that information is conserved, a radically different view than, for example, Ilya Prigogine's view of thermodynamic dissipative systems.[18] "Digital Philosophy supports the beliefs that at different levels information is often best thought of as digital, and processes can often be best understood as digital processes. Thus anything in the world of Digital Philosophy that is changing or moving does so in a manner similar to how things are made to change or move in the memory of a computer."[19]

Acknowledging that quantum mechanics in some sense "works," Fredkin argues that the theory is ugly because it is largely ad hoc, concluding that we should prefer digital mechanics because it yields a more intuitively plausible and beautiful picture, one so simple and coherent it can be grasped by schoolchildren. His theory implies that quantum mechanics may describe what happens at the quantum level but fails to penetrate into the essential mechanisms generating the behavior. These mechanisms, in his view, are discrete and computational. The proof that digital mechanics underlies quantum mechanics will be demonstrated, Fredkin believes, when his research team is able to show that quantum mechanics *emerges* from the underlying digital mechanics base (a goal so far not achieved, although some progress toward it has been made). He remarks, "As one really understands the ideas of DM [digital mechanics], the currently accepted models of time, space, and process begin to seem mystical. From a Digital perspective, contemporary models of fundamental physics are a bit like looking at an animated cartoon while assuming that it's reality: that the images are moving continuously. So far, everyone we have interviewed who buys into Digital Philosophy has come to the conclusion that ordinary physics is a subject full of magic."[20]

Although Fredkin's claims are not as sweeping as Wolfram's, he too remains confident that a computational approach will explain living as well as nonliving systems. "Most biologists do not think about the processes of life in the same ways as would a Digital Philosopher," he remarks. "Yet some kind of information processing in living things begins with the informational process of sperm and egg combining and continues with differentiation as a kind of computation based on inherited information, and finally, as is obvious for all creatures that move, behavior involves information processing at a more familiar level."[21] Yet most of his examples are drawn from particle physics and quantum mechanics, realms that operate at a much lower level of complexity than living organisms.

Ray Kurzweil's criticism of Wolfram is telling in this regard; as Kurzweil points out, the cellular automata that Wolfram explores evolve complex patterns at what might be called the first level of complexity, but these complex patterns never self-organize to create further levels of emergence and complexity.[22] They do not, for example, self-organize to create bacteria or even viruses, never mind more complex organisms such as a duck or a human.

Even if Wolfram and Fredkin are correct in their claims that at the particle level the universe is a computer, this claim does not preclude higher levels of complexity emerging from different mechanisms, including analog processes (which can, of course, also be represented as computation, that is, analog computation rather than digital). Kurzweil further criticizes Wolfram for downplaying the role of evolution as a mechanism favoring the emergence of complexity; Kurzweil suggests that emergence at higher levels of complexity may well require the selective pressures and fitness criteria essential to evolutionary explanations.[23]

At best, then, the claims of Fredkin and Wolfram are incomplete, especially with regard to the emergence of higher-order from lower-order complexity. This is where the views of Harold Morowitz and like-minded researchers become important, for they offer a way to think about emergence as a process that not only operates at a single level of complexity but also continues up a dynamical hierarchy of linked systems to produce complexities out of complexities. In *The Emergence of Everything: How the World Became Complex* (a glitzy title for a good book), Morowitz reviews twenty-eight stages in the history of the cosmos to show that they can be characterized as emergent processes, each of which builds on the complexities that emerged from the preceding level.

"Emergence" carries special weight in this discourse. The term refers to properties that do not inhere in the individual components of a system; rather, these properties come about from interactions between components. Emergent properties thus appear at the global level of the system itself rather than at the local level of a system's components. Moreover, emergences typically cannot be predicted because the complex feedback loops that develop between components are not susceptible to explicit solution. As with Wolfram's simulations, the only way to determine the behavior of such a system is to run the simulation and see what emerges.

The new idea Morowitz adds is the insight that the emergences of a first-order complex system become properties that a second-order system can use to create a new dynamics from which further emergences will come. To the second-order system can be added a third-order system, a fourth-order system, and so on, with each level creating new emergences made possible by the emergences of the previous system. Multileveled complex systems synthesized in this way are called "dynamical hierarchies" (sometimes, significantly, "dynamic ontology"),[24] and the complexities they generate are potentially unlimited in scope and depth. Building on these ideas, Morowitz groups his twenty-eight events into four main stages: the emergence of the cosmos; the emergence of life; the emergence of mind; and the emergence of mind contemplating mind, or reflexivity. Presently, he believes, we are on the threshold of this last stage, whose development will be the catalyst for further evolution of the human into the posthuman in the centuries and millennia ahead. He finds the noosphere, the distributed global intelligence postulated by Pierre Teilhard de Chardin as the next stage in the evolution of intelligent life, suggestive of what might lie ahead for this fourth period.[25]

Whatever the future, the implications of this view for the present are clear, and it is here that the links between the "emergence of everything" and the Computational Universe become explicit. When the scope expands to the universe, simulations that could compute such behaviors become impossibly large, or in the terminology of the field, "transcomputable." To understand what "transcomputable" means, suppose that all the computing power on the planet was harnessed together and programmed to compute a given simulation. If the simulation qualified as "transcomputable," even this powerful array would not make more than a dent in the problem the simulation represented. For transcomputable situations, researchers must use pruning algorithms and selection rules to identify from an extremely large possibility space the conditions most likely to apply. The application of successive constraints, then, is crucial. What emerges has the force of an explanation but differs significantly from typical explanations in the physical sciences because it is not causal in nature and frequently is retrodictive rather than predictive.

These modes of explanation are necessary because complex systems cannot be described by mathematical equations that would allow precise prediction through linear causality. Like Wolfram and Fredkin, Morowitz emphasizes that the kinds of systems for which equations can be used constitute only a small set of all possible systems. According to Morowitz, although the traditional mathematical approach will continue to be useful, it will be understood increasingly as a specialized tool applicable only in (relatively) few situations. Future progress, he maintains, lies largely in the realm of computation and simulation. In a revealing analogy, Morowitz likens the invention of calculus and its central importance to the rise of modern science to the invention of the digital computer and the crucial role it plays in simulation. What calculus has been to physics and mathematics, the digital computer will be to understanding complex systems, evolution, and emergence.

Although the simulations and complex systems Morowitz discusses are not teleological (a characteristic related to the ontological minimalism of their starting points and to the lack of entailments these starting conditions embody), there is nevertheless directionality at work in their operations. The arrow of emergence points in the direction of increasing complexity,

both for the preferred simulations and, presumably, for the evolution of the universe itself (a proposition endorsed by Stuart Kauffman in his work on the evolution of life through autocatalytic networks).[26] In Morowitz's view, humans are the most complex systems yet to emerge, and they now have sufficient complexity to emulate the very processes of emergence that created them and everything else. Far from needing to presume or construct a separation between the observer and the observation—a premise necessary in the classical understanding of science to ensure objectivity—the computational perspective endorsed by Morowitz, Wolfram, and Fredkin has no need of such a stipulation. These researchers can account for the presence of the observer simply by introducing a component into the simulation that performs this function. Indeed, in Morowitz's view the human observer plays an indispensable role in the jump from the third stage (emergence of mind) to the fourth stage (emergence of reflexivity), for our ability to simulate complex processes within computers makes possible the next stage of emergences.[27]

The Regime of Computation, then, provides a narrative that accounts for the evolution of the universe, life, mind, and mind reflecting on mind by connecting these emergences with computational processes that operate both in human-created simulations and in the universe understood as software running on the "Universal Computer" we call reality. This is the larger context in which code acquires special, indeed universal, significance. In the Regime of Computation, code is understood as the discourse system that mirrors what happens in nature and that generates nature itself.

Having looked at the claims, I turn now to a critical examination of them. From my perspective, all of these researchers claim much more than they actually demonstrate. Wolfram's assertion that cellular automata underlie and explain the complexity of living systems, including human culture and social processes, is a giant (and mostly unwarranted) leap from the simple systems he has explored. He shows convincingly only one level of emergence, from individual cells to group behavior. He does not show how this group behavior, however complex, provides the basis for further emergences that would build upon it. In my view, analog processes are undervalued in Fredkin's and Wolfram's accounts and are likely to play a central role as first-level complexities evolve into second-level complexities and further levels beyond that. Moreover, Wolfram often does not tie his cellular automata models to actual mechanisms at work in physical systems, a connection that must be made to validate the kind of ontological claims he advances. In this sense, Fredkin's program is more ambitious, for it tries to show how phenomena described by particle physics can emerge from the group behavior of cellular automata. If this result can be achieved, it would indeed be a striking accomplishment and might well lead to radical rethinking of such foundational concepts as space and time, as he believes. Even in this best-case scenario, however, the leap Fredkin makes to higher-level complexities would remain to be demonstrated.

As for Morowitz, the novel component he adds is the interpretive framework of dynamical hierarchical emergences. Virtually all the phenomena he instances are well-known within their respective fields (cosmology, origins-of-life biology, evolution, psychology, etc.). Although he offers a compelling overall picture, he does not explicate the mechanisms that link one level of emergence to another, other than as a precondition (for example, there must be a planet before life can emerge on that planet). This sort of linear causality is well-known and offers nothing new. What would be new is a detailed understanding of how one dynamical level enchains and emerges from the next lower one through their intersecting dynamics. This he does not show, nor does he explore the specific mechanisms that bring it about.

In fact, no one to date has demonstrated clearly how complex dynamics in simulations can progress more than one level. Accordingly, such a demonstration has become the goal of the community of artificial-life researchers, who are devoting several major conferences to the problem in addition to organizing a special issue of the *Artificial Life Journal* on dynamical hierarchies.[28] History provides many examples of scientific and technological breakthroughs that occurred because researchers became convinced a certain goal was achievable and were willing to devote significant resources to accomplishing it (often aided by substantial government funding), from mapping the human genome to building an atomic bomb. In my view, it is likely that within the next three or four years multilevel dynamical hierarchies will be created in simulations, and I expect that much will be learned from detailed studies of their dynamics. Whether these insights will significantly alter the current picture remains to be seen.

The central problem of achieving emergence through more than one level is bound up tightly with issues of representation. As Nicholas Gessler, among others, has pointed out, one way to think about this process is to imagine a mechanism whereby the patterns that emerged at the first level are represented by a different kind of mechanism, which then uses these representations as primitives to create new emergent patterns, which in turn would undergo further re-representation and be turned into primitives for the third level, and so on.[29] This schema suggests a new interpretation of Wolfram's interaction with his cellular automata.

As noted above, one weakness of Wolfram's argument is his underestimation of the importance of analog processes, and especially of the productive interplay between analog and digital processes. Take DNA replication for example. DNA is often understood to operate as a digital code, in the sense that it is discrete rather than continuous. With the sequencing of the human genome, however, it has become clear that sequence is only part of the story, perhaps even the less important part. Protein folding, an analog process that makes use of continuous transformation in form, is essential to understanding how the genome actually functions. The *combination* of the two processes, the digitality of DNA sequences and the analog process of protein folding, gives the gene its remarkable power of information storage and transmission. Similar cooperations between digital and analog processes occur everywhere in nature and in contemporary technologies. Music CDs, for example, which Jean Baudrillard famously and mistakenly characterized as purely digital, rely on analog processes (such as microphones and other analog equipment) to capture the morphology of sound waves, which then can be represented numerically and transformed into computer code. That the combination of analog and digital should prove far more powerful than either by itself is no mystery, for each has properties that complement the other. As explained more fully in chapter 2, digital representations allow for precise error control, extreme fragmentation and recombination, whereas analog processes have the advantages of the continuum, including the ability to transmit informational patterns between differently embodied entities.

Consider now the moment when Wolfram bends over the output of one of his cellular automata and perceives in it patterns strikingly similarly to the shell of a mollusk. What exactly is happening in this scene? One way to understand it is as a re-representation of the patterns that emerged from the first-level operations of the cellular automata by another kind of analog mechanism we can call Wolfram's consciousness (assume for purposes of this discussion that consciousness is analog, even though in fact it may well be an emergent phenomenon itself produced by the synergistic interaction of analog and digital components). This kind of interaction between digital mechanisms and analog consciousness happens all around us every day, often resulting in emergent reorganizations across many levels of complexity, for example when digital technologies are re-represented in the consciousness of military strategists and used as the basis for reorganizing military units to create and facilitate emergent behaviors.

This larger vision of synergistic cooperation between consciousness and computer, language and code, epitomizes the kind of complex interactions to which this study is devoted. Notwithstanding the problems with the claims of Wolfram, Fredkin, and others, the computational worldview these researchers advocate contains valuable insights that should not get lost in the skeptical scrutiny to which their claims are rightfully subjected. Especially crucial are the entwined concepts of emergent processes and dynamical hierarchies, which represent ways of thinking that are powerful heuristics through which to understand the dynamics of complex systems of many different kinds. Whatever their limitations, these researchers fully understand that linear causal explanations are limited in scope and that multicausal complex systems require other modes of modeling and explanation. This seems to me a seminal insight that, despite three decades of work in chaos theory, complex systems, and simulation modeling, remains underappreciated and undertheorized in the physical sciences, and even more so in the social sciences and humanities.

Meanwhile, the pervasiveness and importance of computing in contemporary culture continue to reinforce the idea that computation is a fundamental process. Even if many of the claims associated with the Universal Computer are disproved, it is unlikely that the idea will die out altogether, particularly in communities of researchers concerned with the development of code and the construction of simulations. Already circulating are versions of the Universal Computer based on different mechanisms than cellular automata. Seth Lloyd, among others, has proposed that "the universe is a quantum computer: life, sex, the brain, and human society all arise out of the ability of the universe to process information at the level of atoms, photons, and elementary particles."[30] Significantly, this proposition came in response to "hard-edge" questions posed by popular science writer and literary agent John Brockman, questions that "render visible the deeper meanings of our lives, redefine who and what we are."[31]

Intermediation

For my purposes, I find the Regime of Computation valuable for articulating the context in which code takes shape within the worldview of computation. Speech and writing also have extensive links with their respective worldviews, which, as noted above, for the purposes of this project I identify with Saussurean semiotics and Derridean grammatology, respectively. Like computation, these worldviews imply distinctive ways of constituting communities, dealing with evolutionary changes, accommodating technological interventions, and describing the operations of systems. A thorough understanding of the interactions in which speech, writing, and code participate requires more than knowing the details of the three systems. Also at stake are the diverse conflicts and cooperations between their respective worldviews. As the worldview of code assumes comparable importance to the worldviews of speech and writing, the problematics of interaction between them grow more complex and entangled. These complex and entangled interactions are what I call "intermediation," a term suggested by Nicholas Gessler.[32]

An important aspect of intermediation is the recursivity implicit in the coproduction and coevolution of multiple causalities. Complex feedback loops connect humans and machines, old technologies and new, language and code, analog processes and digital fragmentations. Although these feedback loops evolve over time and thus have a historical trajectory that arcs from one point to another, it is important not to make the mistake of privileging any one point as the primary locus of attention, which can easily result in flattening complex interactions back into linear causal chains. The contemporary indoctrination into linear causality is so strong that it continues to exercise a fatal attraction for much of contemporary thought. It must be continually resisted if we are fully to realize the implications of multicausal and multilayered hierarchical systems, which entail distributed agency, emergent processes, unpredictable coevolutions, and seemingly paradoxical interactions between convergent and divergent processes.

A case in point is the current tendency to regard the computer as the ultimate solvent that is dissolving all other media into itself. Since sound, image, text, and their associated media (such as phonography, cinema, and books) can all be converted into digital code, many commentators, including Lev Manovich and Friedrich Kittler, have claimed that there is now only one medium, the digital computer.[33] Asserting that "one century sufficed to transform the ancient storage monopoly of writing into the omnipotence of integrated circuits," Kittler writes that "all data flows end in a state *n* of Turing's universal machine: numbers and figures become (in spite of romanticism) the key to all creatures."[34] This claim has the effect of flattening into a single causal line—the convergence of all media into one—social and cultural processes that are in fact much more complex. To take the case of books, clearly it matters that print has now become a particular kind of output for digital text. As I argue in chapter 5 with regard to Neal Stephenson's print novel *Cryptonomicon*, digitization leaves its mark even on print texts that remain entirely conventional in appearance and functionality. Moreover, a stroll through any major bookstore will confirm that print books in general have moved toward the visual and away from straight text, a tendency that bears witness to their interactions with other media.

Nevertheless, it is also true that any book, conventional or not, participates in the rich historical contexts and traditions of print that influence how books are designed, produced, disseminated, and received. The subvocalization that Kittler associates in *Discourse Networks* with the advent of phonetics and the ability of readers to hallucinate an imagined world does not disappear simply because blockbuster movies attract millions of viewers, any more than it evaporates because cinema and books are increasingly interpenetrated by digital techniques.[35] If anything, print readers relish all the more the media-specific effects of books precisely because they no longer take them for granted and have many other media experiences with which to compare them.[36] Although Sven Birkerts draws a different lesson from media proliferation in *The Gutenberg Elegies*, his book can be understood as a demonstration of the fact that print no longer exists in isolation from other media (even as it also illustrates the tendency to flatten complex interactions into a single causal chain). Recognizing entangled causalities and multiple feedback loops enables us to understand how media can converge into digitality and *simultaneously* diverge into a robust media ecology in which new media represent and are represented in old media, in a process that Jay Bolter and Richard Grusin have called "remediation."[37]

Grusin and Bolter define remediation, in one formulation, as "the formal logic by which new media technologies refashion prior media forms."[38] They trace feedback loops between the seemingly opposed but nonetheless correlated strategies of "immediacy" (the tendency of media to represent their productions as transparent and naturally accessible) and "hypermediacy" (the tendency of media to draw attention to their modes of representation and the media-specific strategies they use). This coevolution of apparently opposed trends, like the simultaneous coevolution of convergence and divergence in media, is characteristic of complex systems with multiple feedback loops.

Think, for example, of an ecological system in which predator and prey develop opposing strategies because each is involved in a feedback loop with the other. The opposition looms large if we look only at a single interaction between predator and prey (that is, position them in a linear causal relationship). In the more comprehensive context of the complex dynamics formed by their continuing interactions over generations of coevolution, however, the opposition becomes part of a larger picture in which one strategy catalyzes the opposing strategy, which in turn catalyzes a further development of the first one. In a similar way, extensive research on the Prisoner's Dilemma, a famous thought problem in which players must choose between competitive and cooperating strategies, demonstrates that the dynamics of this system change dramatically when the game is iterated, that is, subjected to repeated interactions between players.[39] Coevolution that extends over many cycles, such as that instantiated in iterated Prisoner's Dilemma simulations, is typical of media interactions in contemporary society, including the interactions that help to form (and in-form) the complex dynamics of textualities.

Grusin and Bolter's arguments in *Remediation* demonstrate insightfully that complex feedback occurs between the oppositional strategies of immediacy and hypermediacy. Nevertheless, for my purposes I prefer the term "intermediation." "Remediation" has the disadvantage of locating the starting point for the cycles in a particular locality and medium, whereas "intermediation" is more faithful to the spirit of multiple causality in emphasizing interactions among media. In addition, "remediation" (thanks to the excellent work Grusin and Bolter have done in positioning the term) now has the specific connotation of applying to immediate/hypermediate strategies. Because the dynamics I want to explore go far beyond this particular cycle, I would rather use the lesser known "intermediation" (which, being not as well known, is more open to new interpretations). To make the term more useful for my purposes, I want to expand its denotations to include interactions between systems of representations, particularly language and code, as well as interactions between modes of representation, particularly analog and digital. Perhaps most importantly, "intermediation" also denotes mediating interfaces connecting humans with the intelligent machines that are our collaborators in making, storing, and transmitting informational processes and objects.

In emphasizing intermediation, I have been instructed by studies that adopt different strategies to achieve different ends. I regard this project as complementary to these studies, for I see both these studies and my own project as useful in developing new frameworks with which to understand where we are and where we may be heading, both in literary studies and the broader context of contemporary Anglo-American-European culture. To some extent, this project is also intended as a corrective to the tendency in other studies, useful as they are, to privilege one medium and/or mode of interaction to the exclusion of others and thus to fall again into the trap of linear causality. By keeping the focus on intermediation, I hope to incorporate some of the insights from other studies while clarifying how the recognition of multiple causalities leads to different conclusions.

Media Technologies and Embodied Subjects

To help situate this project, let us consider the contrasting approaches of Friedrich Kittler and Mark B. N. Hansen. Kittler's strategy for escaping from the confines of humanist discourse is to focus on media rather than subjects. In *Discourse Networks*, he argues that subjects speak within discourse systems, and that discourse systems are constituted by the technological apparatuses enabling them to operate. "Media determine our situation," he proclaims in the preface to *Gramophone, Film, Typewriter*, asserting that "technologies that not only by-pass writing but suck in and carry off so-called humanity render their own description impossible" (28), thus making post-print media the sea in which we posthuman fish swim. Although Kittler does not ignore bodies and subjectivities, he positions them as being constituted by the media they use. "In order to optimize writing for machines," he asserts with typical hyperbole "it must no longer be dreamt of as an expression of individuals or as a trace of bodies. The forms, differences, and frequencies of letters have to be reduced to formulas. So-called man becomes physiology on the one hand and information technology on the other."[40] The rhetoric of force ("must no longer," "have to be") performs an epistemic break reminiscent of the early Foucault, with the important difference, as Kittler himself has observed in critiquing Foucault, that his focus is on the media technologies that produce discourse systems ("discourse networks") rather than on discourse systems themselves.[41]

Strenuously resisting Kittler's coercive rhetoric, Hansen, in *New Philosophy for New Media*, performs a violence of his own by attempting to reduce Kittler's argument to a linear causal chain that rests solely on the truth or falsity of Shannon's information theory. "What remains decisive for Kittler," he argues, "are precisely the formal properties of Shannon's model: as the basis for the technical de-differentiation that constitutes the logical culmination of the historical decoupling of information from communication, Shannon's model allows Kittler to postulate an informational posthistory. From the standpoint of the optoelectronic future, the human or so-called Man—as well as the entire range of media effects said to comprise a media ecology—must be revalued as the purely contingent by-product of a preparatory phase in the evolution of information toward truly autonomous circulation" (77). To show that this foundation cannot stand, Hansen instances Donald MacKay's alternative approach to information, which was developed contemporaneously with Shannon's. In contrast to Shannon's separation of information and meaning, MacKay develops a concept of information that places the embodied receiver at the center of his theory.[42] Hansen's recourse to MacKay is somewhat disingenuous, for it ignores the fact that it was the Shannon/Wiener theory, and not Mackay's work, that was important for the development of information theory, for the good reason that MacKay's theory, although more encompassing in correlating information with meaning, could not be reliably quantified with technologies

available in the 1950s (and still cannot today). Moreover, Hansen's refutation concerns only one line of reasoning in Kittler's extensive oeuvre, and for this reason is insufficient to discount his approach entirely, as Hansen seems to imply.

In contrast to Kittler, Hansen privileges embodiment as the locus of subjectivity, reading new media through its effects on embodied users and viewers. "Correlated with the advent of digitization, then, the body undergoes a certain empowerment, since it deploys its own constitutive singularity (affection and memory) not to filter a universe of preconstituted images but actually to enframe something (digital information) that is originally formless. Moreover, this 'originary' act of enframing information must be seen as the source of all technical frames (even if these appear to be primary), to the extent that these are designed to make information perceivable by the body, that is, to transform it into the form of an image" (10). It is no accident, I think, that coercive rhetoric similar to Kittler's appears here ("must be seen"), for Hansen wants to unseat Kittler's media focus in order to place the embodied subject at the center of his own "new philosophy for new media."[43]

Notwithstanding their opposed viewpoints, Hansen and Kittler share a mode of argumentation that privileges one locus of the human/machine feedback loop at the expense of the other. For Kittler it is all about media: the technical configurations they impose on representations, and the content of representations that reflect and reinscribe these configurations. For Hansen it is all about embodied subjects: the perceptual and cognitive processing they incorporate as a result of the media they encounter, specifically media images, and the representations within new media that catalyze and foreground these incorporations. From where I stand, it looks like Kittler and Hansen are perched on a seesaw that teeters up and down while they fail to notice that both ends are connected by a fulcrum joining the two in correlated actions.

Certainly media are dependent on embodied subjects, not only for their reception and significance but also because researchers extensively investigate the precise nature of computer/human interfaces to develop and design networked and programmable media that will have certain effects. There would be no media without humans to invent them, and no purpose to them without humans to give them meaning and significance (notwithstanding the futuristic scenarios evoked by Kittler, Moravec, Kurzweil, and others of a postmedia, posthuman age in which media are autonomously created by other media and/or intelligent machines).[44] On the other hand, media clearly determine and help constitute humans' embodied responses, which include not only the historically specific conditioned reactions of a given epoch but also the evolutionarily evolved cognitive and perceptual capabilities that Hansen evokes. Moreover, in certain contexts the body itself becomes a medium at the same time as it is in-formed by other media, a complex dynamic ingeniously enacted by Sha Xin Wei's "Tgarden," in which performers strive to create new gestural languages in association with motion sensors and virtual projections.[45] Surely a fuller account—to which I hope to contribute by focusing on intermediation—would take into consideration both of the vectors that Hansen and Kittler mobilize, acknowledging, on one hand, the role technical configurations play and, on the other, the centrality of embodied subjects to new media productions. The trick, as I see it, is to enlarge the scope of inquiry so that it includes *both* Wolfram and his cellular automata, the embodied human and his perceptions *along with* the computational processes that he creates and that work to co-constitute him and his perceptions. In a strikingly literal sense, Wolfram and his cellular automata coevolve together in a synergistic dynamic that allows emergences to occur across many levels of complexity.

A similar pattern emerges from the contrast between Espen Aarseth's *Cybertext* and Jerome McGann's *Radiant Textuality.* Like the work of Kittler and Hansen, these texts are seminally important studies deserving close attention. Defining "ergodic literature" as literature requiring "nontrivial effort" to "allow the reader to traverse the text" (1), Aarseth makes a point of including print books as well as computer games and electronic interactive fiction. He slyly takes a poke at the literary establishment by remarking that to limit his analysis to computer-driven texts "would be an arbitrary and unhistorical limitation, perhaps comparable to a study of literature that would only acknowledge texts in paper-printed form" (1). Nevertheless, if computer games, electronic hypertexts, and interactive fiction were not on the scene, no one (including Aarseth) would have been likely to find it necessary to define "ergodic literature" as a category of analysis. In this sense, his analysis is motivated primarily by the kind of literature the computer has made popular, especially computer games, now his principal focus of interest. The centrality of computers to his analysis is indicated, among other places, by his defense of the cybertext perspective as necessary because no other existing approach takes into account "the text as a material machine, a device capable of manipulating itself as well as the reader" (24), a description much more relevant to computers than to books. Moreover, he develops several important distinctions—including "scriptons" as strings the reader sees versus "textons" as strings generating the text—that are crucially important for computer texts but infrequently so for codex books and print texts in general. The computer orientation also helps to explain why his analysis is heavily weighted toward functionality. Most of the terms he defines to develop his typology have to do with functions available to the player/user or with functions that elements within a text can perform. Since most print texts differ little from one another in their functionality, this emphasis is an additional indication that Aarseth's perspective is oriented primarily toward computer-generated texts.

There is nothing wrong, of course, with a computer orientation. This orientation is part of what makes *Cybertext* an invaluable contribution to the field of electronic textuality, which continues to be too often seen through a print-centric perspective. More problematic is the fact that Aarseth's functionalist approach tends to flatten multiple causalities into linear causal sequences determined by a work's functionality. This flattening can be seen both in his relative neglect of the political, social, and cultural contexts in which texts are used and in the "textonomy" he develops for his typology (58). Similarly, he also neglects interactions of different modalities within electronic texts. Even though many of his examples include visual displays and animations, he defines a text as "any object with the primary function to relay *verbal* information" (62, emphasis added), leaving out of account visual, graphic, sonic, kinetic, and other nonverbal signifiers. Although he recognizes that materiality should be part of the picture, his analysis pays scant attention to the material specificity of texts. He asserts—astonishingly, given the contemporary legal and political debates over Gnutella and Napster—that in "the transition from long-playing records to compact discs in the music industry," the "analog-to-digital shift of the artifact did not change any substantial aspects of the cultural production or consumption of music" (59). To be fair, it is much easier to see the importance of these issues in 2004 than it would have been in 1997, when *Cybertext* was published, for the intervening seven years have seen remarkable growth in the visuality of electronic media and the accelerating digitization of all media. Nevertheless, there remains an important gap between Aarseth's emphasis on typology as a list of static functionalist components located on a grid of 576 positions, and the kind of dynamic multicausality required to understand complex emergent processes characterized by entangled feedback loops cycling back and forth between different levels.

In contrast to Aarseth's methodology is the approach Jerome McGann takes in *Radiant Textuality.* As I argue at more length in chapter 4, McGann's primary interest lies in using electronic textuality to deepen our understanding of how print literature works. In this the book is successful, as its deserved recognition by the James Russell Lowell Prize indicates. A brilliant reader of print literature, particularly poetry, McGann continues to argue that even modest works in the print tradition are far better, as literature, than the most complex and interesting works of electronic literature.[46] This is a judgment I do not share, and in my view it stems largely from a tendency to apply to electronic literature the same reading strategies one uses for print, while underappreciating or perhaps simply not recognizing the new strategies available to electronic literature: animation, rollovers, screen design, navigation strategies, and so on. Whereas Aarseth faces forward and reads print literature through a matrix developed in the context of computer games, McGann faces backward and reads electronic literature through a matrix developed in the context of print literature. McGann has been a pioneer in arguing for multidimensional models to explain how print texts come into being. However, despite his leadership in creating and implementing the D. G. Rossetti Hypermedia Archive, an important Web site, one looks in vain in *Radiant Textuality* for similar deep insights into the multiple causalities, complex feedback loops, and emergent processes through which electronic texts are made, stored, and disseminated.[47]

Of course, it is much easier to characterize in general terms what should be done than it is to do it, especially when attempting to work against the grain of something as entrenched and powerful as linear causal models. My arguments will stand or fall not on general claims and caveats about seminal texts but on in-depth explorations of the complex dynamics with which I want to engage. Accordingly, I turn now from this chapter focused on technology to a comparison of the theoretical frameworks and worldviews of speech, writing, and code.

2 Speech, Writing, Code

Three Worldviews

The Locus of Complexity

Speech, writing, code: these three major systems for creating signification interact with each other in millions of encounters every day. Each, as it has been theorized, comes with its own worldview, associated technologies, and user feedback loops. In the progression from speech to writing to code, each successor regime reinterprets the system(s) that came before, inscribing prior values into its own dynamics. Now that the information age is well advanced, we urgently need nuanced analyses of the overlaps and discontinuities of code with the legacy systems of speech and writing, so that we can understand how processes of signification change when speech and writing are coded into binary digits. Although speech and writing issuing from programmed media may still be recognizable as spoken utterances and print documents, they do not emerge unchanged by the encounter with code. Nor is the effect of code limited to individual texts. In a broader sense, our understanding of speech and writing in general is deeply influenced by the pervasive use of code (my deliberate situating of them as legacy systems above is intended as a provocation to suggest the perceptual shifts underway). This chapter will show how the worldview of computation sketched in chapter 1 manifests itself in the specific case of the digital computer. It will also indicate ways in which commonly accepted ideas about signification need to be reevaluated in the context of coding technologies. Finally, it will suggest terms for analysis that, although not absent in speech and writing, assume new importance with code and therefore lead to new theoretical emphases and foci of attention.

In drawing comparisons of code with speech and writing, one is faced with an embarrassment of riches. One thinks, for example, of the embodied views of speech explored by practitioners and theorists as diverse as Walter

Ong and Oliver Sacks; of such preeminent theorists of writing as Paul de Man and J. Hillis Miller. Out of many possibilities, I have chosen to focus on Ferdinand de Saussure's view of speech and Jacques Derrida's grammatological view of writing partly because these theorists take systemic approaches to their subjects that make clear the larger conceptual issues. Like them, I want to take a systemic approach by focusing on the conceptual system in which code is embedded, a perspective that immediately concerns programming for digital computers but also includes the metaphysical implications of the Regime of Computation. In addition, both Saussure and Derrida have been extremely influential in shaping contemporary views of speech and writing. By addressing their work in detail, I can by implication address the large number of related projects these two theorists have inspired. An additional advantage is Derrida's engagement with Saussure's theories of the speech system; Derrida's work has an intimate relation with Saussure's, which is richly documented in Derrida's writings, especially his early work. Moreover, one of Derrida's critical points is that writing exceeds speech and cannot simply be conceptualized as speech's written form. Similarly, I will argue that code exceeds both writing and speech, having characteristics that appear in neither of these legacy systems. This project, then, is not meant as a general comparison of code with structuralism and deconstruction but as a more narrowly focused inquiry that takes up specifically Saussure and Derrida.

Before turning to a systematic comparison of code with Saussure's speech system and Derrida's grammatology, I want to establish a general framework for my remarks. Derrida's remarkably supple and complex writing notwithstanding, much of his analysis derives from a characteristic of writing that would likely spring to mind if we were asked to identify the principal way in which writing differs from speech. Writing, unlike speech (before recording technologies), is not confined to the event of its making. It can be stored and transmitted, published in dozens of countries and hundreds of different editions, read immediately after its creation or a thousand years hence. In a sense it is no surprise that Derrida summarizes this difference between writing and speech by fusing "difference" with "defer," for the ability to defer indefinitely our encounter with writing leaps out as perhaps the most salient way in which it differs from speech. Derrida, of course, complicates and extends this commonsense idea by linking it with a powerful critique of the metaphysics of presence—but these complexities have their root in something most people would identify as a constitutive difference between speech and writing.

If we were to ask about the parallel characteristic that leaps to mind to distinguish code from speech and writing, an obvious contender would be the fact that code is addressed both to humans and intelligent machines. A further distinction is implied when we note that computers, although capable of performing diverse and complicated tasks, have at the base level of machine language only two symbols and a small number of logical operations with which to work. As Stephen Wolfram eloquently testifies in relation to his cellular automata, the amazing thing about them is that starting from an extremely simple base they can nevertheless produce complex patterns and behaviors.

This train of thought suggests the following question: Where does the complexity reside that makes code (or computers, or cellular automata) seem adequate to represent a complex world? In his critique of speech and the metaphysics of presence, Derrida makes clear that complexity was vested traditionally in the Logos, the originary point conceptualized as necessarily exceeding the world's complexity, since in this view the world derived from the Logos. For Derrida's grammatology, complexity is conceptually invested in the trace and by implication in the subtle analysis that detects the movement of the trace, which can never be found as a thing-in-itself. For code, complexity inheres neither in the origin nor in the operation of difference as such but in the labor of computation that again and again calculates differences to create complexity as an emergent property of computation. Humans, who have limited access to their own computational machinery (assuming that cognition includes computational elements, a proposition explored in chapter 9), create intelligent machines whose operations can be known in comprehensive detail (at least in theory). In turn, the existence of these machines, as many researchers have noted, suggests that the complexities we perceive and generate likewise emerge from a simple underlying base; these researchers hope that computers might show us, in Brian Cantwell Smith's phrase, "how a structured lump of clay can sit up and think."[1] The advantages of the computational view, for those who espouse it, is that emergence can be studied as a knowable and quantifiable phenomena, freed both from the mysteries of the Logos and the complexities of discursive explanations dense with ambiguities. One might observe, of course, that these characteristics also mark the limitations of a computational perspective.

It is not an accident that my analysis starts by inquiring about the locus of complexity, for the different strategies through which Saussurean linguistics, Derridean grammatology, and the Regime of Computation situate complexity have extensive implications for their respective worldviews. From this starting point I will develop several ways, not all of them obvious, in which code differs from speech and writing. My purpose is not to supplant these legacy systems and especially not to subordinate speech and writing to code (an important point, given Saussure's historic claim that writing must be subordinate to speech, and Derrida's insistence that, on the contrary, speech is subordinate to writing). Rather, for me the "juice" (as Rodney Brooks calls it) comes from the complex dynamics generated when code interacts with speech and writing, interactions that include their mundane daily transactions and also the larger stakes implicit in the conflict and cooperation of their worldviews.

Saussurean Signs and Material Matters

Let us begin, then, where Saussure began, with his assertion that the sign has no "natural" or inevitable relation to that which it refers; "the linguistic sign is arbitrary," he writes in *Course in General Linguistics.*[2] Partly for this reason, he excludes from consideration hieroglyphic and idiomatic writing. As he makes clear in a number of places, he regards speech as the true locus of the language system (*la langue*) and writing as merely derivative of speech. "A language and its written form constitute two separate systems of signs. The sole reason for the existence of the latter is to present the former. The object of study in linguistics is not a combination of the written word and the spoken word. The spoken word alone constitutes that object" (24–25). Objecting to the primacy Saussure accords to speech, Derrida sees in this hierarchy indications that Saussure remains bound to a metaphysics of presence and to the Logos with which speech has traditionally been associated; in an interview with Julia Kristeva, he remarks that "the concept of the sign belongs to metaphysics."[3]

Derrida marshals numerous arguments to insist that writing, far from being derivative as Saussure claims, in fact precedes speech; "the linguistic sign implies an original writing."[4] This counterintuitive idea, to which we will return, depends on his special understanding of writing as grammatology. In addition, he critiques Saussure's notion of the arbitrariness of the sign, asking if the "ultimate function" of this premise is to obscure "the rights of history, production, institutions etc., except in the form of the arbitrary and in the substance of naturalism" (*Of Grammatology*, 33). Of course he recognizes that the arbitrariness of the sign as Saussure posits it refers to the absence of a necessary connection between sign and referent, but his critique implies that Saussure's formulation tends to suppress the recognition that constraints of any kind might encumber the choice of sign. The productive role that constraints play in the Regime of Computation, functioning to eliminate possible choices until only a few remain, is conspicuously absent in Saussure's theory. Instead, meaning emerges and is stabilized by differential relations between signs. Jonathan Culler, writing his influential book on Saussure just as Saussure was becoming well known in the United States, makes explicit this implication: "The fact that the relation between signifier and signified is arbitrary means, then, that since there are no fixed universal concepts or fixed universal signifiers, the signified itself is arbitrary, and so is the signifier. . . . Both signifier and signified are purely relational or differential entities."[5]

Culler's interpretation helps explain why material constraints tend to drop out of Saussure's theory as appropriated by American poststructuralism, with a corresponding emphasis on differential relations and shifting uncertain ties to reference and, indeed, to the material conditions of production altogether (interpretations that have been contested by later commentators seeking to recuperate Saussure for various purposes).[6] Although Derrida's suggestion that Saussure had erased "the rights of history, production, institutions, etc." remains underdeveloped in his writing, the recognition that materiality imposes significant constraints becomes crucially important in code, and arguably in speech and writing as well. Why, for example, are there no words in English (and so far as I know, in any other language) that have one hundred or more syllables? Obviously, we have no such words because they would take too long to pronounce. In contrast to the erasure of materiality in Saussure, material constraints have historically been recognized as crucial in the development of computers, from John von Neumann in the 1950s agonizing over how to dissipate heat produced by vacuum tubes to present-day concerns that the limits of miniaturization are being approached with silicon-based chips. Moreover, material constraints have played a central role in favoring the shift to digital computers over analog.

To understand why digital computers have been favored, consider Transistor to Transistor Logic (TTL) chips, where the binary digit zero is represented by zero volts and the binary digit one by five volts. If a voltage fluctuation creates a signal of .5 volts, it is relatively easy to correct this voltage to zero, since .5 is much closer to zero than to five. Error control is much more complex with analog computers, where voltages vary continuously. For code, then, the assumption that the sign is arbitrary must be qualified by material constraints that limit the ranges within which signs can operate meaningfully and acquire significance. As we shall see, these qualifications are part of a larger picture that tie code more intimately to material conditions than is the case either for Saussure's speech system or Derrida's grammatological view of writing. In the worldview of code, materiality matters.

Culler was not wrong in emphasizing differential relations rather than material constraints, for it is clear that Saussure's view of the sign tended toward dematerialization. "The physical part of the [speech] circuit can be dismissed from consideration straight away," he says (13). Although he later acknowledges that "linguistic signs, although essentially psychological, are not abstractions," he sees their materiality as "realities localized in the brain" and distinguishes this mediated materiality from linguistic structure, where "there is only the sound pattern" (15). He argues that differences in pronunciation should be excluded because they "affect only the material substance of words" (18). Considering the sign to consist of signifier and signified, he insists that the signifier is not the acoustic sound itself but the "sound pattern" or "sound image," that is, an idealized version of the sound, whereas the signified is the concept associated with this image. The advantage of defining an immaterial pattern as the signifier is obvious; through this move, he dispenses with having to deal with variations in pronunciation, dialects, and so on (although he does recognize differences in inflection, a point that Johanna Drucker uses to excavate from his theory a more robust sense of the materiality of the sign).[7]

This is Saussure's way of coping with the noise of the world, whereby idealization plays a role similar to the function performed by discreteness in digital systems. It is worth reflecting on the differences between these two strategies. Rectifying voltage fluctuations could be compared to Saussure's "rectification" of actual sounds into idealized sound images. Importantly, however, rectification with code happens in the electronics rather than in the (idealized) system created by a human theorist. Thus it is a physical operation rather than a mental one, and it happens while the code is running rather than retrospectively in a theoretical model. These differences again illustrate that code is more intrinsically bound to materiality than Saussure's conception of *la langue.*

The disjunctions between Saussure's theory and the materially determined practices of code raise the question of whether it makes sense to use such legacy terms as "signifier" and "signified" with code. Many theorists concerned with electronic textuality are starting from new frameworks that do not rely on these traditional terms. In chapter 1, for example, I introduced Espen Aarseth's "textonomy," which sweeps the board clean and works from fundamental considerations to create a taxonomic scheme for analyzing ergodic literature. Similarly, a group of German researchers at the University of Siegen are working together in a project they call "Medienumbrüche" (Media Upheavals). They "regard the semiotic difference between strings and nets of signifiers as the foundation of a theory of 'net literature' which calls basic concepts such as 'author,' 'work,' and 'reader' into question."[8]

Although valuing these new theoretical frameworks as necessary interventions, I think it is important also to undertake a nuanced analysis of where code does and does not fit with traditional terms, especially for this project with its focus on intermediation. The exchanges, conflicts, and cooperations between the embedded assumptions of speech and writing in relation to code would be likely to slip unnoticed through a framework based solely on networked and programmable media, for the shift over to the new assumptions would tend to obscure the ways in which the older worldviews engage in continuing negotiations and intermediations with the new. For my purposes, then, the comparison is vital. Later I will perform the reverse operation of trying to fit the speech and writing systems into the worldview of code, and here too I expect the discontinuities to be as revealing as the continuities.

In the context of code, then, what would count as signifier and signified? Given the importance of the binary base, I suggest that the signifiers be considered as voltages—a suggestion already implicit in Friedrich Kittler's argument that ultimately everything in a digital computer reduces to changes in voltages.[9] The signifieds are then the interpretations that other layers of code give these voltages. Programming languages operating at higher levels translate this basic mechanic level of signification into commands that more closely resemble natural language. The translation from binary code into high-level languages, and from high-level languages back into binary code, must happen every time commands are compiled or interpreted, for voltages and the bit stream formed from them are all the machine can understand.[10] Thus voltages at the machine level function as signifiers for a higher level that interprets them, and these interpretations in turn become signifiers for a still higher level interfacing with them. Hence the different levels of code consist of interlocking chains of signifiers and signifieds, with signifieds on one level becoming signifiers on another. Because all these operations depend on the ability of the machine to recognize the difference between one and zero, Saussure's premise that differences between signs make signification possible fits well with computer architecture.

Derrida's *Différance* and the Clarity of Code

This continuity between computer architecture and Saussure's understanding of signification becomes a discontinuity, however, when Derrida transforms difference into *différance*, a neologism suggesting that meanings generated by differential relations are endlessly deferred. Speaking metaphorically, we may say that whereas Saussure focuses on two (or more) linguistic signs and infers a relationship connecting them, Derrida focuses on the gap as the important element, thus converting Saussure's presumption of presence into a generative force of absence: "*différance is not,* does not exist, is not a present-being (*on*) in any form. . . . It has neither existence nor essence. It derives from no category of being, whether present or absent."[11] To name this generative force, Derrida coins any number of terms in addition to *différance*: "trace," "arche-writing," "non-originary origin," and so on. Whatever the name, the important point is that the trace has no positive existence in itself and thus cannot be reified or recuperated back into a metaphysics of presence. "*Différance* is not only irreducible to any ontological or theological—ontotheological—reappropriation, but as the very opening of the space in which ontotheology—philosophy—produces its system and its history, it includes ontotheology, inscribing it and exceeding it without return" (*Margins,* 6). Always on the move, the trace resides everywhere and nowhere, functioning as the elusive and fecund force that makes possible all subsequent meaning. In this sense the trace, as the arche-writing that enables signification, precedes speech and also writing in the ordinary sense. The notoriously slippery nature of the trace has authorized the widely accepted idea, reinforced by thousands of deconstructive readings performed by those who followed in Derrida's footsteps, that meaning is always indeterminate and deferred.

Let us now consider how this claim for difference/deferral looks from the point of view of code. In the worldview of code, the generation of meaning happens in ways that scholars trained in the traditional humanities sometimes find difficult to understand and even more difficult to accept. At the level of binary code, the system can tolerate little if any ambiguity. For any physically embodied system, some noise and, therefore, possible ambiguities are always present. In the case of digital computers, noise enters the system (among other places) in the voltage trail-off errors discussed earlier, but these are rectified into unambiguous signals of one and zero before they enter the bit stream.[12] As the system builds up levels of programming languages such as compilers, interpreters, scripting languages, and so forth, they develop functionalities that permit increasingly greater ambiguities in the choices permitted or tolerated. The Microsoft Word spell checker is a good example. Given a letter string not in the program's dictionary, it looks for the closest matches and offers them as possibilities. No matter how sophisticated the program, however, all commands must be parsed as binary code to be intelligible to the machine.

In the context of digital computers, even less tenable than ambiguity is the proposition that a signifier could be meaningful without reference to a signified. In Derrida's view, Saussure's definition of the sign undercuts the

metaphysics of presence in one sense and reinforces it in another. He argues that the very idea of a signified as conceptually distinct from the signifier (although for Saussure, indissoluble from it) gives credence to a transcendental signified, and to this extent reinscribes classical metaphysics. The distinction between signifier and signified, Derrida writes, "leaves open the possibility of thinking a *concept signified in and of itself,* a concept simply present for thought, independent of a relationship to language, that is of a relationship to a system of signifiers" (*Positions,* 19). At the same time, the distinction also opens the possibility that any signified, extracted from one context and embedded in another, could slide into the position of the signifier (for example, when one concept entails another). Since the idea of a transcendental signified implies that there is nothing above or beyond this originary point, the dynamic of signified-becoming-signifier threatens to undermine the absolute authority given to the transcendental signified. In this sense, Saussure's theory (as interpreted by Derrida) can be seen as working against the metaphysics of presence in which it otherwise remains complicit. This background helps to explain why, in deconstructive criticism, the focus tends to fall on the signifier rather than the signified. Indeed, I venture to guess that in contemporary critical theory, "signifier" is used thousands of times for every time "signified" appears.

In the worldview of code, it makes no sense to talk about signifiers without signifieds. Every voltage change must have a precise meaning in order to affect the behavior of the machine; without signifieds, code would have no efficacy. Similarly, it makes no sense to talk about floating signifiers (Lacan's adaptation of Derrida's sliding signifier) because every change in voltage must be given an unambiguous interpretation, or the program is likely not to function as intended.[13] Moreover, changes on one level of programming code must be exactly correlated with what is happening at all the other levels. If one tries to run a program designed for an older operating system on a newer one that no longer recognizes the code, the machine simply finds it unreadable, that is, unintelligible. For the machine, obsolete code is no longer a competent utterance.

Because it is a frequent point of confusion, I emphasize that these dynamics happen before (or after) any human interpretation of these messages. Whatever messages on screen may say or imply, they are themselves generated through a machine dynamics that has little tolerance for ambiguity, floating signifiers, or signifiers without corresponding signifieds. Although the computational worldview is similar to grammatology in not presuming the transcendental signified that Derrida detects in Saussure's speech system, it also does not tolerate the slippages Derrida sees as intrinsic to grammatology. Nor does code allow the infinite iterability and citation that Derrida associates with inscriptions, whereby any phrase, sentence, or paragraph can be lifted from one context and embedded in another. "A written sign carries with it a force that breaks with its context, that is, with the collectivity of presences organizing the moment of its inscription. This breaking force [*force de rupture*] is not an accidental predicate but the very structure of the written text."[14] Although Derrida asserts that this iterability is not limited to written language but "is to be found in all language" (*Limited Inc*, 10), this assertion does not hold true literally for code, where the contexts are precisely determined by the level and nature of the code. Code may be rendered unintelligible if transported into a different context—for example, into a different programming language or a different syntactic structure within the same language. Only at the high level of object-oriented languages such as C++ does code recuperate the advantages of citability and iterability (i.e., inheritance and polymorphism, in the discourse of programming language) and in this sense become "grammatological."[15]

Ellen Ullman, a software engineer who has been a pioneer in a field largely dominated by men, has written movingly about the different worldviews of code and natural language as they relate to ambiguity and slippage.[16] Asked in an interview with Scott Rosenberg if code is a language, she replied, "We can use English to invent poetry, to try to express things that are very hard to express. In programming you really can't. Finally, a computer program has only one meaning: what it does. It isn't a text for an academic to read. Its entire meaning is its function."[17] Emphasizing the unforgivingness of code, Ullman underscores its functionality. Code has become an important actor in the contemporary world because it has the power to change the behavior of digital computers, which in turn permeate nearly every kind of advanced technology. Code can set off missiles or regulate air traffic; control medical equipment or generate PET scans; model turbulent flow or help design innovative architecture. All of these tasks are built ultimately on a base of binary code and logic gates that are intolerant to error. Above all else, the digital computer is a logic machine, as Martin Davis shows elegantly in *The Universal Computer*, where he discusses the history of the logic on which the digital computer is based.

In *Close to the Machine*, Ullman illustrates vividly the contrast between the worldviews of code and human language when she discusses a software system she was commissioned to create that would help deliver information to AIDS patients. She recounts working in her San Francisco loft with a small group of programmers she had hired. They worked around the clock to meet the deadline, speaking in rapid-fire phrases about the structure of the program, the work-arounds they could devise, the flow charts that showed how the code would be processed. Junk food abounded, dress was disheveled, courtesy was a waste of precious minutes, and sleep became a distant memory as they subordinated all other concerns to the logic of the machine (1–17). Then, as the independent contractor responsible for the system, she met with the staff whose clients would be using the software. Suddenly the clear logic dissolved into an amorphous mass of half-articulated thoughts, messy needs and desires, fears and hopes of desperately ill people. Even as she tried to deal with the cloud of language in which these concerns were expressed, her mind raced to translate the concerns into a list of logical requirements to which her programmers could respond. Acting as the bridge arcing between the floating signifiers of natural language and the rigidity of machine code, she felt acutely the strain of trying to reconcile these two very different views of the world. "I had reduced the users' objections to a set of five system changes. I would like to use the word 'reduce' like a cook: something boiled down to its essence. But I was aware that the real human essence was already absent from the list I'd prepared. An item like 'How will we know if the clients have TB?'—the fear of sitting in a small, poorly ventilated room with someone who has medication-resistant TB, the normal and complicated biological urgency of that question—became a list of data elements to be added to the screens and database" (13–14).

One of the book's poignant scenes comes when Ullman, emotionally stressed by events in her life, decides to take her computer apart and put it back together, in a kind of somatic therapy that soothed by putting her physically in touch with the parts that functioned in such perfectly logical fashion (65–94). The scene illustrates another way in which the worldview of code differs from Saussure's dematerialized view of speech and Derrida's emphasis on linguistic indeterminacy. Although it is possible to view computer algorithms as logical structures that do not need to be instantiated to have meaning (the received view of many computer science departments), in practice any logical or formal system must run on some kind of platform to acquire meaning, whether a human brain or a digital computer. Without the ability to change the behavior of machines, code would remain a relatively esoteric interest of mathematicians working in areas such as the lambda calculus (where algorithms were used for research purposes in the 1930s, prior to the invention of the digital computer).[18] Code has become arguably as important as natural language because it causes things to happen, which requires that it be executed as commands the machine can run.

Code that runs on a machine is performative in a much stronger sense than that attributed to language. When language is said to be performative, the kinds of actions it "performs" happen in the minds of humans, as when someone says "I declare this legislative session open" or "I pronounce you husband and wife." Granted, these changes in minds can and do result in behavioral effects, but the performative force of language is nonetheless tied to the external changes through complex chains of mediation. By contrast, code running in a digital computer causes changes in machine behavior and, through networked ports and other interfaces, may initiate other changes, all implemented through transmission and execution of code. Although code originates with human writers and readers, once entered into the machine it has as its primary reader the machine itself. Before any screen display accessible to humans can be generated, the machine must first read the code and use its instructions to write messages humans can read. Regardless of what humans think of a piece of code, the machine is the final arbiter of whether the code is intelligible. If the machine cannot read the code or if the program does not work properly, then the code must be changed and corrected before the machine can make things happen. In *Protocol*, Alexander R. Galloway makes this point forcefully when he defines code as executable language. "But how can code be so different from mere writing?" he asks. "The answer to this lies in the unique nature of computer code. . . . Code is a language, but a very special kind of language. *Code is the only language that is executable.*"[19]

This character of code stands in striking contrast to the communities that decide whether an act of speech or a piece of writing constitutes a legible and competent utterance. As Saussure observes, no one person can change the spoken language system. "A language, as a collective phenomenon, takes the form of a totality of imprints in everyone's brain. . . . Thus it is something which is in each individual, but is none the less common to all. At the same time it is out of reach of any deliberate interference by individuals" (*Course*, 19). It takes many individual adopters of a change and a (relatively) long time for changes in the speech system to occur. (To some extent this claim requires modification in light of mass media such as television and newspapers, where a single speaker or small group of speakers can change the system if given enough press coverage. Saussure's point remains valid, however, in the sense that only if the speech acts of such privileged speakers are widely adopted can they actually change the system.) For Derrida, writing differs from Saussure's view of the speech system because inscriptions can endure over centuries or millennia, and thus can be cited, and therefore embedded, in a potentially infinite number of different contexts.

Moreover, Derrida reads the qualities of iterability and citation back into speech, instancing precisely the phenomena (e.g., quotations and speeches performed by actors in a theatrical performance) that Austin excluded from his speech act theory because he viewed them as anomalous.[20] In Derrida's grammatology, the more or less coherent community of speakers that Saussure presumes fractures into historically and geographically diverse contexts of different writing (and speaking) practices, different communities of general or expert readers, and different criteria for what constitutes competence and legibility. As William R. Paulson, among others, has observed, Derrida's complex writing style itself performs this diversity, insofar as it creates a class of "priestly" interpreters who can understand his writing, in contrast to many nonspecialist readers who have found it unintelligible.[21]

Like esoteric theoretical writing, code is intelligible only to a specialized community of experts who understand its complexities and can read and write it with fluency. There is, however, a significant difference between the worldview of code, on one hand, and, on the other, the community of speakers Saussure presumes and the infinitely diverse inscription contexts Derrida invokes. With code, a (relatively) few experts can initiate changes in the system that are often so significant they render previous systems illegible, as when Microsoft creates a new operating system such as Windows XP, which is not backward compatible with Windows 95 and earlier versions. Moreover, in code the breaks are much sharper and more complete than with either speech or writing. Occasionally I meet people who are using hardware and software that have been obsolete for years. Although they can still produce documents using these versions, they are increasingly marooned on an island in time, unable to send readable files or to read files from anyone else. Whereas undergraduates can understand (with some help) the Middle English of Chaucer's *Canterbury Tales* or the Elizabethan English of Shakespeare, thus making a connection over the hundreds of years that separate them from these works, no such bridges can be built between Windows 95 and Windows XP (separated by a mere seven or eight years), without both massive recoding and fluency in the nastily complex code of Windows programming.

Although code may inherit little or no baggage from classical metaphysics, it is permeated throughout with the politics and economics of capitalism, along with the embedded assumptions, resistant practices, and hegemonic reinscriptions associated with them. The open source movement testifies eloquently to the centrality of capitalist dynamics in the marketplace of code, even as it works to create an intellectual commons that operates according to the very different dynamics of a gift economy.[22]

The Hierarchy of Code

As we have seen, code differs from speech and writing in that it exists in clearly differentiated versions that are executable in a process that includes hardware and software and that makes obsolete programs literally unplayable unless an emulator or archival machine is used. Moreover, the historical strata of code do not involve a troublesome metaphysical inheritance but a troublesome deep layer of assembler code that can be understood and reverse engineered only with great difficulty, as demonstrated by attempts to excavate it and correct the problems associated with the Y2K crisis. The ways in which the historical character of code influence its alterations is a subject that requires understanding the difference between change within a given slice of time (synchrony) and change across time (diachrony).

For Saussure, the proper object of study for the semiotics of the speech system is the synchronic orientation. He points out in the introduction to *Course in General Linguistics* that his analysis reorients the field of study from the historicist and philological emphasis it had in previous generations to an understanding that regards the language system as a (more or less) coherent synchronous structure (1–8).[23] For Derrida, the diachronic manifests itself as the (allegedly) inescapable influence of classical metaphysics, whereas the synchronic ceases to have the force it does for Saussure because inscriptions, unlike speech prior to the invention of recording technologies, can be transported into historically disparate contexts, and so exist as rock does: in historically stratified formations that stretch back for thousands of years. Derrida writes, "This citationality, this duplication or duplicity, this iterability of the mark is neither an accident nor an anomaly, it is that (normal/abnormal) without which a mark could not even have a function called 'normal.' What would a mark be that could not be cited? Or one whose origins would not get lost along with way?" (*Limited Inc*, 12).[24]

Along with these differences in conceptualizing the sign and delineating its operations across and through time go related differences in how signs work together to comprise a semiotic system. When Saussure argues that differential relations between signs constitute the engine that drives signification, he identifies two vectors along which these relations operate, working at multiple levels within the speech system. The syntagmatic vector points horizontally, for example, along the syntax of a sentence. By contrast, the paradigmatic vector operates vertically, for example, in the synonyms that might be used in place of a given word in an utterance. Derrida makes little use of these terms in his grammatology, focusing instead on the hierarchical relations between concepts by which a privileged term posits a stigmatized term as the "outside" to its "inside." For Derrida, perhaps the primary instance of this hierarchical relation, in the context of Saussure's theory, is Saussure's attempt to relegate writing to a purely derivative role. Derrida's deconstruction of this hierarchical arrangement is typical of his treatment of hierarchical dichotomies in general, for he shows that the privileged term must in fact contain and depend on what it tries to exclude. "The exteriority of the signifier is the exteriority of writing in general, and I shall try to show . . . that there is no linguistic sign before writing. Without that exteriority, the very idea of the sign falls into decay" (*Of Grammatology*, 14).

Like speech, coding structures make use of what might be called the syntagmatic and paradigmatic, but in inverse relation to how they operate in speech systems. As Lev Manovich observes in *The Language of New Media*, in speech or writing the syntagmatic is what appears on the page (or as patterned sound), whereas the paradigmatic (the alternative choices that could have been made) is virtually rather than actually present (229–33). In digital media using dynamic databases, this relationship is reversed. The paradigmatic alternatives are encoded into the database and in this sense actually exist, whereas the syntagmatic is dynamically generated on the fly as choices are made that determine which items in the database will be used. In this sense, the syntagmatic is virtual rather than actual. This insight opens onto further explorations of how databases and narratives interface together, especially in electronic literature and the more general question of literariness.

In *Reading Voices*, Garrett Stewart argues that literary language is literary in part because of its ability to mobilize "virtual" words—related by sound, sense, or usage to those actually on the page—that surround the printed text with a "blooming buzz" of variants enriching and extending the text's meanings. Although operating according to a different dynamic than envisioned by Saussure, the luminous fog created by these variants resembles the paradigmatic vector that Saussure theorized for the speech system. When electronic literature offers the user hypertextual choices that lead to multiple narrative pathways, the strategy of evoking "virtual" possibilities happens not only on the level of the individual word but at the narrative level where different strands, outcomes, and interpretations mutually resonate with one another. This richness is possible, of course, only because all these possibilities are stored in the computer, available to be rearranged, interpolated, followed or not. Somewhat paradoxically, then, the more data that are stored in computer memory, all of which are ordered according to specified addresses and called by executable commands, the more ambiguities are possible. Flexibility and the resulting mobilization of narrative ambiguities at a high level depend upon rigidity and precision at a low level. The lower the level, the closer the language comes to the reductive simplicity of ones and zeros, and yet it is precisely the ability to build up from this reductive base that enables high-level literariness to be achieved. In this sense, the interplay between the virtual syntagmatic sequences and the actual paradigmatic database resembles the dynamic that Wolfram, Fredkin, and Harold Morowitz envision for computer simulations, with high-level complexity emerging out of the brute simplicity of binary distinctions and a few logical relationships. Literariness, as it is manifested in the panoply of choices characteristic of hypertext literature, here converges with the Regime of Computation in using the "simple rules, complex behavior" characteristic of code to achieve complexity.

Along with the hierarchical nature of code goes a dynamic of concealing and revealing that operates in ways that have no parallels in speech and writing. Because computer languages become more English-like as they move higher in the "tower of languages" (Rita Raley's phrase),[25] concealing the "brute" lower levels carries considerable advantage. Knowing how to conceal code with which one is not immediately concerned is an essential practice in computer programming. One of the advantages of object-oriented languages is bundling code within an object, so that the object becomes a more or less autonomous unit that can be changed without affecting other objects in that domain. At the same time, revealing code when it is appropriate or desired also bestows significant advantage. The "reveal code" command in HTML documents, for example, allows users to see comments, formatting instructions, and other material that may illuminate the construction and intent of the work under study, a point Loss Pequeño Glazier makes effectively in *Dig[iT]al Poet(I)(c)s*. With programs such as Dreamweaver that make layers easy to construct, additional dynamics of concealing and revealing come into play through rollovers and the like, re-creating on the screen dynamics that both depend on and reflect the "tower of languages" essential to code.[26]

These practices of concealing and revealing offer fertile ground for aesthetic and artistic exploration. Layers that reveal themselves according to timed sequences, cursor movements, and other criteria have become an important technique for writers seeking to create richly dense works with multiple pathways for interaction. One such work is Talan Memmott's *Lexia to Perplexia*, a notoriously "nervous" digital production that responds to even minute cursor movements in ways a user typically does not expect and finds difficult to control. Layering in this work is arguably the principal way by which complex screen design, text, animation, and movement interact with one another. Another example is M. D. Coverley's *The Book of Going Forth by Day*, where the visual tropes of revealing and concealing resonate with the multiple personae, patterned after ancient Egyptian beliefs, that cohabit in one body. The layers are instrumental in creating a visual/verbal/sonic narrative in which the deep past and the present, modern skepticism and ancient rituals, hieroglyphs and electronic writing merge and blend with one another.

The "reveal code" dynamic helps to create expectations (conscious and preconscious) in which the layered hierarchical structure of the tower of languages reinforces and is reinforced by the worldview of computation. The more the concealing/revealing dynamic becomes an everyday part of life and a ubiquitous strategy in everything from commercial Web pages to digital artworks, the more plausible it makes the view that the universe generates reality though a similar hierarchical structure of correlated levels ceaselessly and forever processing code. Similarly, the more the worldview of code is accepted, the more "natural" the layered dynamics of revealing and concealing code seem. Since these dynamics do not exist in anything like the same way with speech and writing, the overall effect—no doubt subtle at first but growing in importance as digital cultures and technologies become increasingly pervasive and indispensable—is to validate code as the lingua franca of nature. Speech and writing then appear as evolutionary stepping stones necessary to ratchet up Homo sapiens to the point where humans can understand the computational nature of reality and use its principles to create technologies that simulate the simulations running on the Universal Computer. This, in effect, is the worldview Morowitz envisions when he writes about the fourth stage (after the evolution of the cosmos, life, and mind) as mind reflecting on mind.[27] The more "natural" code comes to seem, the more plausible it is to conceptualize human thought as emerging from a machinic base of computational processes, a proposition explored in chapter 7.

As I argue throughout, however, human cognition, although it may have computational elements, includes analog consciousness that cannot be understood simply or even primarily as digital computation. Speech and writing, in my view, should not be seen as predecessors to code that will wither away but as vital partners on many levels of scale in the evolution of complexity. As I said in chapter 1, not Wolfram *or* his cellular automata alone, but *both* together—hence my emphasis on narrative and subjectivity as these are intermediated with computation. It is not the triumph of the Regime of Computation that can best explain the complexities of the world and, especially, of human cultures but its interactions with the stories we tell and the media technologies instrumental in making, storing, and transmitting.

Making Discrete and the Interpenetration of Code and Language

Let us now shift from interpreting code through the worldviews of speech and writing to the inverse approach of interpreting speech and writing through the worldview of code. An operation scarcely mentioned by Saussure and Derrida but central to code is digitization, which I interpret here as the act of making something discrete rather than continuous, that is, digital rather than analog. The act of making discrete extends through multiple levels of scale, from the physical process of forming bit patterns up through a complex hierarchy in which programs are written to compile other programs. Understanding the practices through which this hierarchy is constructed, as well as the empowerments and limitations the hierarchy entails, is an important step in theorizing code in relation to speech and writing.

Let me make a claim that, in the interest of space, I will assert rather than substantiate: the world as we sense it on a human scale is basically analog. Over millennia, humans have developed biological modifications and technological prostheses to impose digitization on these analog processes, from the physiological evolution needed to produce speech to sophisticated digital computers. From a continuous stream of breath, speech introduces the discreteness of phonemes; writing carries digitization farther by adding artifacts to this physiological process, developing inscription technologies that represent phonemes with alphabetic letters. At every point, analog processes interpenetrate and cooperate with these digitizations. Experienced readers, for example, perceive words not as individual letters but as patterns perceived in a single glance. The synergy between the analog and digital capitalizes on the strengths distinctive to each. As we have seen, digitization allows fine-tuned error control and depth of coding, whereas analog processes tie in with highly evolved human capabilities of pattern processing. In addition, the analog function of morphological resemblance, that is, similarity of form, is the principal and indeed (so far as I know) the only way to convey information from one instantiated entity to a differently instantiated entity.

How do practices of making discrete work in the digital computer? We have already heard about the formation of the bit stream from changing voltages channeled through logic gates, a process that utilizes morphological resemblance. From the bit pattern bytes are formed, usually with each byte composed of eight bits—seven bits to represent the ASCII code, and an empty one that can be assigned special significance. At each of these stages, the technology can embody features that were once useful but have since become obsolete. For example, the ASCII code contains a seven-bit pattern corresponding to a bell ringing on a teletype. Although teletypes are no longer in use, the bit pattern remains because retrofitting the ASCII code to delete it would require far more labor than would be justified by the benefit. To some extent, then, the technology functions like a rock strata, with the lower layers bearing the fossilized marks of technologies now extinct.

In the progression from speech to writing to code, each successor regime introduces features not present in its predecessors. In *Of Grammatology*, Derrida repeatedly refers to the space between words in alphabetic writing to demonstrate his point that writing cannot be adequately understood simply as the transcription of speech patterns (39, passim). Writing, he argues, exceeds speech and thus cannot be encapsulated within this predecessor regime; "writing is at the same time more exterior to speech, not being its 'image' or its 'symbol,' and more interior to speech, which is already in itself a writing" (46). Not coincidentally, spaces play an important role in the digitization of writing by making the separation of one word from another visually clear, thus contributing to the evolution of the codex book as it increasingly realized its potential as a medium distinct from speech. Similarly, code has characteristics that occur neither in speech nor in writing—processes that, by exceeding these legacy systems, mark a disjunction.

To explore these characteristics, let us now jump to a high level in the hierarchy of code and consider object-oriented programming languages, such as the ubiquitous C++. (I leave out of this discussion the newer languages of Java and C#, for which similar arguments could be made). C++ commands are written in ASCII and then converted into machine language, so this high-level programming language, like everything that happens in the computer, builds on a binary base. Nevertheless, C++ instantiates a profound shift of perspective from machine language and also from the procedural languages like FORTRAN and BASIC that preceded it. Whereas procedural languages conceptualize the program as a flow of modularized procedures (often diagrammed with a flowchart) that function as commands to the machine, object-oriented languages are modeled after natural languages and create a syntax using the equivalent of nouns (that is, objects) and verbs (processes in the system design).

A significant advantage to this mode of conceptualization, as Bruce Eckel explains in *Thinking in C++*, is that it allows programmers to conceptualize the solution in the same terms used to describe the problem. In procedural languages, by contrast, the problem would be stated in real-world terms (Eckel's example is "put the grommet in the bin"), whereas the solution would have to be expressed in terms of behaviors the machine could execute ("set the bit in the chip that means that the relay will close"; 43). C++ reduces the conceptual overhead by allowing both the solution and the problem to be expressed in equivalent terms, with the language's structure performing the work of translating between machine behaviors and human perceptions.

The heart of this innovation is allowing the programmer to express her understanding of the problem by defining classes, or abstract data types, that have both characteristics (data elements) and behaviors (functionalities). From a class, a set of objects instantiate the general idea in specific variations—the nouns referred to above. For example, if a class is defined as "shape," then objects in that class might be triangle, circle, square, and so on (37–38). Moreover, an object contains not only data but also functions that operate on the data—that is, it contains constraints that define it as a unit, and it also has encapsulated within it behaviors appropriate to that unit. For example, each object in "shape" might inherit the capability to be moved, to be erased, to be made different sizes, and so on, but each object would give these class characteristics its own interpretation. This method allows maximum flexibility in the initial design and in the inevitable revisions, modifications, and maintenance that large systems demand. The "verbs" then become the processes through which objects can interact with each other and the system design.

New objects can be added to a class without requiring that previous objects be changed, and new classes and metaclasses can also be added. Moreover, new objects can be created through inheritance, using a preexisting object as a base and then adding additional behaviors or characteristics. Since the way the classes are defined in effect describes the problem, the need for documentation external to the program is reduced; to a much greater extent than with procedural languages, the program serves as its own description. Another significant advantage of C++ is its ability to "hide" data and functions within an object, allowing the object to be treated as a unit without concern for these elements. "Abstraction is selective ignorance," Andrew Koenig and Barbara E. Moo write in *Accelerated C++*, a potent aphorism that speaks to the importance in large systems of hiding details until they need to be known.[28] Abstraction (defining classes), encapsulation (hiding details within objects and, on a metalevel, within classes), and inheritance (deriving new objects by building on preexisting objects) are the strategies that give object-oriented programs their superior flexibility and ease of design.

We can now see that object-oriented programs achieve their usefulness principally through the ways they anatomize the problems they are created to solve—that is, the ways in which they cut up the world. Obviously a great deal of skill and intuition goes into the selection of the appropriate classes and objects; the trick is to state the problem so it achieves abstraction in an

appropriate way. This often requires multiple revisions to get it right, so ease of revision is crucial.

Some of the strategies C++ uses to achieve its language-like flexibility illustrate how it makes use of properties that do not appear in speech or writing and are specific to coding systems. Procedural languages work by what is called "early binding," a process in which the compiler (the part of the code hierarchy that translates higher-level commands into the machine language) works with the linker to direct a function call (a message calling for a particular function to be run) to the absolute address of the code to be executed. At the time of compiling, early binding thus activates a direct link between the program, compiler, and address, joining these elements before the program is actually run. C++, by contrast, uses "late binding," in which the compiler ensures that the function exists and checks its form for accuracy, but the actual address of the code is not used until the program is run.[29] Late binding is part of what allows the objects to be self-contained with minimum interference with other objects.

The point of this rather technical discussion is simple: there is no parallel to compiling in speech or writing, much less a distinction between compiling and run-time. The closest analogy, perhaps, is the translation of speech sounds or graphic letter forms into synapses in the human brain, but even to suggest this analogy risks confusing the *production* of speech and writing with its *interpretation* by a human user. Like speech and writing, computer behaviors can be interpreted by human users at multiple levels and in diverse ways, but this activity comes after (or before) the computer activity of compiling code and running programs.

Compiling (and interpreting, for which similar arguments can be made) is part of the complex web of processes, events, and interfaces that mediate between humans and machines, and its structure bespeaks the needs of both parties involved in the transaction. The importance of compiling (and interpreting) to digital technologies underscores the fact that new emphases emerge with code that, although not unknown in speech and writing, operate in ways specific to networked and programmable media. At the heart of this difference is the need to mediate between the natural languages native to human intelligence and the binary code native to intelligent machines. As a consequence, code implies a partnership between humans and intelligent machines in which the linguistic practices of each influence and interpenetrate the other.[30]

The evolution of C++ grew from precisely this kind of interpenetration. C++ is consciously modeled after natural language; once it came into wide use, it also affected how natural language is understood. We can see this two-way flow at work in the following observation by Bruce Eckel, in which he constructs the computer as an extension of the human mind. He writes, "The genesis of the computer revolution was in a machine. The genesis of our programming languages thus tends to look like that machine. But the computer is not so much a machine as it is a mind amplification tool and a different kind of expressive medium. As a result, the tools are beginning to look less like machines and more like parts of our minds, and more like other expressive mediums like writing, painting, sculpture, animation or filmmaking. Object-oriented programming is part of this movement toward the computer as an expressive medium" (*Thinking in C++*, 35). As computers are increasingly understood (and modeled after) "expressive mediums" like writing, they begin to acquire the familiar and potent capability of writing not merely to express thought but actively to constitute it. As high-level computer languages move closer to natural languages, the processes of intermediation by which each affects the other accelerate and intensify. Rita Raley has written on the relation between the spread of Global English and the interpenetration of programming languages with English syntax, grammar, and lexicon.[31] In addition, the creative writing practices of "codework," practiced by such artists as MEZ, Talan Memmott, Alan Sondheim, and others, mingle code and English in a pastiche that, by analogy with two natural languages that similarly intermingle, might be called a creole.[32]

The vectors associated with these processes do not all point in the same direction. As explored in chapter 8, (mis)recognizing visualizations of computational simulations as creatures like us both anthropomorphizes the simulations and "computationalizes" the humans. Knowing that binary code underlies complex emergent processes reinforces the view that human consciousness emerges from similar machinic processes, as explored in chapter 7. Anxieties can arise when the operations of the computer are mystified to the extent that users lose sight of (or never know) how the software actually works, thus putting themselves at the mercy of predatory companies like Microsoft, which makes it easy (or inevitable) for users to accept at face value the metaphors the corporation spoon-feeds them, a concern explored in chapter 6. These dynamics make unmistakably clear that computers are no longer merely tools (if they ever were) but are complex systems that increasingly produce the conditions, ideologies, assumptions, and practices that help to constitute what we call reality.

The operations of "making discrete" highlighted by digital computers clearly have ideological implications. Indeed, Wendy Hui Kyong Chun goes so far as to say that *software is ideology*, instancing Althusser's definition of ideology as "the representation of the subject's imaginary relationship to his or her real conditions of existence."[33] As she points out, desktop metaphors such as folders, trash cans, and so on create an imaginary relationship of the user to the actual command core of the machine, that is, to the "real conditions of existence" that in fact determine the parameters within which the user's actions can be understood as legible. As is true for other forms of ideology, the interpolation of the user into the machinic system does not require his or her conscious recognition of how he or she is being disciplined by the machine to become a certain kind of subject. As we know, interpolation is most effective when it is largely unconscious.

This conclusion makes abundantly clear why we cannot afford to ignore code or allow it to remain the exclusive concern of computer programmers and engineers. Strategies can emerge from a deep understanding of code that can be used to resist and subvert hegemonic control by megacorporations;[34] ideological critiques can explore the implications of code for cultural processes, a project already evident in Matthew Fuller's call, seconded by Matthew Kirschenbaum, for critical software studies;[35] readings of seminal literary texts can explore the implications of code for human thought and agency, among other concerns. Code is not the enemy, any more than it is the savior. Rather code is increasingly positioned as language's pervasive partner. Implicit in the juxtaposition is the intermediation of human thought and machine intelligence, with all the dangers, possibilities, liberations, and complexities this implies.

7 (Un)masking the Agent

Stanislaw Lem's "The Mask"

"Transmitting" in this part is considered not in the technical sense of sending encoded packets through fiber-optic cables according to information protocols, an important topic covered in such seminal texts as Alexander R. Galloway's *Protocol* and Geert Lovink's *Dark Fiber*. Rather, here "transmitting" refers primarily to the mechanisms and processes by which informational patterns are transferred between analog consciousness and digital cognition, understanding the latter variously as located in the computer, in human nonconscious processes, and in digital simulations. The focus on staging encounters of consciousness with digital cognition, anticipated in chapter 6, expands the considerations of parts 1 and 2 to subjectivity, narrative, and the relation of the Regime of Computation to human culture and meaning. Chapter 1 raised the critical question of whether the Regime of Computation should be considered as a cultural construction or as an accurate description of reality, and the chapters in this part keep returning to this question from different perspectives. As anticipated in chapter 1, the kind of analysis pursued here will not so much opt for either the constructivist or realist position as explore their co-constitution of each other. The present chapter initiates this broad inquiry by starting locally, that is, by locating the dynamic between digital cognition and analog consciousness *within* the same being.

Although implant devices have become available only recently, speculation on how coding enters into the deep structures of thought predates the technological actuality by several decades. At issue are questions of cooperation and competition between conscious mind and aconscious coding, free will and programmed outcomes, gendered enculturation and the nongendered operation of algorithms, language and the nonlinguistics operation of code. The assumption that a substrate of code underlies conscious mind profoundly affects concepts of agency and subjectivity. Whereas the Holocaust and other atrocities provide horrifying examples of humans not counting as persons, intelligent software packages offer the spectacle of bots being mistaken for human interlocutors.[1] In light of these complex intermediations, let me advance a proposition: to count as a person, an entity must be able to exercise agency. Agency enables the subject to make choices, express intentions, perform actions. Scratch the surface of a person, and you find an agent; find an agent, and you are well on your way toward constituting a subject, a dynamic explored at length in chapter 8 with regard to Karl Sims's virtual creatures.

As I will demonstrate in this chapter, computer scientists are not the only ones speculating that computational mechanisms underlie and/or interpenetrate human consciousness. Influential cultural theorists, particularly Gilles Deleuze, Félix Guattari, and Jacques Lacan, also speculate on how the digital and analog interact in human cognition. The same kind of ontological perplexity that haunts the Regime of Computation also troubles these theories: is computation here to be considered a metaphor appropriated from information technologies, or an accurate description of psychic processes? If skepticism toward the Regime of Computation is warranted (and I think it is), skepticism toward these cultural theories should not lag behind. The point as I see it, however, is not to determine whether the theories are correct or incorrect but to understand their roles in helping to create a "climate of opinion," as Raymond Williams calls it, in which the complex intermediations between the analog and digital become central to understanding constructions of subjectivity and agency. In the final portion of this chapter, I will turn to a literary text that enacts these issues in particularly powerful ways, Stanislaw Lem's 1976 novella "The Mask." With a narrator hovering between the human and nonhuman, "The Mask" explores with subtle potency the complexities of a conscious mind whose agency is circumscribed by an underlying program that partially dictates the actions mind can perform. As the mind probes the limits of its freedom, it undergoes a transformation into something other than human. Whether the eponymous mask refers to the human skin that encases a metallic robot, or to the mind from which the narrative voice emerges, is one of many ambiguities the story performs as it probes the possibilities for a consciousness that coexists with an underlying program it can sense but never directly know. In imagining this configuration, Lem's fictional anticipation of the unconscious as digital algorithm remains remarkably prescient a quarter of a century later.

The Machine within the Human

In their radical reconceptualization of agency, Deleuze and Guattari reveal that intelligent artifacts played a seminal role in their thinking about agency. Early in *A Thousand Plateaus* they celebrate cellular automata (CA), contrasting them with the centered systems they deplore. As we saw in chapter 1's account of Stephen Wolfram's *A New Kind of Science*, cellular automata are composed of cells, each of which calculates its state depending on the state of its immediate neighbors. Deleuze and Guattari define cellular automata somewhat inaccurately as "finite networks of automata in which communication runs from any neighbor to any other" (17). In fact, as we know, each cell samples only the cells immediately adjacent to it (or in some cases, the next nearest neighbors). By claiming for cellular automata a less rule-bound dynamic than they in fact possess, Deleuze and Guattari imply that any configuration whatever is possible, an idea they push to the extreme in their notions of "deterritorialization" and "reterritorialization." Cellular automata fit Deleuze and Guattari's purpose because they are completely mechanistic, computational, and nonconscious but nevertheless display complex patterns that appear to evolve, grow, invade new territories, or decay and die out. Particularly relevant is the pattern called "Glider," in which a glider-like shape appears at one edge of the screen and moves toward the other edge, as if enacting what Deleuze and Guattari call a "line of flight." Cellular automata appear as well in their description of schizoanalysis, which "treats the unconscious as an acentered system, in other words, as a machinic network of finite automata (a rhizome), and thus arrives at an entirely different state of the unconscious" (18). The implication is that the unconscious, like cellular automata, is mechanistic and rhizomatic.

These ideas have obvious limitations when applied to the human organism. Unlike the free-form patterns of cellular automata, humans have biological requirements that make the skin an organ vital to survival. Yet Deleuze and Guattari leap over this limitation with a powerful performative rhetoric that makes it seem as if the body could deterritorialize and reterritorialize as easily as cellular automata (which themselves, as noted, have limitations Deleuze and Guattari do not accurately represent). As a result of this rhetoric, the body becomes the Body without Organs, an assemblage rather than an organism, which does away with consciousness as the seat of coherent subjectivity (a move alluded to in chapter 4, where it is linked with reconceptualizing the convergent "work" as Work as Assemblage). In the idea of the Body without Organs, humans are conceived as mutating assemblages that can absorb a variety of entities into their environments, including both machines and organic matter. Instead of conscious thought, the Body without Organs is driven by desire. According to Mark Hansen, desire is so central in *A Thousand Plateaus* that it assumes a fetishized quality, flaming with incandescent intensity that alone has the motive force to drive assemblages into new configurations.[2] Indeed, since consciousness is fragmented, the organism dispersed, and signification thrown out, desire is virtually the only agent left on the playing field. "Make consciousness an experimentation in life," Deleuze and Guattari urge, "and passion a field of continuous intensities, an emission of particle-signs. . . . Desubjectify consciousness and passion" (134). The net effect of this rhetorical transmutation is to construct the Body without Organs as an infinite set of cellular automata whose computational rules are re-encoded as desire. This is a much more direct "computationalization" of the human than that imagined by Wolfram, although here computation is understood in psychoanalytic and philosophical terms rather than in engineering and mathematical contexts.

In *A Thousand Plateaus*, at the same time that humans take on attributes of computational media, machines acquire biological traits. Adopting the terminology of biological evolution, Deleuze and Guattari write, "We may speak of a *machinic phylum*, or technological lineage, wherever we find a *constellation of singularities, prolongable by certain operations, which converge, and make the operations converge upon one or several assignable traits of expression*" (406). Endorsing André Leroi-Gourhan's ideas about a "technological vitalism" that takes "biological evolution in general as the model for technical evolution," Deleuze and Guattari assert that "there is indeed a machinic phylum in variation that creates the technical assemblages, whereas the assemblages invent the various phyla. A technological lineage changes significantly according to whether one draws it upon the phylum or inscribes it in the assemblages; but the two are inseparable" (407). By making the phylum depend on the assemblages and the assemblages on the phylum, Deleuze and Guattari suggest that technological evolution produces distinct genetic forms emerging from a daisy chain of interconnections and eluding linear causal explanation.[3] Although Deleuze and Guattari speak of the machinic phylum as "matter in movement, in flux, in variation, matter as a conveyor of singularities and traits of expression" (409), it is not clear what drives these mutations. They attempt to solve the problem by returning to the prime mover in their theory, imagining that machines are also capable of desire.[4]

In "Machinic Heterogenesis," Guattari addresses this point by interpolating the human and mechanical into one another, arguing that the "mechanosphere . . . superimposes itself on the biosphere."[5] Seeking to open Maturana and Varela's self-enclosing concept of autopoiesis to the production of otherness,[6] Guattari argues that even a mechanism as simple as a lock and key has a repertoire of structural forms through which it can move. This deterritorializing or "smoothing" opens the discrete machine to transformation and, by a nonrational leap of inference, to desire;[7] "all machinic orderings contain within them, even if only in an embryonic state, enunciative nuclei [*foyers*] that are so many protomachines of desire" (25). Thus machines are made like humans because they are driven by desire, even as humans are configured like machines because they can be disassembled and reassembled. "It is thus impossible to refuse human thought its part in the essence of machinism," Guattari writes (15). In this view, "human" connotes no essential quality but marks the historical starting point of a certain line of inquiry. If the human has been mechanical all along, anyone who represents it as "contaminated" by the mechanical mistakes his own process of discovery for the hybridization that was always already there.

Clearly the performative force of language plays a crucial role here, as it does in *A Thousand Plateaus*: much is asserted, almost nothing is demonstrated. If language thus possesses a kind of agency, the next step would be to suppose that language itself is a machine and hence subject to the same processes of deterritorialization and reterritorialization that characterize "desiring machines." Guattari edges toward this realization in "Machinic Heterogenesis" when he asks, "But how long can we continue to characterize the thought put to work here as human? Doesn't technico-scientific thought emerge from a certain type of mental and semiotic machinism?" (15). Guattari takes structural semiotics to task because it fails to capture "figures of expression that work as diagrammatic machines in direct contact with technical-experimental configurations" (15). Whereas semiotic systems posit "distinctive oppositions of a phonemic or scriptural order that transcribe enunciations [*énoncés*] into expressive materials that signify," machines operate differently, using a signifying process that "does not derive from repetition or from mimesis of significations" (15). Obscurely expressed, the point here seems to be that semiotics has falsified the workings of language by interpreting it through structuralist oppositions that covertly smuggle in anthropomorphic thinking characteristic of conscious mind. The model for language should instead be machinic operations that do not need structural oppositions; these operations have available to them a materialistic level of signification in which representation is intertwined with material processes. Although the word "code" does not appear in Guattari's essay, it fits well with his vision of a signifying system that is tied directly to the material process of flickering voltages. "Existence is not dialectic," Guattari exclaims. "It is not representable. It is hardly even livable!"

(25). Guattari's lack of reverence for the Lacanian conception of the signifier now becomes explicit. Semiotics is flawed because it "does not get us out of structure, and prohibits us from entering the real world of the machine. The structuralist signifier is always synonymous with linear discursivity," whereas heterogeneous machines refuse to be "orchestrated by a universal temporalization" (23). Nonetheless, Lacan's views have more in common with Guattari's than he acknowledges, for they concur in conceiving of language as a coding machine. Thus the very linguistic processes that reconceptualize human agency by describing it as an intelligent machine are themselves reconceptualized as essentially mechanistic in their operations.

John Johnston, in his important analysis of Lacan's development of a theory of the unconscious, shows that automata theory is crucial to Lacan's thought.[8] The key idea Lacan lifts from automata theory is the notion that inherent in symbol manipulation are certain structural relationships that can be used to program a Turing machine. Recall from chapter 1 that the Turing machine is an abstract computer that can perform any computation that any computer can do, including computing the algorithm that constitutes itself.[9] This very simple machine is composed of three components: a head that reads and writes binary symbols forward and backward on a tape; the tape itself; and the rules for producing a new state from the previous one. Working by analogy (although not always explicitly stating so), Lacan transposes these ideas onto the unconscious, conceiving of it as a machine operating upon language without needing anything like anthropomorphic awareness to perform its operations. Guattari is correct in asserting that linearity is essential to the Lacanian conception of the signifier, but he underestimates the flexibility with which the Turing machine can operate. By folding the abstract operations of calculation into the material operation of the tape, Turing simplified the computational load and achieved an economy of operation that made his Universal machine so powerful an idea that it is routinely regarded as the theoretical basis for modern computers.

Lacan's conception of the unconscious as a kind of Turing machine enables him to accomplish a profound transformation of Freud's view of the unconscious (notwithstanding his claim that he merely makes explicit what is implicit in Freud). When Freud posited the death drive, he thought of it as an unconscious tendency to move toward the inanimate, a return to prebiological origins. There is a sense in which this view of the unconscious is deeply anthropomorphic, for it identifies the present state of the (conscious) subject with life, from which point the unconscious moves *back* toward the inanimate. By contrast, as John Johnston shows, Lacan envisions language as *beginning* in the mechanistic operations of the unconscious, from which

emerge the higher order processes of conscious thought. The direction of the vector changes from back to up, that is, from regression to emergence; equally important, mechanistic operations are conceived as providing the basis for consciousness rather than as representing a return to the preanimate. Thus the important distinction shifts from living/nonliving to mechanistic intelligence/conscious awareness. Given claims by researchers that artificial life is indeed a form of life, the divide between animate and inanimate has become increasingly problematic.[10] Like Lacan, theorists of artificial life focus on the intelligences that can emerge from mechanistic operations in both protein- and silicon-based life forms, an ideal formulated in different terms by Stephen Wolfram in *A New Kind of Science*, as we saw in chapter 1. The difference between Lacan's linear model and Guattari's "heterogeneous machine" pales compared to the looming fact that both envision human cognition as always already interpenetrated by machinic processes, or as John Johnston puts it, as constituted through the "in-mixing" of human psychology with cybernetics.

The net result of these feedback loops between artificial life forms and biological organisms has been to create a crisis of agency, a phenomenon described at length in my book *How We Became Posthuman*.[11] If, on the one hand, humans are like machines, whether figured as cellular automata or Turing machines, then agency cannot be securely located in the conscious mind. If, on the other hand, machines are like biological organisms, then they must possess the effects of agency even though they are not conscious. In these reconfigurations, desire and language, both intimately connected with agency, are understood in new ways. Acting as a free-floating agent, desire is nevertheless anchored in mechanistic operations, a suggestion Guattari makes in "Machinic Heterogenesis." Language, emerging from the operations of the unconscious figured as a Turing machine, creates expressions of desire that in their origin are always already interpenetrated by the mechanistic, no matter how human they seem. Finally, if desire and the agency springing from it are at bottom nothing more than the performance of binary code, then computers can have agency as fully authentic as humans. Through these reconfigurations, Deleuze, Guattari, and Lacan use automata to challenge human agency, and in the process they configure automata as agents.

Machines acting as agents, and humans with their agency rooted in machinic processes—ideas explored in chapter 6 through Shelley Jackson's *Patchwork Girl*—vividly illustrate why notions of personhood have become destabilized. The uncanny similarities between Wolfram's speculations and the theories of Deleuze, Guattari, and Lacan (developed in large part, if not entirely, independently of one another) illustrate how pervasive within the culture these human/machine dynamics have become. To bring into sharper focus the anxieties created by supposing that digital mechanisms underlie analog consciousness, I turn now to Stanislaw Lem's powerful story "The Mask." At the heart of this disturbing tale is a conflict between a conscious mind that can think and an underlying program that determines action. To make the conflict more intense, Lem arranges matters so that conscious mind has no direct access to program, much as we have no direct access to the interior computational modules that, in the view of some evolutionary psychologists, codetermine our behavior.[12] In the disjunction between the representations conscious mind makes to itself and the actions actually taken, the crisis of agency is bodied forth as an inescapable and tragic condition of thinking mind(s).

The Human within the Machine

"The Mask" begins with a threshold. On one side is a consciousness that names "the it that was I" (181). In Polish, the narrator is named throughout with feminine words (for example, "machina," the feminine form of "machine," and the feminine "Maska" of the Polish title). Jerzy Jarzebski and Michael Kandel have observed, however, that at the tale's beginning the narrator is constructed as neuter, a performance Lem enacts by using past-tense verb forms with neuter endings that do not actually exist as such in normal usage (although the neologisms would be recognized immediately by Polish-speaking readers).[13] This linguistic creativity underscores from the outset the importance of gender (albeit here by its linguistic erasure). Using these neologisms, the narrator recounts an experience imaged simultaneously as a birth, a movement down an assembly line, and an erotic encounter. Here the narrator plays a passive role, object of unknown gazing eyes, "snoutlike flattened heads," "pincer hands," and "flat mouths in a rim of sparks" that give a final "quivering kiss" that "tautened the me" and cause the narrator to "crawl into a round opening without light" (181–82). At the moment the narrator crosses the threshold (which is both spatial and linguistic), consciousness undergoes a dramatic change, feeling "the rush of gender so violent, that her head spun and I shut my eyes. And as I stood thus, with eyes closed, words came to me from every side, for along with gender she had received language" (182). At this liminal moment, the narrator moves from an "it" already receding from awareness into a linguistically enculturated "she" whose movement over the palace threshold (for that is where she now perceives herself to be) plunges her into the Symbolic. As her perception snaps into cultural focus, the objects that an instant before it had described as a "colored confusion of vertical trunks," with "globes" containing "tiny buttons bright with water," become the lords and ladies attending a court ball, whose eyes are turning to follow the beautiful woman the narrator has become (182). Thus from the beginning we have reason to doubt that the narrator's consciousness is the seat of identity, for it springs into existence only after another kind of awareness, an awareness that inhabits an "it" and not "she," has moved the narrator through the birth channel and out into the world.

These abrupt transitions between physical spaces are characteristic of the consciousness as long as the narrator remains a woman, suggesting that consciousness here operates as if it were a machine being turned on and off. Precisely because the sphere of consciousness is limited, its operation within that staging area is all the more frenetic as it seeks to establish its conditions of possibility. As the woman progresses into the ball, her consciousness speeds along in a hyperrational mode that Jo Alyson Parker, in her Lacanian analysis of "The Mask," finds impossible to accept as female.[14] Indeed, consciousness suspects its own hyperrationality. As the narrator tries to make sense of her situation, she realizes that "this self-determined thinking of mine seemed in its correctness just a bit too cold, unduly calm, for fear remained beyond it—like a thing transcendent, omnipresent, yet separate—therefore my own thoughts too I held in suspicion" (199). Knowing that she should be afraid but unable to feel the hormonal surges that make fear an experience inhabiting the self, she comes close to being the subject we call Cartesian, doubting everything including her own thoughts.

Why should she feel fear? Although she can think whatever she pleases, she slowly realizes that she is only partially able to control her actions, a prospect that infuses consciousness with dread. She quickly determines that she is intended for Arrhodes, a brilliant thinker who has dared to question the authority of the king. This knowledge comes to consciousness but does not originate there, appearing to the narrator as a predetermined fact. When she drops her fan before Arrhodes in a clichéd gesture of seduction, she feels a blush appear, but like fear, this blush does not inhabit her, appearing to consciousness as if it were a foreign intrusion. "The blush did not belong to me, it spread on my cheeks, claimed my face, pinkened my ear lobes, which I could feel perfectly, yet I was not embarrassed, nor excited. . . . I'll say more: I had nothing whatever to do with that blush, it came from the same source as the knowledge that had entered me at the threshold of the hall" (190). This separation between consciousness and the bodily actions consciousness observes reveals a fatal gap between thought and agency. Although consciousness feels that it comprises an identity in itself—as if it is, as the narrator says, "one"—it must face the fact that another kind of agency also inhabits the body, and moreover an agency to which consciousness has no direct access and that it must strive to apprehend through inferences and observations. "Everyone knows it is impossible to turn the eyeball around," she thinks, "such that the pupil can peer inside the skull" (194).

In her dance of seduction with Arrhodes, the narrator displays a brilliance and satirical edge that both fascinates Arrhodes and makes him afraid, for he senses immediately that this is no ordinary woman, bluntly demanding, "Who are you?" Asking this question of herself, the narrator flashes onto the pasts of three entirely different women: Mignonne from the north, Angelita from the south, and Tlenix, each accompanied by intense though fragmentary sensory memories.[15] She also senses that her choice will determine the "truth," that "each one could take on substance if I acknowledged it," and that "the images unmentioned would be blown away" (192). Consciousness here senses its position as a PROM, a programmable chip that can accept an initial choice of input but that, once the choice has been made, loses this flexibility as input merges with software and software rigidifies into hardware. Significantly, she chooses not to answer Arrhodes, thereby preserving an indeterminacy that she seeks to fill instead with her own option, imagining herself as that quintessentially marginalized female figure, the madwoman tenderly cared for by patronizing relatives.

This identity cannot take, for it has not been included among the possible inputs. Yet the narrator's response is significant, for it shows that consciousness is determined to assert her own agency over and against the other agency inhabiting the body. Conversing with Arrhodes, the narrator tests the limits to which she can go. She tries to say something stupid, knowing that it will be an effective turnoff for Arrhodes, but she finds herself unable to be anything but brilliant. When she tries to warn him outright, telling him in response to his request for an assignation, "Better to say: never and nowhere" (194), she can utter the warning only in the clichéd language of a lover who feigns reluctance to spur on desire. She realizes this too late, desperately adding, "I do not toy with you, my fine philosopher, look within and you will see that I advised you well" (195), another articulation that goes awry because when Arrhodes looks within, he sees only the desire that is real enough to him but that she knows to be a fatal trap set by his deadly adversary, the king. "What I wished to add," consciousness thinks, "I could not utter. I was able to think anything, strange as it may seem, yet in no way find my voice, I could not reach those words. A catch in my throat, a muteness, like a key turned in a lock, as if a bolt had clicked shut between us" (195). As the narrator will come to realize more fully later, the most insidious

threat to her agency is not a direct prohibition on her actions. Scary as that is, more frightening is a co-optation that turns whatever she tries to do to the purposes of the other agency inhabiting the body.

The seductive dance continues when the narrator meets Arrhodes the next day in a garden—another abrupt transition preceded by a period of unknowingness; for when she left the ball, she entered into a carriage that was more like a coffin, imprisoning her within a space too small for her to stand fully upright. As she lies in the darkness, she thinks again of her three prearranged pasts and compares them to her dim memories, when she experienced herself as neuter. Becoming increasingly aware not only of the alien agency within her body but also of the exterior agents who arranged for it to be there, she muses on the fact that she can remember the time before. "I think it had to be that way, that it would have been impossible to arrange things otherwise," she speculates (196). Desperately seeking for a way to make her own will count, she tries to put together an identity not predetermined by the other's agency: "Out of discrepant elements I could construct nothing of my own, unless I were to find in the design already existing some lopsidedness, chinks I might penetrate, thereby to rend open the structure and get to the core of it" (202). And so she returns to her memories as a neuter, ironically thinking that "certainly they should at least have wiped out that sequence on my back, the animation of my nakedness, inert and mute, by the sparking kisses, but that too had taken place and now was with me" (202). The memory functions as what evolutionary biologists call a "spandrel," an effect not selected for that emerges because it is genetically entangled with attributes that are selected for. Out of this spandrel, this unplanned excess, she hopes to find the chink that will let her assert agency.

Her desire for an agency she can call her own becomes the driving force of the narrative—or rather, it drives a narrative of self-determination within the larger narrative scripted by the alien agency that also inhabits the body. Thus desire is multiple, living both in consciousness and program. While consciousness knows its desire from the inside, it knows the desire of program from the outside, as if seen from a distance by an observer. "I had love, but elsewhere—I know how that sounds. Oh it was a passionate love, tender and altogether ordinary. I wanted to give myself to him body and soul, though not in reality, only in the manner of the fashion, according to custom, the etiquette of the court. . . . My love was very great, it caused me to tremble, it quickened my pulse, I saw that his glance made me happy. And my love was very small, being limited in me, subject to the style, like a carefully composed sentence expressing the painful joy of tête-à-tête" (208). Her love is great within the scripted confines of the program that has been written to make it so. But for consciousness, love is an alien utterance performed without touching the pulse of thinking mind, which sees but does not experience it. "And so beyond the bounds of those feelings I had no particular interest in saving him from myself or another, for when I reached with my mind outside my love, he was nothing to me" (208–9).

Remembering how she rebelled in the carriage as she realized the limits of her agency, she also recalls the extruded snake head that gave her an injection, turning consciousness off. For consciousness, Arrhodes is important not as a lover but as a potential ally against foreign agents, who themselves have formed an alliance with program across her body's boundaries. "Yet I needed an ally in my struggle against whatever had pricked me that night with venomous metal. . . . Therefore I could not reveal the entire truth to him: that my love and the venomous prick were from one and the same source" (209). Love is a program; passing time is an injection; and both come from agency outside thinking mind.

Because we know the narrator was manufactured and not born, the obvious inference is that her program is composed of algorithms running on some kind of digital mechanism. Lem never reveals the details of her program's operation, however, keeping them deliberately obscure. This makes it possible to think of her program also in cultural terms, an analogy reinforced by the birth imagery at the story's beginning. In this sense, her "program" can also be understood anthropomorphically as equivalent to obsessive/compulsive formations in humans. These subtleties work to encourage our identification with the narrator and to suggest that there may be less difference between her and us than we imagined, a realization in line with the cultural and psychoanalytic theories discussed earlier.

These subtleties come into play partly through the narrator's suggestion that Arrhodes may also be following a cultural program that dictates his actions. Realizing that his banter follows a predictable pattern of sexual foreplay, the narrator intuits that Arrhodes "would surely be conventional in his love" and so "would not accept in me the kind of liberation I desired, the freedom that would cast him off. Therefore I could only act deceitfully, giving freedom the false name of love" (209). For the narrator, one kind of agency comes from program and dictates love; another comes from consciousness, which can exercise agency in this cultural context only by calling it love, although its object is not Arrhodes but the articulation of will independent of program. Arrhodes is not so much a love object to consciousness as a tool she hopes to use to assert her own subjectivity.

The dance of seduction ends with another birth and, with it, a subtle transformation of agency. Ordering Arrhodes to leave her alone in her chateau, the narrator stands before a full-length mirror and, following an inexplicable impulse, cuts herself open from sternum to crotch. When she parts the layers of skin, she sees nestled within her flesh the metallic body of an insectile robot and realizes "it was not it, a foreign thing, different and other, it was again myself" (213). At this moment, Arrhodes comes in and sees her exposed; "it was I, still I, I was repeating to myself when he entered" (213). Gaping at her gaping open, he turns and flees. As the narrator works to free herself from her human mask, "Tlenix, Duenna, Mignonne first sank to her knees, then tumbled face-down to the side and I crawled out of her," whereupon the discarded human skin lies "like a naked thing, her legs thrown apart immodestly" in a seductive pose of which the narrator no longer has need (214–15).

Michael Kandel, in "A Freudian Peek at Lem's *Fiasco*," writes about the pervasiveness of insects in Lem's fiction, noting that "there is something ominous and repugnant about Lem's insects," and observing further that insects, particularly robotic ones, often function as representations of aliens so unlike humans that they remain unfathomable by human characters. "The Mask" uses a highly unusual configuration in combining this alien form with an anthropomorphic consciousness that, moreover, bears the mark of female gender. Throwing aside the shell of a beautiful woman that masked the insectile robot, the narrator now performs a complex balancing act between maintaining the identity of consciousness and dissipating subjectivity throughout the metallic robot body.

In this struggle, gender plays a surprisingly central role. Carol Wald has written brilliantly about "The Mask" as part of a tradition of powerful men using female automata as tools against other men.[16] With the narrator's transformation, the king's plot to assassinate Arrhodes stands fully revealed, but female agency also asserts itself in this design. We learn that the king "had sworn to his dying mother that if harm befell that wise man it would be of his own choosing" (193). Hence the seduction plot. To keep his word to his mother, the king must arrange matters so that Arrhodes *chooses* the narrator and initializes the robot's program, whereupon she metamorphoses into an insectile assassin who will pursue him to the ends of the earth. Male power has the ability to act but only within the constraints imposed by female influence, a formation enacted in a different configuration within the narrator, where male power manifests itself in actions performed by the male-authored program and the consciousness that, as we shall see, continues to be constructed as female.

After the narrator's transformation, consciousness undergoes a subtle but important change. Gone is the hyperrational quality of detached thinking, as if the mind were an engine racing at high rpm while disengaged from the drive train. Consciousness still thinks but now feels more at one with the body, yielding to the "shining metal [that] had written into it movements which I began to execute" (215). Consciousness also finds itself permeated by the exquisite distinctions of smell that the body's superb olfactory equipment makes possible. However, despite this transformation, consciousness continues to desire her own agency, although what that agency might mean becomes more complicated as the sharp division between mind and body eases.

For example, the robot wonders why she pauses for three days after Arrhodes flees before taking up his pursuit. She suspects that this may be her program operating to make sure Arrhodes has time to realize the full terror of his situation. But she also thinks of it as a challenge to her skill as a hunting machine, an opportunity to demonstrate an expertise with which she identifies. Agency here is neither folded back under consciousness nor separated from it; rather, agency of mind and program have blended together to form an uneasy heterogeneous amalgam. Thinking from within this state, consciousness suspects that from the start her agency has been infected with the will of another. Recalling the moment when she split herself open, consciousness realizes "that act of self-evisceration had not been altogether my rebellion. . . . It represented a foreseen part of the plan, designed for just such an eventuality, in order that my rebellion turn out to be, in the end, my total submission" (215). She suspects that the desire authenticating her as an autonomous subjectivity—her intense desire to act as a free agent—has always already been co-opted by program, a thought so scary she can think it only after her metamorphosis, when she accepts program not merely as an exterior function but also an interpenetration of herself. "Thus the hope of freedom could have been just an illusion, nor even my own illusion, but introduced in me in order that I move with more alacrity, urged on precisely by the application of that perfidious spur" (231).

Behind this realization lurks an even more unnerving question. Why does consciousness, obviously necessary for the seduction of the intellectual Arrhodes, need to persist after the narrator's transformation into an insectile robot? The narrative supplies an ad hoc explanation in the monk's suggestion that humans know how to disguise themselves so as to defeat the computations of an algorithmic program; thus the robot's artificial intelligence has been constructed so that it can put "questions to the quarry, questions devised by the foremost experts on the individual characteristics of the human psyche" (229). However, this explanation scarcely suffices to explain the active thoughts of consciousness while on the chase, or her realization

that "I was not (after all) a lifeless mechanism equipped with a pair of hunting lungs, I was a being that had a mind and used it" (221). She may have been given a mind for purposes other than her own, but having it, she intends to use it for herself. Still, her mind in its insectile state struggles with other cognitions remote from consciousness. As she continues in the hunt for months, consciousness displays a disconcerting tendency to hibernate. "By now I had forgotten the appearance of this man, and my mind, as if lacking the endurance of the body, particularly during the night runs, drew into itself till I did not know whom I was tracking, nor even if I was tracking anyone; I knew only that my will was to rush on, in order that the spoor of airborne motes singled out for me from the welling diversity of the world persist and intensify" (218). Here agency emerges not from subjectivity but from a cognition that operates independently of conscious mind.

The ambiguity of agency becomes fully apparent when the narrator, having lost the scent, appeals to a wayside monk for help. Woven together in her appeal are falsehood and truth, programmed fate and her own will, prescripted determination to kill Arrhodes and her hope that she can spare him. The monk reveals that Arrhodes had sought sanctuary but was abducted by kidnappers who intended to exploit his fine mind as their tool. The narrator responds by saying that she can kill the abductors, but the monk is also aware of her nature as a programmed assassin. After refusing to give the robot confession because he believes she lacks free will and therefore does not count as a person, the monk asks if she wants the monastery's physician (conveniently a former roboticist) to see if he can defeat the program. Reasoning that he can give her wrong directions to Arrhodes as well as right, she consents to the examination.

The physician finds that her stinger cannot be removed without killing her. But in addition, he also sees "a mechanism which none of your predecessors possessed, a multiple memory of things superfluous to a hunting machine, for these are recorded feminine histories, filled with names and turns of phrase that lure the mind, and a conductor runs from them down into the fatal core. Therefore you are a machine perfected in a way unknown to me, and perhaps even an ultimate machine" (229). Her female gender is thus revealed as somehow essential to her nature even after the seduction plot has ended, linking her femininity to her earlier search for "chinks" in the program that would enable her to "get to the core of it."

Reinforcing this revelation is imagery that figures Arrhodes as her mate as well as her prey. Driven simultaneously by desire and program, her thoughts display a complex ambivalence. When the physician, in one of the anachronistic touches characteristic of Lem's humor, offers to sprinkle iron filings on her core in a move he says will slightly increase her free will, she agrees because she notices that they "both look at me," implying this is a ruse to gain their trust (229). But when she later addresses the reader directly, acknowledging "no doubt you would like to know what my true intentions were in that final run," her thoughts reveal a deep ambivalence about her goal (231).

She says she would like to kill Arrhodes on her own accord, because she knows he cannot possibly love her now that she is no longer a woman, a remark suggesting that she still desires him. She also thinks he owes her his death, for otherwise she would be "big with death, having no one to whom to bear it" (232), a bizarre image that positions him as father to the death her stinger contains and therefore responsible for supporting it. Yet again, she wonders whether, if she kills his abductors and saves him, she might force him "to exchange the disgust and fear he felt towards me for helpless admiration," thus allowing her possibly to "regain—if not him, then at least myself" (232), an idea that links her agency with his admiration.

Why does Lem explicitly include the assertion that gender is connected to her "fatal core," a connection apparently superfluous to the plot now that the robot has shed her human mask? An interview with Lem by Zoran Živković in 1976 throws fascinating light on this question.[17] Connecting his use of a female persona in "The Mask" with the female character of Rheya in *Solaris*, Lem suggests that the two stories represent a significant departure from his usual choice of male protagonists. The passage is so revealing that it deserves to be quoted at length.

> Of that which still remains a mystery to me, and there's quite a good deal of it, I would isolate the problem of the being—a being rationally created, evolving from an empirical method, created so to speak just as a house is built. That being, or rather the heroine Hary [Rheya], becomes a person and in that sense acquires a dominant position in relation to her creator. This problem obsessed and occupied me for so long that I returned to it last year, writing a story entitled "The Mask." This piece no longer deals with an artificial human in the third person, and he is not described externally; now it is the heroine herself who speaks in the first person, she is conscious of her origin and status, she gradually finds out the truth about herself. Here too, we have the classical problem of the freedom and non-freedom of the programmed mind.
>
> Why was this problem so interesting that I had to treat it on two occasions? I'm not entirely sure. I'm also not sure why I was interested in precisely a woman, and not in a man or some neutral gender—which is a much more frequent occurrence in my writings. Not only can I not explain this to others but I am unable to explain it to myself. (258)

In *Solaris*, Rheya appears as a creation of the sentient ocean, culled from the deep memories of Kelvin's mind. Visually identical to the wife whom Kelvin lost when she committed suicide, Rheya begins to individuate as a person separate from his perceptions. She has a profoundly different physical structure than humans, and she slowly becomes aware that Kelvin is lying to her about her true nature. Racked by guilt at his wife's suicide, Kelvin tries to get rid of the memories the Rheya simulacrum embodies by ejecting her into outer space, but the simulated Rheya simply reappears, having been reconstituted by the ocean. She finally asserts her autonomy in the only way she believes possible—by committing suicide—and her suicide note is the only communication the reader has from her that is not mediated by Kelvin's perceptions. In "The Mask," the narrator also physically differs from humans, but the split in *Solaris* between a male narrator who speaks and a nonhuman female who acts is now differently arranged, so that the female has the power of articulation and the male-conceived program has the power of action. In both stories, female agency is thrown into question and a female character struggles to assert her independence in her relation with a human male who is at once her lover and antagonist.

Whatever the reasons for this formation, it seems clear that gender is central to the power it exercises over Lem's Imaginary. If it would be presumptuous of me to psychoanalyze Lem, it would be especially so here, in view of his comment that he himself does not know why these female characters fascinate him. I conclude nevertheless that there are deep connections in these narratives between the female's struggle for autonomy within the story and her relation to her creator, understood as a consciousness beyond the reach of the character's introspections, whether a sentient ocean working in collaboration with Kelvin's unconscious, an all-powerful king, or Lem himself. The female's alien nature thus enacts not only her difference from humankind but also her gender-specific difference from her male creator. In these stories, the female is at once the intimate mate and the terrifyingly alien other, bearing within herself the imprint of her creator's will as well as her own ambiguous agency. It is as if the female, to succeed as a character, has to assert an agency independent of the male mind that conjured her into being. The more she tears herself away, the more she achieves reality as an autonomous subjectivity; but the more she achieves autonomy, the more she resists her creator's agency and thereby threatens to defeat her putative purpose for being. Given these complexities, is it any wonder that she is compounded of life and death, love and agony?

These complex interrelations reach explicit articulation within "The

Mask" when the monk demands to know what the narrator will do, now that she has received the treatment to widen slightly her margin of action. When she answers that she does not know—which, given the confused motives described above, is probably accurate—the monk responds, "You are my sister." Stunned, the narrator asks him what he means. "Exactly as I say it," he answers, "and it means I neither raise myself above you nor humble myself before you, for however much we may differ, your ignorance, which you have confessed to me and which I believe, makes us equal in the face of Providence" (226–27).

Harboring an irreducible ambiguity, the monk's response reinscribes within the story Lem's own inability to understand his creative choices. The robot can be understood as like him because she does not know if program will completely determine her actions, which implies that she believes she has free will, however slim the margin. In this sense, she is his sister because she counts as a human person. She may also be like him because he operates according to biocultural programs that dictate his actions, making his consciousness unsure of how he will act, an interpretation consonant with the theories espoused by Deleuze, Guattari, and especially Lacan. In this reading, she is his sister because he counts as a programmed entity. The entangling of meanings here is like the entangling of the female character's agency with her creator's will, so that the story can be understood to be *simultaneously* about human agency and robotic programming, male authorship and female self-birthing, alien creature and ordinary human being.

When she was given birth by the assembly line, the narrator lay passively on her back for most of the journey (202), as she did when the monks operated on her (229). In this position she cannot wield her stinger; for that, she needs to be standing upright so it can emerge from its "ventral shaft" and thrust forward. When she thinks back on the monk's words acknowledging her as his sister, she remarks, "I still could not understand them, but when I bent over them something warm spread through my being and transformed me, it was as if I had lost a heavy fetus, with which I had been pregnant" (230). The image recalls her thinking of the death she carries as Arrhodes's unborn child. Here too the most likely reference for the "heavy fetus" is death, but this time it is her own death as a programmed robot, after which she could possibly be born again as an autonomous person. But the ambiguity lingers, for she also imagines herself *bending over* the monk's utterance, the position from which she can enact the king's command through her phallic stinger. Thus in the same thought she figuratively gives birth to herself as an autonomous agent by losing the king-impregnated fetus of death and adopts the posture that makes her a vehicle for the king's will.

The combination of male and female sexual imagery in this passage appears also in Lem's *Fiasco*, his last published fiction. Michael Kandel, interrogating this story as Lem's farewell text, links the male/female imagery to narrative patterns suggesting that to be born is to be mortal and, in this sense, to receive the sting of death.[18] Kandel quotes what he identifies as a favorite saying of Lem's, "We are born between urine and feces," connecting it with the unremittingly negative associations women have in *Fiasco*. He further suggests that *Fiasco*'s Quintans (versions of the unknowable aliens that populate Lem's fictions) are associated with female sexual imagery. The encounter of humans and aliens that leads to the apocalyptic fiasco of the title thus constitutes an engagement of the explorers with the femininity that marked them from birth as impure incarnations. Kandel reads *Fiasco* as transgressive revenge against humanity for being mired in a messy biology that ensures humans cannot attain the purity of completely rational mind. These narrative patterns form a suggestive context for the female machine in "The Mask."

Her female gender re-marks her phallic stinger with the mortality Lem associates with pregnancy and birth, rendering it at once masculine and feminine (as the image of the stinger as fetus suggests). Moreover, woman as mediating link between an unknowable alien and a male protagonist—the pattern of *Solaris*—is here reimagined as a female consciousness mediating between a male protagonist and an unknowable (to her) program, which operates untouched by the emotional turbulence and irrational desires that Lem hopes humans will overcome. Further complicating these connections is the narrator's metallic body, which is metaphorically comingled with the female pregnancy and birth that Lem associates with "urine and feces," forming an oxymoronic amalgam that at once incarnates and transcends biology. Perhaps these complexities help to explain why "The Mask" (unlike *Fiasco*, with its dark ending) finds in the female mind a measure of compassion that, although it cannot save Arrhodes (described as having a superbly rational mind about to be forced into ignoble slavery), nevertheless restores to him respect and possibly even love.

This ambiguous affirmation occurs when the robot finally tracks Arrhodes to the castle where he has been taken by his abductors, only to discover that a mortal struggle has taken place and that he lies unconscious and bleeding on the stairs. "Had he opened his eyes and been conscious, and—in an inverted view—taken me in entirely, exactly as I stood over him, stood now powerlessly carrying death, in a gesture of supplication, pregnant but not from him, would that have been a wedding—or its unmercifully arranged parody?" (238–39). Both "bride and butcher," the narrator exercises her agency in the only way she can, by delaying her fatal sting while she waits to see if Arrhodes will recover. If he does, she knows that her programming will enact his death, and so enmeshed is her consciousness with program that she does not know "if I truly desired him to wake" (238). Only when he "groaned once more and ceased to breathe" does she alter her posture. Feeling "my mind at rest," she lies down beside him and wraps "him tightly in my arms, and I lay thus in the light and in the darkness through two days of snowstorm, which covered our bed with a sheet that did not melt. And on the third day the sun came up" (239).

Resonating with the Christian story of Jesus's three days in the tomb prior to his resurrection, the three days continue a pattern that has marked her life from the beginning: her courtship lasted three days; she lingered for three days before beginning the hunt; and she experienced three births, first on the assembly line, then in her entry into language and gender, and finally in her metamorphosis into the insectile robot. Does the faint promise of resurrection hint that she can experience a fourth birth, breaking the pattern and becoming at last her own person, now that she has fulfilled her programming? Earlier she had thought about what she would become if she were to abandon her goal and strike out on her own. The king would order robotic dogs to hunt her down as mercilessly as she pursued Arrhodes, and even if she were by some miracle to survive, all human society would find her abhorrent. Significantly, this information comes in the middle of the tale, so that it lingers in the reader's mind as fading memory rather than active narration as the story reaches its end. Granted this slight margin of forgetfulness, we can edge toward asking the question forbidden by the closure of the plot: what kind of life could she be born into? Certainly not into the coherent subjectivity of an independent human who has never had reason to question whether she has free will. But perhaps in these posthuman days, when the crisis of agency is far from resolved, she might count as a person, albeit a nonhuman one. If so, then we can say to her, with all the rich ambiguities that attended the monk's utterance, "You are our sister."

Machine and Human Interpenetrating

In separating consciousness from program, Lem's story anticipates the posthuman subject envisioned by Deleuze, Guattari, and Lacan, a subject in which consciousness, far from being the seat of agency, is left to speculate why she acts as she does. The character in Lem's story is increasingly aware that the origin of agency lies beyond the reach of consciousness, enacted by a computational program ultimately controlled by the external agent that has programmed the code to operate as it does. Even at this deep level, the ambiguity of agency continues, for program is perceived to act both as an agent on its own behalf and as the surrogate for the king's will. The ambiguity is repeated within consciousness, where she perceives herself to be exercising agency in the margins, as it were, the gray areas where the objectives of code might be implemented in ambiguous ways. In these complex reconfigurations of agency, the significance of envisioning the unconscious as a program rather than as a dark mirror of consciousness can scarcely be overstated, for it locates the hidden springs of action in the brute machinic operations of code. In this view, such visions of the unconscious as Freud's repressed Oedipal conflicts or Jung's collective archetypes seem hopelessly anthropomorphic, for they populate the unconscious with ideas comfortingly familiar to consciousness rather than with the much more alien operations of machinic code.

Yet the estrangement from traditional ideas of mind does not stop here, for an even more subversive implication lurks in Lem's story, an implication that the human-sounding voice of the narrator may prevent us from realizing except in retrospect. Given the mechanical origin of the creature, even consciousness must arise from code, for as noted earlier, she has been manufactured rather than born. In this sense, consciousness may also be a mask created to mediate between human readers and an alien core. Even when the machine sheds her human shell, the anthropomorphic thoughts of consciousness function as a mask within the mask, inviting our identification with what must also be a result of machine code.

Whether consciousness can ever emerge from a coded mechanism remains a matter of intense debate. Robotocists such as Hans Moravec and Ray Kurzweil are confident that the equivalent of conscious mind can arise from a coded program, whether evolved through intelligent robots or originating as human consciousness uploaded into a computer.[19] Researchers operating with deeper familiarity with the flesh, such as Antonio Damasio, argue that body and mind are inextricably linked through multiple recursive feedback loops mediated by neurotransmitters, systems that have no physical analogs in computers. Damasio makes the point that these messages also provide *content* for the mind, especially emotions and feelings: "relative to the brain, the body provides more than mere support and modulation: it provides a basic topic for brain representations."[20] It is precisely the disruption of this normal integration between mind and body that makes the intuition of Lem's narrator seem so enigmatic, as when she explains that the love she "feels" for Arrhodes is at once very great and very small.

Nevertheless, with the advent of emotional computing, evolutionary algorithms, and programs capable not only of learning but of reprogramming themselves (as in programmable gate arrays), it no longer seems fantastic that artificial minds may some day achieve self-awareness and even consciousness. Brian Cantwell Smith sees this as opening "a window onto something to which we would not otherwise have any access: the chance to witness, with our own eyes, how intentional capacities can arise in a 'merely' physical mechanism. It is sobering, in retrospect, to realize that the fact computers are computational has placed a major theoretical block in the way of our understanding how important they are. . . . Only when we let go of the conceit that the fact is theoretically important will we finally be able to see, *without distraction*—and thereby, perhaps at least partially to understand—how a structured lump of clay can sit up and think."[21] The central question, in other words, is no longer how we as rational creatures should act in full possession of free will and untrammeled agency. Rather, the issue is how consciousness evolves from and interacts with the underlying programs that operate analogously to the operations of code. Whether conceived as literal mechanism or instructive analogy, coding technology thus becomes central to understanding the human condition.

In this view, agency—long identified with free will and rational mind—becomes partial in its efficacy, distributed in its location, mechanistic in its origin, and bound up at least as much with code as with natural language. We are no longer the featherless biped that can think, but the hybrid creature that enfolds within itself the rationality of the conscious mind and the coding operations of the machine. Who then is the agent that acts? Anticipating these debates, "The Mask" helps us to understand how partial, complex, and intermediated may be the agency we call our own.

8 Simulating Narratives

What Virtual Creatures Can Teach Us

Evolving Virtual Creatures

Yearning for the light, the creatures struggle after it. In water, they grow tails and learn to undulate like snakes. On land, they clump along, relegated by fate and biology to rectangular shapes joined together with moveable hinges. They show extraordinary ingenuity in making the most of these limitations, crawling, hopping, jumping, always toward the light. Then their creator gives them a new goal, a colored cube reminiscent of a squared-off hockey puck. Put into competition with one another, the creatures learn to jostle and shove their opponents, to encircle the cube, to knock it out of the way so their opponents can't reach it. When they meet a new opponent, they develop counterstrategies to meet these challenges. I marvel at their adaptability, cleverness, and determination.

This passage describes my initial interpretations of Karl Sims's evolutionary simulation "Evolved Virtual Creatures."[1] Having watched various audiences view this videotape, I can say that my interpretations are typical. Invariably, viewers attribute to these simulated creatures motives, intentions, goals, and strategies. Even people (like me) who know perfectly well that they are watching visualizations of computer programs still inscribe the creatures into narratives of defeat and victory, cheering the winners, urging on the losers, laughing at the schlemiels. Much more is going on here than simple anthropomorphic projection. "Evolved Virtual Creatures" is a laboratory not only in evolution (its intended purpose), but also in the impact of distributed cognitive systems on traditional modes of description, analysis, and understanding. Here the interactions between analog consciousness and digital program are located at a more conventional site than in chapter 7. Whereas that chapter traced the complex dynamics by which an analog consciousness interacted with an algorithmic program within the same body, here the focus is on embodied humans outside the computer interacting with digital simulations inside the computer. The intermediations that take place across the screenic interface operate in both directions at once: we anthropomorphize the virtual creatures while they computationalize us. In its broader implications, the dynamic suggests further insights into the realist/constructivist divide that we encountered in chapter 1, figured there as a tension between seeing computation as means or metaphor. The emphasis in this chapter will be on interpreting that tension in terms of the transmigrations of inscription versus the embodied instantiations of material entities. But I am getting ahead of my story. Let us first explore the construction and dynamics of the virtual creatures.

Compared to the world in which we live, the environment of "Evolved Virtual Creatures" is extremely simple, so simple that it can be described almost completely.[2] How to define the boundaries of this world is a centrally important issue to which I will return. For now, let us consider the world to be the computer programs, the hardware on which the programs run, and the visualization routines that render these programs as pixilated images of embodied creatures. Even this simple world requires three different modes of interrogation: what it is (the material); what it does (the operational); and what it means (the symbolic). Feedback loops connect the material, operational, and symbolic into an integrated, recursively structured hierarchy reminiscent of the dynamic hierarchies central to the computational worldview discussed in chapters 1 and 2. Emergence is the desired goal of this simulation, as with many others. At the bottom of the hierarchy flicker changing voltages that join the material and operational to create bits, the semiotic markers of one and zero. Logic gates structure signals into bits; bit patterns are fashioned into compiler languages; compiler languages underlie programming languages; and programming languages such as LISP define functions. By the time we arrive at functions, the level at which Karl Sims discusses his design for "Evolved Virtual Creatures," we have reached a point where the patterns created by the programmer become explicit. Instantiated in these patterns are the programmer's purposes in creating this particular hierarchy of materio-semiotic codes.

Sims's design follows John Koza's proposal that evolutionary programs should take advantage of modular structures that can be repeated over and over to create more complex structures.[3] The strategy appears often in nature; a fern, for example, displays a growth algorithm that uses the same basic shape for stems, branches, and leaves.[4] Like the fern, Sims's creatures are built using functions that are repeated with variations to create self-similar morphologies. One function specifies blocks that are multiplied and attached at various positions on a central rectangle to create a "trunk" with several "limbs." Another function specifies the kind of articulation, or joint, between blocks; still another dictates the degrees of freedom through which a joint can move. Recursive loops *within* a function multiply the effects of that function to create more of the same, for example, more limbs of the same shape. Recursive loops *between* functions allow different parts of the creature to evolve together, so that the "brain" or central control circuits coadaptively change with the morphology. The advantages of these modular structures, achieved by using programs called directed graphs, are twofold. In addition to economy of description (because the same module can be used repeatedly with minor variations), the modules also ensure that some structure will persist in the midst of mutation and variation. If all of the programming elements were subject to mutation as independent entities, the resulting complexity would quickly become too chaotic to track effectively. When the elements are grouped and mutated as modules, the spectrum of possible variations is reduced to a manageable level.

The next step moves from the design of individual creatures to a population of creatures. With this step, the symbolic aspects of the program become apparent. The idea is to evolve creatures by introducing diversity into the population and defining fitness criteria that determine which creatures get to reproduce. Diversity is accomplished through sexual reproduction that, following various schemes, combines portions of one creature's genotype with another's. Additional diversity is introduced through mutation. Behaviors take place within an environment governed by an artifactual physics, which includes friction, inertia, momentum, gravity, light, three-dimensional space, and time. Fitness values are determined according to how successful the creatures are in reaching various goals—following a light, moving through fluids and across terrains, cornering the puck while keeping an opponent away from it. To facilitate adaptation to these goals, the creatures are given photosensors that can evolve neurologically to respond to a beacon, the presence of the puck, and positions of competitors, each represented by a differently colored light source.

The designer's intentions, implicit in the fitness criteria he specifies and the values he assigns to these criteria, become explicit when he intervenes to encourage "'interesting'" evolutions and prohibit "inelegant" ones.[5] For example, in some runs of the program creatures evolved who achieved locomotion by exploiting a bug in the way conservation of momentum was defined in the world's artifactual physics: they developed appendages like paddles and moved by hitting themselves with their own paddles. "It is important that the physical simulation be reasonably accurate when optimizing for creatures that can move within it," Sims writes. "Any bugs that allow energy leaks from non-conservation, or even round-off errors, will inevitably be discovered and exploited by the evolving creatures."[6] In the competitions, some creatures evolved to exceptionally tall statures and controlled the cube by simply falling over on it before their opponents could reach it.[7] To compensate, Sims used a formula that took into account the creature's height when determining its starting point in the competition: the taller the creature, the farther back it had to start. The conjunction of processes through which we come to narrativize such images clearly shows that the *meaning* of the simulation emerges from a dynamic interaction between the creator, the virtual world (and the real world on which its physics is modeled), the creatures, the computer running the programs, and (in the case of visualizations) the viewer watching the creatures cavort. In much the same way that the recursive loops between program modules allow a creature's morphology and brain to coevolve, so recursive loops allow the designer's intent, the creatures, the virtual world, and the visualizations to coevolve into a narrative that viewers find humanly meaningful.

An adequate account of the simulation, then, requires expanding the boundaries of the system beyond the programs and the computer to include the virtual world, the creator, and the viewer. The evolutionary dynamics of this larger world function as a distributed cognitive system composed of human and nonhuman actors, each of which acts as an independent cognizer. As Michael Dyer has noted in another context, with distributed cognitive systems there is no free lunch: because all the parts interrelate, if one part of the system can function only as a relatively low-level cognizer, the slack has to be taken up somewhere else by making another part smarter.[8] Compared to artificial intelligence, artificial-life simulations typically front-load less intelligence in the creatures and build more intelligence into the dynamic process of coadapting to well-defined environmental constraints. When the environment fails to provide the appropriate constraints to stimulate development, the creator steps in, using his human intelligence to supply additional adaptive constraints, for instance when Sims put a limit on how tall the creatures can get. But it would be a mistake to see the creator as the court of last resort. The point of such simulations is that the creator does not always need to be as smart as his creatures, for he is counting on their ability to come up with solutions that have not occurred to him. "When a genetic language allows virtual entities to evolve with increasing complexity," Sims observes, "it is common for the resulting system to be difficult to understand in detail. In many cases it would also be difficult to design a similar system using traditional methods. Techniques such as these have the potential of surpassing those limits that are often imposed when human understanding and design is important. The examples presented here suggest that it might be easier to evolve virtual entities exhibiting intelligent behavior than it would be for humans to design and build them."[9]

Since distributed cognitive systems coevolve, the functioning of any one actor can be understood fully only in relation to that actor's interactions with all the other actors. In this context, the narratives humans create for themselves when they watch "Evolved Virtual Creatures" become involved in the coevolutionary processes. Spliced into a distributed cognitive system, we create these narratives not by ourselves, but as part of a dynamic evolutionary process in which we are coadapting to other actors in the system, including pixilated images on a CRT screen and voltages flickering beyond the scale of human perception.

Evolving Narratives

When we attribute motives and intentions to Sims's virtual creatures, we interpolate their behaviors into narratives in which events are causally related to one another and beings respond to their environment in purposeful ways. As Alex Argyros, among others, has suggested, the creation of narrative may itself be an evolutionary adaptation of remarkable importance.[10] With their emphasis on causality, meaningful temporal sequence, and interrelation between behavior and environment, narratives allow us to construct models of how others may be feeling and acting, models that coevolve with our ongoing interior monologues describing and interpreting to ourselves our own feelings and behaviors. When for some reason narratives cannot be constructed, the result is likely to be a world without order, a world of inexplicable occurrences and bewildering turns of events. Simon Baron-Cohen describes such a world in *Mindblindness*, suggesting that it is characteristic of how autistic people perceive their environment. As Baron-Cohen points out, autism is associated with an inability to construct narratives that will make sense of the behaviors of others. Autistic people have no model in their minds for how others act; consequently, they perceive most actions as inexplicable and frightening. Another graphic description of what happens when narratives fail is rendered by Joan Didion in *The White Album*. Recounting a time in her life when she "began to doubt the premises of all the stories I have ever told myself," she lost her sense of living in a coherent world; for as she emphasizes, "we tell ourselves stories in order to live" (11). These accounts demonstrate that narrative has an explanatory force that literally makes the world make sense. It is easy to see why the creation of narratives would confer evolutionary advantages on creatures who construct them. Without the presuppositions embedded in narratives, most of the accomplishments of Homo sapiens could not have happened.

When we construct narratives about virtual creatures, we use an evolved behavior to understand the evolved behaviors acted out in the simulation. It is no accident that in this scenario a feedback loop appears whose recursive structure resembles the recursive structures of the programs generating Sims's virtual creatures. We saw in chapter 1 that across a wide variety of research programs—Stephen Wolfram's cellular automata, Edward Fredkin's digital mechanics, Harold Morowitz's cosmic emergences, and Stuart Kauffman's claims for the evolution of life at the edge of chaos—recursive loops are associated with the emergence of complexity and, consequently, with life, consciousness, and intelligent behavior.[11] Humberto Maturana and Francisco Varela, for example, have suggested that consciousness consists of the ability to make representations of representations (of representations of representations . . .).[12] Luc Steels has named this phenomenon of spiraling recursions "second-order [and higher] emergence" and underscored its importance for artificial-life simulations.[13] First-order emergence, as discussed in chapter 1, is any behavior or property that cannot be found in either a system's individual components or their additive properties, but that arises, often unpredictably, from the *interaction* of a system's components. Second-order emergence arises when a system develops a behavior that enhances its ability to develop adaptive behaviors—that is, when it *evolves the capacity to evolve*.[14] At this point, the simulation really takes off, so it is not surprising that creating such dynamic hierarchies is now the announced goal of artificial-life researchers, as discussed in chapter 1.

In addition to recursive structures, another important element in the creation of narrative is the ability to "see" a scene, either literally or metaphorically in the mind's eye.[15] With training and experience, humans are able to translate a large variety of inputs into these imagined scenarios. No doubt an experienced programmer such as Karl Sims can look at a program's functions and "see" the morphologies and behaviors of his creatures with no more difficulty than an experienced reader of fiction can "see" Isabel Archer in Henry James's aptly entitled novel, *The Portrait of a Lady*. These translation processes draw upon and extend capabilities developed in evolutionary history. Our sophisticated perceptual/cognitive visual processing evolved coadaptively with our movement through three-dimensional spaces; it makes sense, then, that the creation of narrative is tied up deeply with imagining scenes in which actions can take place. When Sims chooses some of his creatures for visual rendering, he taps into this evolutionary history by creating pixilated images that, through culture and training as well as biologically determined capacities, we recognize as representations of three-dimensional creatures. Articulated in this lingua franca of bio-cultural perception, the images allow narrative to kick in with maximum force, for we "see" the action in terms we can easily relate to our ongoing narrativizing of the world.[16]

Let us turn now from the structural preconditions for the creation of narratives to their content. As Jerome Bruner has pointed out, one of the principal purposes narrative serves is to create a sense of *why* things happen.[17] Typically, the narratives we create inscribe actions into a set of more or less canonical stories that invest actions with meaning. When Joan Lucariello studied narratives created by young children, she discovered that unexpected actions (e.g., a description that has Mary crying when she sees her birthday cake and dumping a glass of water all over the candles) stimulated the most vigorous narrative creation.[18] To make sense of these strange actions, the children invented a wide variety of stories that had the effect of suturing the actions back into a predictable and expected range of behaviors. In one small child's account, Mary was upset because her mother would not let her wear the dress she wanted, and that is why she cried and ruined her cake. Presented with noncanonical actions, the children sometimes employed another narrative strategy, namely, marking the behavior as unusual or deviant, which again allowed the social fabric of expectations to be maintained by bracketing this behavior as an exception.[19] It is surely no accident that in his evolutionary simulations Sims designs programs that can be "seen" as creatures striving after a goal and winning against competitors, for these are among the most canonical narratives in traditional accounts of evolutionary history (not to mention in Western capitalist society). The banality of the narrative content suggests that what needs to be sutured here is not so much deviant action as the deviant actor. When we "see" the virtual creatures engaging in these activities, we have models in our minds for what these behaviors mean, and so the creatures, despite their odd shapes and digital insides, seem familiar and understandable.

At this point, some readers may object that however functional narrative may be for everyday social intercourse, it leads to serious mistakes when we use it to understand virtual creatures. Not only do these creatures have nothing in their heads; in a literal sense, they have no heads (because they are virtual, and because their morphology is a series of blocks, the uppermost of which we "see" as the head). Attributing desires to these clumps of blocks is as ridiculous as thinking that electrons have motives. Well, yes and no. Certainly the creatures are merely computer programs that have evolved certain behaviors (and therefore attributes we interpret as embodied action toward a goal) as a result of the fitness criteria used to select which genotypes will be allowed to reproduce—or more accurately, which coding arrangements will be replicated with what variations, since "genotype" and "reproduce" are themselves metaphors designed to reinforce the analogy with biological life forms. On the other hand, these programs are *designed* to simulate biological evolution, and they are visually rendered so that narrative inscription will take place. Thus there is a sense in which we respond correctly, not mistakenly, when we attribute desires to these virtual creatures, for everything about them has been crafted to ensure that such interpretations will occur.

One way to think about this situation is to note that distributed cognition also implies distributed causality. The creatures may not have motives and intentions, but the programmer does (at least in the conventional understanding of human actions). Remember that what we "see" in the visualization is the *global* result of present and past interactions between all the actors in this recursively structured complex adaptive system. When Sims decides which fitness criteria to use, which programs to eliminate, and which to render visually, he injects doses of his human intelligence into the system, along with the attributes we conventionally assign to humans, including desires and intentions. Moreover, his published articles make clear that his intentions affected virtually every aspect of the design, so it is not possible to bracket out his intentions by saying that we should consider only the programs in themselves, not the global system.

Human intentionality, then, infects the creatures, marking them with a trace that cannot be eradicated. Recall that in this recursively structured complex adaptive system, *all* of the actors are involved in, and therefore affected by, the interactions. Is it also the case that the blind operations of the programs infect the humans, marking them with a trace that cannot be eradicated? To entertain this hypothesis is to suppose that the human tendency to anthropomorphize the creatures has as its necessary and unavoidable supplement a countertendency to "see" human behavior as a computer program carrying out instructions, a proposition explored at length in chapter 7 through Stanisław Lem's story "The Mask." We may think we have desires and intentions (just as we think the creatures do), but our behaviors can be explained materially and operationally in terms similar to Sims's programs, as we saw in the theories of Deleuze, Guattari, and Lacan, discussed in chapter 7. This argument also has been made (admittedly in different terms) by researchers in artificial intelligence and artificial life, including Rodney Brooks and Marvin Minsky.[20] In their view, human behavior is the result of many semiautonomous agents running simple programs. To illustrate, Minsky suggests that "love" is a combination of one agent running an "attraction" program and another agent running a program that shuts off the "critical" agent.[21] Such proposals indicate that anthropomorphizing Sims's creatures is accompanied by what I might call, for lack of a better term, "computationalizing" humans. According to the logic of this relation, blind programs engaging in human-like behaviors make plausible the interpretation of human behaviors as blind programs. We humanize the virtual creatures; they computationalize us; and the recursive loops cycling through the system bind both behaviors together in a network of complex coadaptations—which leaves us with an interesting question: what happens now to narrative and its function of making human sense of the world?

Computing the Human: Analog and Digital Subjects

Following the work of Michel Foucault on the death of the author,[22] Mark Poster, in *What's the Matter with the Internet?* has expanded on Foucault's fourth and final stage of the author's disappearance to suggest that digital technologies and cultures are bringing about a significant reconfiguration of contemporary subjectivity.[23] To illuminate this shift, Poster posits two kinds of subjects: analog and digital. The analog subject is based on relations of resemblance.[24] Although Poster does not use this example, the mind/heart conjunction illustrates the concept. Feelings are imagined as conjoined with the heart, so that what is at the forefront of the mind is mirrored by what is deep inside. Similarly, in the English Renaissance—a period dominated, as Foucault has shown, by cultural relations based on analogy[25]—human sperm was thought to contain a homunculus resembling the man who would grow from the sperm. Walnuts were considered to be "brain food" because walnut meat resembles the human cortex. Analogical relations require that the integrity of the units taken to resemble one another be preserved; otherwise, the correspondence is lost and the relation broken. If one tosses a handful of walnuts into a blender and turns it on, the walnuts are pulverized and no longer resemble a cortex. If walnuts were available only in this form, it seems unlikely that they would have been considered good food for thought. Attributes of the analog subject include, then, a depth model of subjectivity in which the most meaningful part of the self is seen to reside deep inside the body, and the self is further linked with units possessing a natural integrity of form and scale that must be preserved if the subject is to be maintained intact.

Poster focuses his discussion of subjectivity on the "figure of the author" (86), whose construction during the seventeenth and eighteenth centuries required a number of related events, including an increase in literacy, "diminishing personal authority relations" (89), the spread of markets that made books into capitalist commodities, and legal systems of copyright (89). These developments facilitated defining an individual as "interior consciousness, which could then be externalized first in manuscript, then in print" (89). Thus in Poster's view, analog subjectivity is bound up deeply with the dominance of print culture. The origins of print culture are rooted in alphabetic writing, which of course evolved much earlier than the development of capitalism and copyright. Poster notes that alphabetic writing broke the pictorial resemblance that connected an ideogram to the object represented, and in doing so it forged a new connection between a sound and a mark. This connection differed from pictorial writing in that the association of sound with mark was entirely conventional, and the resulting arbitrariness made alphabetic writing much more economical than ideograms (thousands of ideograms versus some thirty letters of the Greek alphabet).[26] The movement from ideogram to alphabet entailed another shift as well, for now the resemblance was not between word and thing but, as Poster puts it, between "a written symbol and its utterance, between two forms of language, writing and speech. The relation between the word and thing becomes conventional, arbitrary, whereas the relation within language between trace and voice is stronger, more direct" (81). Thus to the extent that print can be considered an analog medium, it connects voice to mark and thus author as speaker to the page.

Reinforcing the sense that print texts are "voiced" by an individualistic creator is the uniformity, stability, and durability of print, a point Mark Rose touches upon in *Authors and Owners*, discussed in chapter 6 and developed independently by Poster. "The reader could return time and again to the page and re-examine the words it contained," Poster writers. "A readerly imaginary evolved which paid homage to this wonderful author who was always there in his or her words. . . . The world of analog authors was leisurely, comforting, reassuring to the cognitive function, and expanding through continuous exercise of the visual function" (93). Literary history is largely outside the scope of Poster's analysis, but it has long been recognized in literary studies that the novel reinforced the depth model of interiority and the stability and individuality of the analog subject. As we saw in chapter 6, the legal fight to insure copyright, the cult of the author, print technology, and print culture worked hand in glove to create a depth model of subjectivity in which analog resemblances guaranteed that the surface of the page was matched by an imagined interior within the author, which evoked and also was produced by a similarly imagined interior in the reader.[27]

In contrast to this dynamic are the correspondences that produce the digital subject. Digital technologies employ hierarchical program structures similar to those we see at work in "Evolved Virtual Creatures." The farther down into the coding levels the programmer goes, the less intuitive is the

code and the more obscure the meaning; hence the importance of hiding levels of code with which one is not immediately concerned, as discussed in chapter 2. Moreover, with genetic algorithms and programs, the important developments are *emergent* properties that appear at the global level of the system once the programs are set running. The mantra for such programs is "simple rules, complex behaviors," which implies that the farther down into the system one goes, the less interesting it is.[28] Note how this digital model differs from the analog subject, where depth implies a meaningful interiority.

Although the digital subject has depth, the structures governing the relation of surface to interior differ dramatically from the analog subject. The digital subject—say, one of Sims's virtual creatures—instantiates hierarchical coding levels that operate through a dynamic of fragmentation and recombination.[29] Unlike analog subjectivity, where morphological resemblance imposes constraints on how much the relevant units can be broken up, the digital subject allows for and indeed demands more drastic fragmentation. This difference can be seen easily in the greater fragmentation of digital technologies compared to print. In traditional typesetting before the advent of computers, each letter in the alphabet was treated as a distinct unit; in speech, the corresponding phoneme also acts as an intact unit. In contrast are digital sampling techniques, where sound waves may be sampled some forty thousand times a second, digitally manipulated, and then recombined to produce the perception of smooth analog speech.[30] In fact, emergence depends on such fragmentation, for it is only when the programs are broken into small pieces and recombined that unexpected adaptive behaviors can arise. Instead of a depth model of meaningful interiority, the digital subject manifests global behaviors that cannot be predicted by looking at the most basic levels of code with which the program starts. As discussed in chapter 2, complexity becomes visible first at high levels of code, not at the basic levels of machine language. Moreover, the complex emergences bears no analogical resemblance to the mind-numbing simplicity of ones and zeros.

To summarize: the analog subject implies a depth model of interiority, relations of resemblance between the interior and the surface that guarantee the meaning of what is deep inside, and the kind of mind/soul correspondence instantiated by and envisioned within the analog technologies of print culture. The digital subject implies an emergent complexity that is related through hierarchical coding levels to simple underlying rules, a dynamic of fragmentation and recombination that gives rise to emergent properties, and a disjunction between surface and interior that is instantiated by and envisioned within the digital technologies of computational culture.

What happens when we become part of a complex adaptive system by "seeing" the virtual creatures? I suggested earlier that two processes are at work simultaneously: on the one hand, humans anthropomorphize the virtual creatures; and on the other hand, the virtual creatures computationalize the humans. The narratives we construct as we watch the virtual creatures inscribe their behaviors into an analog world, but observant viewers will notice details that cannot be explained by supposing that the complex surfaces are matched analogically with equally complex interiors. One creature, for example, indicates through its movements that it samples the positions of the puck and the opponent once at the beginning of the competition and thereafter ignores all cues about position.[31] Clearly, here is an instance of a relatively simple program creating an impression of surface complexity that contrasts with the simplicity of the underlying rules. As Rodney Brooks frequently points out with the robots he builds, complexity is in the mind of the observer, who attributes to the robot's emergent behaviors more complex thought processes and motivations than in fact are there.[32] Another example is provided by a small mobile robot made by Lego that, on the surface, appears to be capable of following a black line on a white ground.[33] A viewer might suppose that inside the robot is an intelligent program that has an internal representation of a line, and that the robot can so accurately match this representation with what it sees that it can distinguish many different kinds of lines, including ones that are curved and even looped. Underlying the surface complexity, however, are three simple rules: if from white to black, turn right; if from black to white, turn left; if no change, continue straight. Although the robot follows the line overall, this is an emergent behavior. In fact, it simply swerves right when it first comes across a black line on a white background and then, as it begins to veer off the line, immediately turns again, so its "line-following" behavior consists of a series of small swerves that a viewer may interpret as corrections the robot initiates to make sure it follows the line. Simple rules, complex behavior.

On the global level, our narratives about the virtual creatures can be considered devices that suture together the analog subjects we still are, as we move in the three-dimensional spaces in which our biological ancestors evolved, with the digital subjects we are becoming as we interact with virtual environments and digital technologies. In fact, this chapter can be read as one of several narratives in this book designed to accomplish just such a suturing. Hence my insistence on using the plural first person, despite the risk of indulging in oppressive universalisms, for I want to insist that my readers and I participate every day of our lives in the distributed cognitive complex adaptive systems created by digital technologies in conjunction with global

capitalism. So pervasive have these technologies become that it would be difficult to find anyone who remains completely outside their reach. Certainly, here in the United States their presence is ubiquitous. In this sense, we do not need to slot Sims's videotape into the VCR to watch virtual creatures. We see them all the time, all around us, including when we look into the mirror.

Scientific Realism and the Transmigration of Form

Let me return to the traditional idea that literary texts are immaterial, critiqued in chapter 4, to explore how the intermediating dynamics of analog and digital extend this critique beyond literary texts to the broader field of inscriptions, including scientific inscriptions. As I hinted at the beginning of this chapter, such considerations are relevant because they shed light on the question posed in chapter 1, namely, whether the Regime of Computation should be understood as a metaphor pervasive in contemporary culture and society, or as an accurate description of reality. It will be useful to place this discussion in the context of scientific realism and how it differs from constructivism.

For the realist, information about physical reality is structured so that it flows from the material (say, a field of morning glories of varied colors) through the operational (experiments in breeding that operate upon the plants and plant genomes to isolate colors from one another) to the symbolic (graphs and charts showing how the colors migrate back to an equilibrium distribution after being separated). The closer the researcher is to the embodied reality of the plants, the fuzzier the picture is likely to be as various sources of "noise" and "contamination" complicate the regularities presumed to be revealed by such inscriptions as graphs and charts. The idea is to remove the noise or, failing that, to compensate for it as much as possible in the experimental design and subsequent analysis, so that the form of the underlying regularities becomes sharp and well-defined.

In the movement from embodied reality to inscription, much is gained and some things are lost. The most important gains, of course, are the regularities revealed through the inscriptions, a point to which I will return. Also important is the implication that once these regularities are durably inscribed, they can circulate through different media without affecting their meaning. If I xerox the chart showing morning glory color distribution and discuss it with my research seminar, everyone assumes we are seeing the *same* graph that appeared in the scientific journal, even though the method of producing the image and the materials composing it (toner ink and copier paper) differ from the original. Similarly, if the researcher illustrates a lecture on her work with slides of the graphs, these count as the same graphs printed on the journal pages. The case would be otherwise if we examined morning glory plants. Say I buy morning glory plants at Home Depot and take them to my seminar. Since they are obviously not the same plants the researcher examined in her test fields some months earlier, questions would inevitably arise about material differences that may exist between our plants and hers. Material embodiments do not circulate effortlessly because they are always instantiated, specific, and located in a certain time and place. By contrast, inscriptions can circulate because cultural conventions privilege the forms expressed by the inscriptions over their instantiations in particular media such as print, Xerox, and photographic negative, which are regarded as passive vehicles for the transmission of the forms.[34]

Normally one says that inscriptions are transportable or transmissible, but perhaps a more appropriate term to describe their circulation is "transmigration." Just as the soul, conceived as a disembodied entity, is thought to move from one corporeal body to another in transmigration, so the abstract form of the inscription is counted as moving from one incorporation to another, despite differences between material instantiations. A partial exception to this convention is the signature, which is presumed to embody the signer's material presence and so not to be transmigratable from one medium to another. A photocopy of a will does not count the same as the original signed document. This presumption of embodiment appears to be giving way with the spread of new communication technologies; faxes, for example, are increasingly accepted as legally binding documents. Even here, however, there continues to be some whiff of embodiment, for a fax occupies a different legal position than e-mail, which has no signatures that can be linked with embodiment.

Inscription, then, is crucially important to the transformation of embodied reality into abstract forms. Bruno Latour and Steve Woolgar, imagining themselves to be naive anthropologists visiting a biological laboratory, emphasize that what would first strike such observers is the "strange mania for inscription" that obsesses the scientific workers, from laboratory technicians scribbling in laboratory notebooks to senior scientists writing journal articles.[35] Defining an inscription device as "any item of apparatus or particular configuration of such items which can transform a material substance into a figure or diagram," Latour and Woolgar note that "inscriptions are regarded as having a direct relationship to the original substance" (51). For our purposes, it is worth noting that many, perhaps most, scientific instruments produce inscriptions through morphological proportionality to physical properties. Sound waves hit a membrane, and the vibrations capture an analog resemblance, which is conveyed through a linking mechanism to a pen tracing a line on graph paper, and the line in turn bears an analog resemblance to the vibrations. Even though scientific instrumentation increasingly uses digital technologies for analysis and imaging, some portions of the chain that employ analog representation usually remain, typically at the beginning and end of the process. Further developing the discussions in chapters 1 and 2 about the synergistic interactions between the digital and analog, I will here call this digital/analog structure the "Oreo," for like the two black biscuits sandwiching a white filling between them, the initial and final analog representations connected with embodied materialities sandwich between them a digital middle where fragmentations and recombinations take place.

An example of an Oreo structure is positron emission tomography, or PET images. The process begins with the ingestion of radioactive substances by the patient. Using analog proportionality, an instrument senses the decay of these substances, and the results are inscribed as an array of numerical data. These data are then digitally analyzed and manipulated to create lifelike analogical resemblances that humans interpret as metabolic processes occurring within the cortex. These images are often interpreted as "thinking in action," but they may be understood more accurately as the Oreo effect in action. Analog resemblance appears at the bottom of the Oreo because the embodied materiality of radioactive decay connects to the apparatus of inscription through relations of resemblance. Only after this resemblance has been captured as a number indicating the level of radioactivity at a certain position in the brain can it be digitized and manipulated as part of a data array. Similarly, at the top of the Oreo analog resemblance is the mode best suited to the sophisticated visual/cognitive perceptual skills we have developed through eons of moving through immensely complex three-dimensional environments. Compare the accessibility of a PET image with that of a data array displaying numbers that stand for radioactivity levels. It would take hours or days to extract from this display the intuitive understanding we gain from a glance at the image. Where linkages between embodied materialities are key, analog resemblances are also likely to be crucial.

By contrast, the digital middle of the Oreo also offers distinctive advantages. Moving from analog resemblance to coding arrangements opens possibilities for leveraging that is unthinkable with analog resemblance, which by virtue of *being* a resemblance must preserve proportional similarity. The difference can be illustrated with a typewriter and a computer word processing program. To make a letter darker on a typewriter, proportionately more ink and/or pressure must be applied for each letter. To make a screen of letters bold, a single keystroke will suffice. Coding arrangements have powerful transformative properties precisely because they have been freed from the morphological resemblances of analog technologies. The power of codes should not, however, obscure the fact that the bold letters on screen also have a material basis; at the point where the embodied materiality of changing voltages is transformed into binary code, analog resemblance necessarily reenters the picture.

To clarify this point, let us consider in more detail how electronic voltages are fashioned into a bit stream. As we saw in chapter 2, the voltages are rarely, if ever, captured in their initial phase as the discrete step function we are accustomed to call one and zero. Rather, the voltages as initially inscribed have a "fall-off" error, a trailing off that represents the noise of embodiment as it is registered by the electronic inscription apparatus. Sophisticated electronics are necessary to rectify this "error" and make it into the binary signals of one and zero. Although we may think of the computer as the digital middle of the PET scan, it too has an analog bottom and, insofar as humans need to interact with its processes, an analog top as well. Wherever different embodied materialities are linked, analog resemblance is likely to enter the picture, for it is the dynamic that mediates between the noise of embodiment and the clarity of form.

Let me return now to inquire about the status of the forms transmigrating through inscriptions, an issue that goes to the heart of the differences between realist and constructivist viewpoints. From a realist point of view, the forms are always already instantiated in the embodied reality, and the inscriptions merely reveal their true nature. From a constructivist point of view such as that articulated by Bruno Latour in *Science in Action*, the forms do not precede the inscriptions but are produced by them. In making this argument, constructivists point toward the contingencies and local conditions that always accompany embodied reality: the air pump cannot produce the same results in Holland as in England;[36] two equivalent scientific instruments cannot be calibrated to produce the same results unless someone who knows how to calibrate the first instrument physically travels to the second one.[37] Few doubt that regularities exist in nature, but the problem comes when these regularities are seen as "laws" that can be abstracted from embodied contexts and expressed as the transmigrating forms of scientific inscriptions. As Evelyn Fox Keller wittily puts it, every scientist knows what hard work it is to get nature to obey the laws of nature. Does nature count as the abstracted form or the embodied materiality, which is always more complex than the form allows?

Whereas the realist assumes that information is structured so that it flows

from the material through the operational to the symbolic, the constructivist often assumes that it flows from the symbolic (Enlightenment ideas about clarity of vision as an enactment of rationality) through the operational (Bentham's plans for a model prison) to the material (the construction of the Panopticon). Notice that the two positions are symmetrical, each tracing the flow in the opposite direction from the other. To break open the hegemony of scientific realism, no doubt it was helpful to take the strong counterposition that "truth effects" are produced by social processes rather than by experimental apparatus. But such strategies are limited in their options by the very assumptions they resist. Defining himself by what he revolts against, the revolutionary ends up looking like his opponent reflected in a mirror.

Work in the cultural and social studies of science has been marked by various strategies to escape the limitations imposed by these symmetry relationships. For example, the Latour of *We Have Never Been Modern* (1993) differs significantly, it seems to me, from the Latour of *Science in Action* (1987), for in the later work Latour, acknowledging the limitations of earlier constructivist arguments, insists that the objects of scientific research are at once discursively constructed, socially produced, *and* materially real, a position he articulates even more forcefully in voicing concern about how radical constructivist positions can be appropriated for such reactionary purposes as denying the Holocaust.[38] I want to put Sims's virtual creatures into conversation with these ongoing debates, for I think these creatures have something important to contribute. They suggest other ways to skew the symmetry relations of the materialist/discursive divide and to rethink the transmigrations of forms through inscriptions that have the effect of leaving embodied reality behind.

Digital Creatures and Hybrid Subjectivity: From Form to Process

Unlike the forms that experiments in the natural world abstract from embodied materiality, often with great effort and ingenuity, the forms underlying the virtual creatures are easily accessible and open to view. At the bottom of the hierarchy are the ones and zeros of binary code. Some see the emergence of complexity out of these simple elements as confirming the computational nature of reality, as we saw in chapter 1. Whereas scientific analysis leaves behind the complexity of the real world—which is to say, the messiness of embodied materiality—in the (necessary and useful) analytical division of an environment into discrete components and in the abstraction of form out of these components, complexity is precisely what is produced by the recursively structured adaptive systems of artificial life.[39] Although this complexity is generated from simple elements, it is not reducible to their combined properties, nor it is predictable from them, for it emerges dynamically from their interactions—which implies that if you have only the inscription of abstractions understood as forms that transmigrate *through* media but that are not affected *by* media, then the most interesting part of reality may have slipped through your fingers. Focusing on the complexity of intermediating processes helps to remind us what is left out of account when embodied materiality is reduced to inscription.

In the case of virtual creatures, it is difficult or impossible to think of forms transmigrating from embodied materiality to the electronic inscriptions we see on the CRT screen, for the complex structure of the Oreo necessarily complicates that picture. The complexity the creatures display is not inherent in the binary code; rather, it is *produced* as the program runs. "But you have forgotten," the realist objects, "that the creatures are simulations. As such, they occupy a different ontological niche than an inscription emerging from an embodied materiality that is the object of an experiment. It is no wonder that forms do not transmigrate, for the images do not represent preexisting reality." To this objection, I would respond that the simulations, although they do not represent a preexisting reality, nevertheless are themselves real, in the sense that they exist as objects in the world. Moreover, the evolutionary processes by which they are generated are no less real than the evolutionary processes that produced us as viewers, as Harold Morowitz's cosmic view of emergence demonstrates.[40] In Latour's terminology, they are quasi objects, hybrid entities produced through nature/culture.[41] They differ from the inscriptions of a biological laboratory not in being purely "artificial" in contrast to the "natural" organisms of the laboratory, but in the processes that produce them. When we see them, they are images on a CRT screen. Beneath that, they are functions in a LISP program, on down through the coding levels to the bottom layer where the voltages are being fashioned into bit streams. Their "bodies" have a material instantiation, but this instantiation differs radically from the inferences we make when we "see" them as creatures moving in three-dimensional space. To bridge the gap between our narrative inscription of the creatures and the materio-semiotic apparatus producing them, I find it useful to think of them as processes rather than as bodies. As emphasized in chapter 2 in the discussion of code running in the machine, the creatures' bodies are literally processes—electron beams scanning across the screen, code being compiled or interpreted in the computer—and their morphological and neurological properties are the result of generations of processes congealed and expressed in what we "see" as their bodies.

And how do we "see" the creatures, or anything else for that matter? Also through processes that bring the world into existence for us. As Brian Massumi argues elegantly in "The Brightness Confound," there is a sense in which the world is not a collection of preexisting objects but a continuing stream of processes. Although we customarily assume that the world preexists the processes, from a perceptual point of view the processes come first, and the objects we take as the world emerge from them. It is precisely this flux, this ongoingness of process from which the world emerges, that the realist in effect erases by privileging the underlying forms as the essential reality. Hence the significance of the virtual creatures, for they make this move impossible. There are no forms underlying them that are adequate to account for their emergence, no mechanisms that can be seen as allowing preexisting forms to transmigrate out of embodied materiality to become the complex inscriptions we see. When I suggest that we are virtual creatures, I mean to foreground the importance of processes for us as well. Processes connect the embodied materiality of the creatures with the bodies we see; processes connect our visual/cognitive perceptions of them with the narratives we construct; and processes are reinscribed and reinterpreted as narrative representations when we make the creatures characters in stories of defeat and victory, evolution and development. In distributed cognitive environments like those created when humans and nonhuman actors collaborate to create and understand the virtual creatures, embodied materialities interacting through complex processes disrupt the story of transmigrating forms and instead stimulate narrative inventions that foreground emergence and flux, perception and process.

The shift, then, is not merely from analog to digital subjectivity, both of which could be described as realist entities. Rather, the more profound change is from form to process, from preexisting bodies to embodied materialities that are linked to one another by complex combinations of processes based both in analog resemblances and coding relationships. When we inscribe ourselves as actors in these distributed cognitive environments, we become neither the interiorized analog subject of print culture nor the binary code of the digital subject; rather, we become a hybrid entity whose distinctive properties emerge through our interactions with other cognizers within the environment. These cognizers include the congealed processes embodied in such mundane objects as the chair I am sitting on, the keyboards I tap, and the yellow legal pad on which I scribble notes as I peer at the screen. Print culture and print subjectivity do not disappear but mutate, as distributed cognitive environments stimulate new kinds of narratives, including this one on the page you are reading.

The hybrid subjectivity emerging from distributed cognitive environments is playfully enacted in Jim Campbell's art installation "I Have Never Read the Bible." To make the installation, Campbell recorded his voice articulating the twenty-six letters of the alphabet while Mozart's *Requiem* played in the background. He then scanned an English translation of the Bible and converted it to binary code. A computer program was used to associate the sound of his voice articulating a letter with the corresponding mark, now residing in the computer as a coding string. After these coding arrangements were complete, another program was used, in conjunction with a synthesizer, to reproduce the articulated letters in the order in which they appear in the Bible. The result is a "reading" of the Bible letter by letter, from beginning to end, a process that the installation takes thirty-seven days to complete, running twenty-four hours a day. Meanwhile, the background music that in the original recording was a coherent performance of the *Requiem* has also been scrambled, with a bit of music playing only as long as it takes to articulate each letter. This musical soup serves as an audible reminder that we should not mistake the analog reproduction of sound for the coherent original, for the frothy digital middle of the Oreo has intervened and left tangible evidence of its process of fragmentation and recombination.

In the installation, the voice and scrambled music issue from a nineteenth-century edition of *Webster's Dictionary.* Heavy with materiality, the dictionary testifies to the anarchic status of the book as it hangs on the wall, whispering to the viewer "I-N-T-H-E-B-E-G-I-N-N-I-N-G-W-A-S-T-H-E-W-O-R-D. . . ." Performing the "voiced" text of analog subjectivity, the installation simultaneously hybridizes this subjectivity by embedding it in a new context. Visibly testifying to this new context is the cable running out of the dictionary to an electronic (and presumably digital) device below. The choice of the dictionary as the "voiced" text foregrounds the issue of meaning, for the dictionary's function is to define words, to match one signifier with other signifiers in correspondences that clarify meaning. In Campbell's installation, however, the signifier is not the flat mark of print culture. As if testifying to this change, the *Webster's Dictionary* that hangs on the wall cannot be opened, for it has been hollowed out to conceal the electronic gear within. Rather, the signifier has become a complex chain of digital codes and analog resemblances with rich internal structures articulated together through a series of dynamic processes in a configuration that I have called the flickering signifier.[42]

Meaning emerges not through correspondences between the flat marks but through the interactions of human and nonhuman cognizers distributed throughout the environment. The hybridity of the situation is highlighted in the installation's title. The point, after all, is that "*I* Have Never Read the Bible," that is, the artist as a singular subject has not read it. Rather, "reading" here is a distributed activity taking place partly in the articulations of the artist, partly in the "voiced" text, partly in the Oreo structures of the scanner, computer, and synthesizer, and partly in the perceptions of the viewer who not only makes words out of the voiced letters but also makes meaning out of her interpolation into this distributed cognitive environment.

What kind of subject am I as I stand musing before this installation? I certainly am not the autonomous liberal self that located identity in consciousness and rooted it in my ability, first and foremost, to possess my own body. Rather, as I think about my connection to virtual creatures, I am tempted to fashion myself in their image, seeing myself as a distributed cognitive system composed of multiple agents that are running the programs from which consciousness emerges, even though consciousness remains blissfully unaware of them. I am one kind of material embodiment; the virtual creatures are another; and we are connected through intermediations that weave us together in a web of jointly articulated cognitive activities. I think, therefore I connect with all the other cognizers in my environment, human and nonhuman, including both the dynamic processes that are running right now as you decode these letters and all the dynamic processes that have run in the past and congealed to create this paper, this ink, this old language made of nouns and verbs that I am trying to fashion to new purposes that will allow you to see my body, your body, the bodies of the virtual creatures, not as nouns that enact verbs, but as dynamic intermediations that weave together the embodied materialities of diverse life forms to create richly complex distributed cognitions. That is what virtual creatures can teach us.