Foreword

MACHINIC BODIES, GHOSTS, AND PARASELVES: CONFRONTING THE SINGULARITY WITH BRIAN ROTMAN

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The specter of a postbiological and posthuman future has haunted cultural studies of technoscience and other disciplines for more than a decade. Concern (and in some quarters enthusiasm) that contemporary technoscience is on a path leading beyond simple human biological improvements and prosthetic enhancements to a complete human makeover has been sustained by the exponential growth in power and capability of computer technology since the early 1990s. Also driving interest in such futuristic scenarios has been the increasing centrality of computational media to nearly every aspect of science, technology, medicine, and the arts, combined with the digital communications revolution of the mid-1990s spawning both the Internet and the rapid proliferation of mobile computer-based communications that have already produced significant changes in the organization and production of knowledge as well as in the functioning of the global economy. The deeper fear is that somehow digital code and computer-mediated communications are getting under our skin, and in the process we are being transformed.

While limitations to silicon-based computing might have temporarily deflated some of the more exotic predictions of futurists such as Ray Kurzweil or Hans Moravec, current developments connected with nanotechnology, quantum computing, biotechnology, and the cognitive neurosciences provide ample resources for sustaining and even encouraging their posthuman imaginary. More than $4 billion in government investments worldwide in nanotechnology research and development by 2006 has produced some promising results: carbon nanotube wires have been developed

for ultra miniaturized electronics components; the first building blocks of a controllable computation in biological substrates at nanoscale have been achieved. In the next phase of the nanotech initiative, Mihail Roco, the senior advisor to the U.S. National Science Foundation and chief architect of the National Nanotechnology Initiative, predicts the development of active nanostructures that change their size, shape, conductivity, and other properties during use, enabling the production of electronic components such as transistors and amplifiers with adaptive functions reduced to single, complex molecules. By 2010 Roco predicts that researchers will cultivate expertise with systems of nanostructures, directing large numbers of intricate components to specified ends, including the guided self-assembly of nanoelectronic components into three-dimensional circuits and whole devices. Medicine could employ such systems to improve the tissue compatibility of implants, or to create scaffolds for tissue regeneration, or perhaps even to build artificial organs (Roco 2006, 39). In the fourth stage of the current nanotechnology initiative, after 2015–20, the field will expand to include molecular nanosystems: heterogeneous networks in which molecules and supramolecular structures serve as distinct devices. Among the products of this phase of development Roco predicts new types of interfaces linking people directly to electronics. When considered in light of current research successes in the development of brain–machine interfaces,[1] the sorts of scenarios envisaged by Kurzweil in recent texts such as *The Singularity is Near: When Humans Transcend Biology*, in which he charts the conditions for the merger of computer-based intelligence and human biology to occur around 2045, begin to sound eminently plausible (Kurzweil 2005, 138). While he does not endorse Kurzweil's notions of a futuristic singularity, Rodney Brooks sees a similar merger of (nanoscale) robotic technology with biotechnology on our horizon:

> We are on a path to changing our genome in profound ways. Not simple improvements toward ideal humans as is often feared. In reality, we will have the power to manipulate our own bodies in the way we currently manipulate the design of machines. We will have the keys to our own existence. There is no need to worry about mere robots taking over from us. We will be taking over from ourselves with manipulatable body plans and capabilities easily able to match that of any robot (2002, 236).

Brooks's admonition that we are machines on a continuous path of coevolution with other machines prompts reflection on what we mean by

"posthuman." If we are crossing to a new era of the posthuman, how have we gotten here? And how should we understand the process? What sorts of "selves" are imagined by Brooks and others as emerging out of this postbiological "human"?

Cultural theorists have addressed the topic of the posthuman singularity and how, if at all, humanity will cross that divide. Most scholars have focused on the rhetorical and discursive practices, the metaphors and narratives, the intermediation of scientific texts, science fiction, electronic texts, film, and other elements of the discursive field enabling the posthuman imaginary. While recognizing that posthumans, cyborgs, and other tropes are technological objects as well as discursive formations, the focus has been directed less toward analyzing the material systems and processes of the technologies and more toward the narratives and ideological discourses that empower them. We speak about machines and discourses "co-constituting" one another, but in practice, we tend to favor discursive formations as preceding, and to a certain extent breathing life into, our machines. The most far-reaching and sustained analysis of the problems has been offered by N. Katherine Hayles in *How We Became Posthuman* and her more recent book, *My Mother Was a Computer*. Hayles considers it possible that machines and humans may someday interpenetrate. But she rejects as highly problematic, and in any case not yet proven, that the universe is fundamentally digital, the notion that a Universal Computer generates reality, a claim that is important to the positions staked out by proponents of the posthuman singularity such as Harold Morowitz, Kurzweil, Stephen Wolfram, and Moravec. For the time being, Hayles argues, human consciousness and perception are essentially analog, and indeed, she argues, currently even the world of digital computation is sandwiched between analog inputs and outputs for human interpreters (Hayles 1999; 2005, especially 206–13). How we will become posthuman, Hayles argues, will be through interoperational feedback loops between our current mixed analog–digital reality and widening areas of digital processing. Metaphors, narratives, and other interpretive linguistic modes we use for human sense making of the world around us do the work of conditioning us to behave as if we and the world were digital. Language and ideological productions thus serve as kinds of virus vectors preparing the ground for the gradual shift in ontology. In the case of Wolfram and others, Hayles argues, the appropriation of computation as a cultural metaphor assumed to be physically true constitutes a framework in which new problems are constructed and judgments made. "On the global level, our narratives

about 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" (2005, 204). The narratives of the computational universe serve then as both means and metaphor. In our current analog/digital situation Hayles proposes an analytical strategy she calls intermediation to analyze the new processual human/machine texts of the posthuman era.

> As an embodied art form literature registers the impact of information in its materiality in the ways in which its physical characteristics are mobilized as resources to create meaning. This entanglement of bodies of texts and digital subjects is one manifestation of what I call intermediation, that is, complex transactions between bodies and texts as well as between different forms of media. Because making, storing, and transmitting imply technological functions, this mode of categorization insures that the different versions of the posthuman will be understood, in Kittlerian fashion, as effects of media. At the same time in my analysis of literary texts and especially in my focus on subjectivity, I also insist that media effects, to have meaning and significance, must be located within an embodied human world (2005, 7).

From the media-theoretic perspective Hayles adopts in *My Mother Was a Computer*—a perspective she refers to as Kittlerian—subjects are the effects of media. In order to make effective use of Hayles's theory of intermediation we need to understand how the complex transactions between bodies and our inscription practices might take place and how to understand the "entanglement" she describes of media with the formation of human subjects.

How can we think beyond the notion of virtual creatures as rhetorical devices and explore instead how the embodied human subject is being shaped by a technoscientific world? Can we get at the embodied levels of the interactive feedback loops Hayles describes to examine the metabolic pathways and emerging neural architectures through which these technologies are getting under our skin? Brian Rotman's latest book, *Becoming Beside Ourselves*, offers a solution to this problem in a profound and elegant analysis deriving from material semiotics. Rotman circumvents the issue of an apocalyptic end of the human and our replacement by a new form of *Robo Sapiens*. Instead he draws upon the work of anthropologists, philosophers, language theorists, and more recently cognitive scientists

shaping the results of their researches into a powerful new argument for the co-evolution of humans and technics, specifically the technics of language and the material media of inscription practices. The general thrust of this line of thinking may best be captured in Andy Clark's phrase, "We have always been cyborgs" (2003). From the first "human singularity" to our present incarnation, human being has been shaped through a complicated co-evolutionary entanglement with language, technics, and communicational media. Drawing upon empirical findings from recent cognitive neuroscience, studies of sign language, gesture, and the impact of new imaging and computational sciences on contemporary habits of thinking, Rotman teases out the significance of Clark's apt phrase in a powerful framework of material semiotics. The materiality of media rather than their content is what matters. Communicational media are machines operating at the heart of subject formation. Like Gilles Deleuze and Félix Guattari, Rotman views machinic operations at the basis of consciousness and mind as an emergent phenomenon; and while unlike Wolfram (2002) and Edward Fredkin (2001), he is less certain about embracing cellular automata as the fundamental ontology of the universe, Rotman sketches out a position sympathetic toward Deleuze's and Guattari's notions of the human body being understood as an assemblage of mutating machines—a Body without Organs—rather than as a teleologically orchestrated organism with consciousness as the core of coherent subjectivity. Consistent with the flattening of differences between biological and inorganic machines central to contemporary nanotechnology and cognitive neuroscience, Deleuze and Guattari argued that, as bodies without organs, human assemblages are capable of absorbing a variety of entities, including other machines and organic matter. In Rotman's elaboration of this perspective, media machines are not just prosthetic extensions of the body, they are evolving assemblages capable of being absorbed into the body and reconfiguring the subject. Every medium, whether it be speech, alphabetic writing, or digital code, and each media ecology, such as the configuration of gramophone, film, and typewriter discussed by Friedrich Kittler (1992, 1999), projects a virtual user specific to it. This projected virtual user is a ghost effect: an abstract agency distinct from any particular embodied user, a variable capable of accommodating any particular user within the medium.

Materialist semiotics of the sort Rotman proposes in concert with recent work in cognitive neuroscience, studies of gesture and language from psychology and evolutionary ethology, and a variety of recent de-

velopments in the computational sciences may point the way.[2] The path Rotman pursues in addressing the questions of the subject, embodiment, and agency was suggestively if inadequately marked out by Deleuze and Guattari in their emphasis on the human as machinic assemblage and in Guattari's suggestive notion that techno-machines operate invisibly at the core of human subjectification, particularly what Guattari referred to as "a-signifying semiological dimensions (of subjectification) that trigger informational sign machines, and that function in parallel or independently of the fact that they produce and convey significations and denotations, and thus escape from strictly linguistic axiomatics" (1995, 4). For media philosophers the question is whether Deleuze's and Guattari's cryptic and sketchily developed theses about "a-signifying semiological dimensions" of subjectification can be put on a solid foundation of what might be called "corporeal axiomatics" in contrast to Guattari's reference to "linguistic axiomatics."

Several key ideas from Rotman's earlier books, *Signifying Nothing: The Semiotics of Zero*, and *Ad Infinitum . . . The Ghost in Turing's Machine: Taking God out of Mathematics and Putting the Body Back In. An Essay in Corporeal Semiotics*, help us appreciate the power of the new work, which in many ways forms a trilogy extending and completing the critical framework offered in those earlier projects. In order to appreciate Rotman's newest contribution, I find it important to have in mind his theses about the role of signifying systems in the constitution of subject positions and agency, powerful ideas that form the core of those two earlier books. The new work has enriched these frameworks from semiotics with consideration of the importance of "bottom-up" architectures and distributed modes of agency/subjectivity deriving from Rotman's considerations of recent work in the computational sciences, distributed cognition, and cognitive neuroscience.

In *Signifying Nothing*, *Ad Infinitum . . .* , and several related essays, Rotman engages in a deeply critical dialogue with recent work in the philosophy of mathematics, language, and philosophy of mind. He has crafted a semiotic approach to mathematics which builds on some suggestive fragments of Charles Sanders Peirce in discussing the relation of signs (in Rotman's case, mathematical signs), interpreting subjects, writing, and agency. He folds all this brilliantly with the work of Foucault and Derrida in fashioning an original semiotic approach to the principal questions of postmodern philosophy by examining as isomorphic signifying moves the near-simultaneous introduction into Western culture of zero in mathe-

matics, the vanishing point in painting, and imaginary money in economic exchange. Rotman shows that in the shifts from Roman to Hindu numerals, from iconic to perspectival art, and from gold money to imaginary bank money a common meta-sign indicating the absence of other signs emerges from what Rotman calls a new set of semiotic capacities—public, culturally constituted, historically identifiable forms of utterance and reception which *codes* make available to individuals. This new meta-sign requires the formulation of a new sign-using agency, a secondary subjectivity, in order to be recognized: in mathematics the invention of algebra by Viète; in painting the self-conscious image created by Vermeer and Velázquez; in the text, the invention of the autobiographical written self by Montaigne; in economics, the creation of paper money by gold merchants in London.

Rotman followed the astonishing *Signifying Nothing* with the equally brilliant *Ad Infinitum*. . . . Not for the fainthearted, the book pursues one of the defining ideologies of Western mathematics: namely, its characterization as pure and abstract disembodied reason. In many ways, this book can be read as the analog in the philosophy of mathematics and science studies to Derrida's attack in *Of Grammatology* on logocentrism and real presence as central to Western metaphysics. Building on the semiotic model he had developed in *Signifying Nothing* and an earlier article, "Toward a Semiotics of Mathematics," Rotman examines nineteenth- and early twentieth-century developments in semiotics, particularly the semiotics of Peirce and Saussure. He uses this framework to analyze the development of Hilbert's abstract mathematics and the problems relating to infinity in mathematical reasoning that were central to the creation of modern mathematical set theory by Frege, Gödel, Hilbert, and others. Similar to the argument in *Signifying Nothing*, Rotman shows that operations with mathematical signs, and particularly functions such as counting, differentiating, etc., cannot be undertaken without an implicit but never-acknowledged "mathematical agent"—the one who counts. This move, to acknowledge reason as always embodied, leads to a consideration of Turing's and Church's work on computability, which also depended heavily on assumptions drawn from the mathematics of infinite sets. For Rotman, "information" is not somehow immaterial, but deeply physical, so that computers no more than mathematicians can disregard the embodied character of reasoning.

Rotman's work on semiotics, embodied reason, and agency in these earlier texts provides a basic set of concepts and strategies for his analysis

of gesture and the machinic body in *Becoming Beside Ourselves*. The revolutions in the computational sciences, the rise of cognitive science, and the explosive developments in recent neuroscience, particularly work on distributed cognition, the embodied mind, and emergence that have taken off since the 1990s, provide empirical sources for Rotman's discussion of ghostly subjects and machinic bodies. This incorporation of results and implications of empirical science is what really distinguishes Rotman's *Becoming Beside Ourselves* and allows him to elevate the discussion to an exciting new plane. Drawing upon a framework he originally set out in the 1988 essay, "Toward a Semiotics of Mathematics," Rotman elaborates in chapter 3, "Technologized Mathematics," one of his key theses about the ways in which computational devices anastomose with and reshape the human. In the intervening years since Rotman wrote *Signifying Nothing* and *Ad Infinitum* . . . , a revolution in the computational sciences took place, particularly through the developments of parallel computing—not even contemplated as relevant by Turing—and the emergence of techno-scientific fields (by which I mean fields in which the science is inextricably bound to the machines that enable it) of modeling, near to real-time simulation, visualization, and computer-generated virtual environments. Rotman discusses the impact of these developments in transforming conditions of proof in mathematics to a near-experimental discipline. He examines the role of images, diagrams, and other forms of mathematical representation, issues particularly relevant to recent discussions concerning the role of graphic methods, "imaging," and visualization in computational sciences. In this chapter Rotman analyzes in terms of his own distinctive brand of material semiotics the transformation being effected in our experience of bodies and of agency by computer-mediated communication and especially technologies of visualization, emerging virtual reality, and even haptic feedback in new digital systems for motion capture. He argues that these forms of representation are not just supplements to a linear, alphabetic text that carries the "real" meaning of an utterance, but constitute languages all their own.

Rotman's theory of signification aims at showing that each media regime and each system of signification projects a specific configuration of the subject and a horizon of agency as a consequence of its normal operation. Moreover, in Rotman's view these semiotic systems evolve with the media machines that embed them. They are techno-cultural artifacts that co-evolve with their human host-parasites. Conceived in this fashion lan-

guage, media, and possibly the new generations of intelligent machines we imagine just over the horizon might be considered companion species dependent on, but also powerfully shaping, us through a co-evolutionary spiral. Indeed, offered as a replacement for what she regards as her now outdated earlier notion of the cyborg, Donna Haraway advocated a similar line of inquiry in her "Companion Species Manifesto": "Earth's beings are prehensile, opportunistic, ready to yoke unlikely partners into something new, something symbiogenetic," Haraway writes (2003, 32). Co-constitutive companion species and co-evolution are the rule, not the exception.[3]

Is there any foundation for relating this approach to the biological evolution of human cognition to the theory of signification and the notions of media machines discussed by Rotman, Kittler, Hayles, Hansen, and others? Rotman pursues this question deep into the structure of symbolic communication and its embodiment in the neural architecture of evolving human brains. He draws especially upon the works of Terrence Deacon and Merlin Donald on the evolution of language for considering the formative power of media technologies in shaping the human and some of the critical issues in current debates about posthumanity. For Deacon and for Donald what truly distinguishes humans from other anthropoids is the ability to make symbolic reference. This is their version of the Singularity; *Homo symbolicus*, the human singularity. Although language evolution in humans could not have happened without the tightly coupled evolution of physiological, anatomical, and neurological structures supporting speech, the crucial driver of these processes, according to Deacon, was *outside* the brain; namely, human cultural evolution. The first step across the symbolic threshold was most likely taken by an australopithecine with roughly the cognitive capabilities of a modern chimpanzee. Symbolic communication did not spontaneously emerge as a result of steady evolution in size and complexity of hominid brains. Rather, symbolic communication emerged as a solution to a cultural problem. To be sure the evolution of language could not have arisen without a primitive prerequisite level of organization and development of the neurological substrates that support it. But in Deacon's view those biological developments were more directly driven by the social and cultural pressures to regulate reproductive behavior in order to take advantage of hunting-provisioning strategies available to early stone-tool-using hominids. Deacon argues this required the establishment of alliances, promises and obligations linking reproductive pairs

to social (kin) groups of which they were a part. Such relationships could not be handled by systems of animal calls, postures, and display behaviors available to apes and other animals but could only be regulated by symbolic means. A contract of this sort has no location in space, no physical form of any kind. It exists only as an idea shared among those committed to honoring and enforcing it. Without symbols, no matter how crude in their early incarnation, that referred publicly and unambiguously to certain abstract social relationships and their future extensions, including reciprocal obligations and prohibitions, hominids could not have taken advantage of the critical resources available to them as habitual hunters (1997, 401). In short, symbolic culture was a response to a reproductive problem that only symbols could solve: the imperative of representing a social contract. What was at stake here was not the creation of social behavior by the social contract as described by Rousseau, but rather the translation of social behavior into symbolic form.

Once the threshold to symbolic communication had been crossed natural selection shifted in dramatic ways. Deacon bases his model on James Mark Baldwin's original proposals for treating behavioral adaptation and modification as a co-evolutionary force that can affect regular Darwinian selection (Baldwin 1895, 219–23; 1902).[4] Baldwinian evolution treats learning and behavioral flexibility as a force amplifying and biasing natural selection by enabling individuals to modify the context of natural selection that affects their future offspring. Behavioral adaptations tend to precede and condition major biological changes in human evolution because they are more responsive than genetic changes. As Robert Richards points out, this is not a form of Lamarckism, since changes acquired during an organism's own lifetime are not passed on directly to offspring. Rather, Baldwin's model proposes that by adjusting behavior or physiological responses to novel conditions during the lifespan of the organism, an animal could produce irreversible changes in the adaptive context of future generations (Deacon 1997, 322–23).

Deacon uses Baldwinian evolution in a provocative way to address the question of the co-evolution of language and the brain. Though not itself alive and capable of reproduction, language, Deacon argues, should be regarded as an independent life form that colonizes and parasitizes human brains, using them to reproduce (1997, 436).[5] Although this is at best an analogy—the parasitic model being too extreme—it is useful to note that, while the information that constitutes a language is not an organized ani-

mate being, it is nonetheless capable of being an integrated adaptive entity evolving with respect to human hosts. This point becomes more salient when we think of language as a communication system and examine the effects of media, including electronic media, more broadly.

For Deacon, the most important feature of the adaptation of language to its host is that languages are social and cultural entities that have evolved with respect to the forces of selection imposed by human users. Probably the primary selective force on language evolution is the pressure to produce linguistic operations that children can learn quickly and easily. Just like computer interfaces, languages evolve around user-friendliness, and languages that do not adapt to their user-niche disappear. In this Baldwinian co-evolution of physical and cultural processes, neurological structure and language ability—brain and speech—interact: changes in the newborn's brain, manifest in its cognitive abilities, exert a selective pressure on which features of language are learnable and which are not; this in turn feeds back, influencing the brain to change in certain ways, which further impacts the grammatical structures and semantic possibilities of spoken language available to the infant. And so it goes. The outcome, over thousands of generations, is the emergence of human language in which symbolic reference emerges from and is distributed among a web of evolutionarily older forms of reference. While apes, chimpanzees, and other animals are able to operate with symbols in certain carefully constructed contexts, everyday human cognition demands the construction of novel symbolic relationships. A considerable amount of normal, everyday problem solving involves symbolic analysis or efforts to figure out some obscure symbolic association. Deacon argues that the greater computational demands of symbol use launched selection pressure on increased prefrontalization, more efficient articulatory and auditory capacities, and a suite of ancillary capacities and predispositions which eased the new tools of communication and thought. Each assimilated change added to the selection pressures that led to the restructuring of hominid brains.

> More than any other group of species, hominids' behavioral adaptations have determined the course of their physical evolution, rather than vice versa. Stone and symbolic tools, which were initially acquired with the aid of flexible ape-learning abilities, ultimately turned the tables on their users and forced them to adapt to a new niche opened by these technologies. Rather than being just useful tricks, these behavioral prostheses for obtaining food and organizing social behaviors be-

> came indispensable elements in a new adaptive complex. The origin of "humanness" can be defined as that point in our evolution where these tools became the principal source of selection on our bodies and brains. It is the diagnostic trait of *Homo symbolicus* (Deacon 1997, 345).[6]

In Deacon's theory evolutionary selection on the prefrontal cortex was crucial in bringing about the construction of the distributed mnemonic architecture that supports learning and analysis of higher-order associative relationships constitutive of symbolic reference. The marked increase in brain size over apes and the beginnings of a stone tool record are the fossil remnant effects of the beginnings of symbol use. Stone tools and symbols were the architects of the *Australopithecus-Homo* transition and not its consequences.

Symbolic reference is not only the source of human singularity. It is also the source of subject formation in all its varied manifestations. Directly relevant to Rotman's discussion of modern subject formation in distributed computer networks is the hierarchical structure of reference central to Deacon's and Donald's work. Like Rotman, Deacon bases his theory of reference on Peirce's semiotics. Peirce made the distinction between iconic, indexical, and symbolic forms of reference; where icons are mediated by similarity between sign and object, indices are mediated by some physical or temporal connection between sign and object, and symbols are composed of relations between indices and mediated by formal or conventional links rather than by more direct neurological connection between sign and object.

For both Rotman and Deacon symbolic reference is virtual, unreal, and tarries with the ghostly. Symbolic reference rests on the powerful combinatorial, associative logics of forming relationships between signs, and its mnemonic supports need only be cashed in and reconstructed in terms of their lower level indexical and iconic supports when needed. Symbolic reference is so powerful because it allows us to ignore most of the vast web of word-object, word-word, and object-object indexical associations and make rapid calculations using the mnemonic shortcut of symbol-symbol relationships instead. It is this virtual character of symbolic reference that is the source of its power and of its interest for our concerns with subject formation. The ignored indexical relationships are still the implicit grounding of word reference, but these interpretive steps can be put off until it can be determined exactly which are relevant and which are not. For Deacon symbols are neurological tokens. Like buoys indicating

an otherwise invisible best course, they mark a specific associative path, by following which we reconstruct the implicit symbolic reference. The symbolic reference emerges from a pattern of virtual links between such tokens, which constitute a sort of parallel realm of associations to those that link these tokens to real sensorimotor experiences and possibilities. Thus it does not make sense to think of the symbols as located anywhere within the brain, because they are relationships between tokens, not the tokens themselves; and even though specific neural connections may underlie these relationships, the symbolic function is not even constituted by a specific association but by the virtual set of associations that are partially sampled in any one instance. Widely distributed neural systems must contribute in a coordinated fashion to create and interpret symbolic relationships. It is this virtual aspect of symbolic reference that leads to some interesting possibilities and peculiarities of subject formation. As Lao Tsu wrote, "Thirty spokes share the wheel's hub, but it is the hole in the center that provides its usefulness" (*Tao Te Ching*, quoted in Deacon 1997, 433).

All of this has important consequences for consciousness and subject formation. Three points are especially relevant to Rotman's discussion. The power of symbolic reference is due to its *virtual* character; its *shared* deployment; and its exteriority, the fact that it is largely *external* to the individual mind, being located in cultural systems and artifacts. From an evolutionary perspective, consciousness is always consciousness *of* something, and hence involves some form of representation. Animal minds, even of minimal complexity, construct and process internally generated indices with respect to an external world to which they are partially adapted. All nervous systems irrespective of their size and complexity support iconic and indexical representational processes. These are the basic ingredients of adaptation. Human brains share a design logic with other vertebrate brains, and so we share those aspects of consciousness that are mediated by iconic and indexical representations that those other species experience.

But minds capable of symbolic representation operate on a radically different playing field. Symbolic representation is not just a further complex addition to the capabilities of animal brains. Rather it has completely made over the human brain to aid language processing. As a result humans, capable of symbolic reference, are able to form an independent mental representation of another. Being confined to indexical representations animal brains can represent associations between stimuli, including the behaviors of others, and these relationships can be complex extending

to a familiarity with the predispositions of others. But the step of forming an independent mental representation of the subjective experience of another requires an abstraction only possible with symbolic reference. Indeed, our ability to inhabit the different personas constructed by writers is only made possible by the structure of symbolic representation. Symbolic representation maintains reference irrespective of indexical attachment to any particular experiences, so that when a narrative of someone's experience is reconstructed by another, it can be regrounded in terms of the reader's or listener's own experience by interpreting it in terms of the iconic and indexical representations that constitute the listener's memory. Symbolic reference is interpreter-independent; it strips away any necessary link to the personal experiences and musings that ultimately support it. Although all readers of a novel share a common symbolic understanding of the events narrated, each individual's experience in response to them is distinct.

Unlike the interpretation of icons and indices (a process uniquely personal and insular within each brain), symbolic representations are in part externally interpreted. They are shared. Symbolic reference is at once a function of the whole web of referential relationships and of the whole network of users extended in space and time. It is as though the symbolic power of words is only on loan to its users. If symbols ultimately derive their representational power, not from the individual, but from a particular society at a particular time, then a person's symbolic experience of consciousness is to some extent society-dependent—it is borrowed. Its origin is not within the head.

> Consciousness of self in this way implicitly includes consciousness of other selves, and other consciousnesses can only be represented through the virtual reference created by symbols. The self that is the source of one's experience and intentionality, the self that is judged by itself as well as by others for its moral choices, the self that worries about its impending departure from the world, this self is a symbolic self. It is a final irony that it is the virtual not actual reference that symbols provide, which gives rise to this experience of self. This most undeniably real experience is a virtual reality (Deacon 1997, 452).

The theories of cognitive evolution upon which Rotman draws all point to the extraordinary flexibility of the neurological architecture of human cognition. Humans as a species have plastic, highly conscious ner-

vous systems, the capacities of which allow us to adapt to intricate challenges of a changing cognitive environment. Rather than being rigidly hard-wired to structures inside the brain, symbolic communication created a mode of extrabiological inheritance with a powerful and complex character, and with an autonomous life of its own. The individual mind is a hybrid product, partly biological and partly ecological in origin, shaped by a distributed external network the properties of which are constantly changing.

The work we have discussed by evolutionary biologists and cognitive neuroscientists has dealt primarily with the origins of language, particularly with speech and to a limited extent with writing. This work has emphasized that the leap to the symbolizing mind did not depend on a built-in hard-wired tendency to symbolize reality. The direction of flow was *from* culture to the individual mind, from *outside-to-inside*.[7] Rotman is interested in expanding this analysis to include media other than speech and writing, especially technologically mediated and computer-based forms of communication. He locates rich suggestions for the path to pursue in the work of Deleuze and Guattari.

It is in chapter 2 on gesture that Rotman's "Deleuzian turn" takes flight most dramatically. A number of "new humanists" are interested in drawing upon work in the natural sciences, particularly recent work in cognitive science and fields such as functional MRI, to shed new light on traditional humanistic questions, such as the role of emotion and affect in processes of reasoning, previously treated as the territory of abstract, disembodied mind. Other areas in which the findings of empirical science are impinging on recent work in the humanities are analyses of neuroaesthetic bases for artists' construction and viewers' appreciation of images and analysis of the role of narrative and metaphor in normal reasoning processes. But Rotman's use of these recent scientific fields is the most impressive—in fact, the only—attempt with which I am familiar of an analysis aimed at resolving key issues in postmodern philosophy. In chapter 3 on computing and mathematics and in chapter 1 on the "Alphabetic Body" Rotman draws on the work of recent cognitive neuroscience to advance his "Deleuzian" theses on the machinic body as an assemblage of relatively independent and autonomous units. For instance, recent work in the neurosciences supports a reevaluation of the human innate sense of number. Rather than being associated with a singular "faculty," particular organ, or region of the brain, counting, according to the cognitive neuroscientist Stanislas

Dehaene, is not even an evolved skill, but a capacity assembled from different and independent brain activities each on their own having nothing to do with number.

What Rotman offers in *Becoming Beside Ourselves* is an extension and revitalization of Derrida's grammatological project, updating it for the computationally intensive environments that increasingly constitute us as posthuman. In his critique of Western metaphysics Derrida pointed to the logic of the supplement as a way of deconstructing the power of logocentrism. Whereas speech is normally treated as primary, the site of presence to oneself, and writing is treated as secondary, a supplement that comes after speech as a technique for notating it, Derrida argued that writing comes *before* speech. Writing, Derrida argued, is really a form of graphism, a general mode of signifying operating in all cultural production. Writing and speech are both dependent on this higher form of writing, what Derrida called arche writing, a writing before the letter.

But Derrida did not successfully extend this provocative analysis to other signifying systems such as images. As Rotman points out, Derrida's commentary on Husserl's *The Origins of Geometry*, for instance, never mentions the complete absence of diagrams or reference to them throughout the text. While critiquing the Western metaphysical system, Derrida's deconstruction remained bound to the world of print it called into question. Rotman's project on corporeal writing introduces the exploration of graphism in the wider sense as a synthesis of semiotics, computation, and experimental science.

Rotman's brilliant treatment of gesture, speech, and their relations to other signifying systems moves consideration of the posthuman subject onto a new page of clarity and rigor. Some of the resources Rotman draws upon are neurological studies that argue for a form of internal touching, a virtual auto-hapticity that appears to be the condition for self-consciousness. He draws on empirical investigations of verbal narration in cognitive psychology that demonstrate that gesticulation—previously believed to be an unnecessary supplement to speech and thought—is a deep component of utterance, having to do with the semantics, pragmatics, and discursive aspects of speech. These studies call into question the causal or conceptual priority of speech by demonstrating a tight temporal binding, accurate to fractions of a second, discovered to operate between gesticulation and speech. Drawing on these sorts of empirical studies, Rotman argues that thinking that eventuates in speech has its origins

in pre-verbal visuo-kinetic images which then become gesticulated and verbalized to form utterance. Spoken thought starts as a yet-to-be realized gesture. Thought, including abstract thought such as mathematical reasoning, rests on metaphors and diagrams derived from repeated and deeply layered patterns of body movement. Moreover, he draws upon other work on phonetics and speech synthesis which demonstrates that it is precisely as a gestural system that speech is best apprehended and perceived by a listener. Drawing on the work of the evolutionary neurobiologist Terrence Deacon once again, Rotman argues that auditory processing of speech sounds does not appear to be based on extracting basic acoustic parameters of the signal before mapping them onto speech sounds. Speech sounds appear designed instead to predict which oral-vocal movements produced them and ignore the rest. We listen, Rotman concludes, not to speech sounds as such but to what they signal about the movements of the body causing them. We listen to speech as symptoms of gestures.

In two very engaging chapters, "The Alphabetic Body" referred to above and "Gesture and Non-Alphabetic Writing," which introduces the notion of the body without organs of speech, Rotman explores recent work on American Sign and argues for gesture and other non-alphabetic systems of expression as languages in their own right. In these chapters, Rotman points to the importance of the materiality of media in "wiring" thought, and in the chapter on alphabetism, even draws upon work from ethology and neurobiology to bolster his claim that in the historical process of establishing non-pictorial alphabetism as the basis for thought, the alphabet disrupted "the integrated complementarity of upper and lower, tongue and larynx, articulation and breath, consonant and vowel; it effects a pulling apart and deactivating of the circuits between neocortex and the midbrain." (Rotman 2002, 97) The powerful result of this disjunction, he argues, was the hierarchical subordination of the midbrain to the neocortex, and attendant to that the cutting loose of words from voice. Going one step further, Rotman argues that the result of this vertical neurological separation was the institution of a primary dualism of mind over body, the ultimate expression of which is the notion of the pure, disembodied mind, that constant theme threaded through all Rotman's work.

What then about the posthuman? Are we transitioning to some new form of self adapted to our environment of ubiquitous computing technology, and if so, how is this self assembled and transformed by the machinic processes of our technoscientific milieu? Since the rise of *Homo*

sapiens between 100,000 and 200,000 years ago, there has been little change in brain size or, as far as can be determined, in brain structure. A critical contributing factor to the rapid cultural evolution that took off with *H. sapiens* and has continued at an ever-increasing pace since is the development of supplements to individual internal biological memory in the form of visuo-graphic systems and external memory media, especially written records and other forms of symbolic storage (see especially Donald 1991, 308–12). Rather than being limited by our neural architecture, these external material supports have only enhanced the symbolizing power of the mind. In a sense, the recent development of the Internet and distributed forms of electronic communication only further accelerate a process that has defined and shaped human being since that first singularity. From the perspective of the work in evolutionary cognitive science we have discussed, any change in the way information gets processed and represented inevitably constitutes a change in the cognitive economy of the subject, a difference in psychic architecture and ultimately of consciousness itself. Teasing out the implications of this notion, Rotman argues that the medium of alphabetic writing introduced as silent collateral machinic effects an entire neurological apparatus enabling practices, routines, patterns of movement and gestures, and kinematic, dynamic, and perceptual activities as part of the background conditions—in terms of Deleuze and Guattari, the a-signifying dimensions of the medium lying beneath the medium's radar as part of its unconscious—giving rise to the lettered self, a privately enclosed, inward and interiorized mind, structured by the linear protocols and cognitive processing that reading and writing demand.

This mode of psychic organization is giving way to new forms as part of the massive shift in computational media taking place. Of particular importance to our present situation is the influx of parallel computation into what has been almost exclusively a serial computational regime. The parallel/serial duo is nothing new. In fact, as Rotman argues, the dynamic tension between parallel and serial modes of thinking and representation have characterized every media regime. Rotman examines the tandem opposition of serial and parallel forms across many types of activity: music (melody versus harmony), symbolic forms (text versus image), arithmetic (ordinal versus cardinal numbers), film editing (Eisenstein versus intercut montage), electrical circuits (serial versus parallel), and especially serial versus parallel modes of computing. The serial/parallel duo come together and are always in a certain tension with one another. Seriality is exempli-

fied in narratives, routines, algorithms, melodies, timelines; parallelism is exemplified in scenes, episodes, harmonies, contexts, atmospheres, and images. Parallelism foregrounds presence, simultaneity, co-occurrence. Serialism foregrounds linear order and sequence and occurs in counting, listing, lining up, and telling. Serialism privileges a certain mode of cognitive and psychic organization, according to Rotman: namely, the individual mind/brain in which thinking takes place inside the closed, individual thinker. Everything outside the individual symbol-processing brain is assigned to context and plays no substantive role in the thinking process. This model of the mind and of thinking is being challenged and displaced by the researches of contemporary cognitive science, which are demonstrating that what was previously marginalized as context is actually a crucial element in how we think. Not only is thinking always social, culturally situated, and technologically mediated, but individual cognition requires symbiosis with cognitive collectivities and external memory systems to happen in the first place. Parallel computing, Rotman writes, puts into flux the relations between internal self and external other, "since it is a machinic implementation, not of individual linear thinking but of distributed bio-social phenomena, of collective thought processes and enunciations, that cannot be articulated solely on the level of an isolated, individual self. Its effects are to introduce into thought, into the self, into the 'I' that engages its various forms, parallelist behavior, knowledge, and agency that complicate and ultimately dissolve the idea of a monoidal self" (92).

Long characterized by linear processing of code, computing is undergoing a massive shift toward parallelism. In nearly every venue of computing, from high-end processing of massive data sets, such as the human genome, and large-scale imaging projects, such as GIS maps, to routine gaming machines such as the Sony PlayStation 3, computing is being performed by multiple machines working simultaneously in parallel on different parts of the job to be computed, or (as in video-editing workstations, game machines, and even some new laptops) multiple processors in the same machine. In addition the computational affordances of cell phones, pervasive technologies for multi-tasking such as instant messaging, manipulation of multiple avatars of the self in communally inhabited virtual worlds such as *World of Warcraft* and *Second Life*, and engagement with a variety of forms of distributed agency, blends of artificial and human agents in networked circuits—all these contribute, Rotman argues, to

making the parallelist self radically different from the single, serial, alphabeticized psyche it is in the process of displacing.

Both crucial to and symptomatic of this shift to parallelism is the centrality of visualization technology and of the strategic influx of images into all forms of contemporary cognitive work. Everywhere pragmatic images, graphs, charts, tables, figures, maps, simulations, and other forms of visual artifact are permeating our reading and writing practices. These apparently innocuous information-bearing, instructional, explicatory, and otherwise instrumentally oriented images are, from Rotman's perspective, a (welcome) dimension of parallelism, prompting him to cite artist Helen Chadwick's dreamlike meditation, "What if dangerous fluids were to spill out, displacing logic, refuting a coherent narrative, into a landscape on the brink of I?" Nothing better represents this "spillage of the Ego" as a prelude to the emergence of a para-self, Rotman urges, than the prevalence of the post-photographic digital image, and especially the GIS map. The post-photographic image dissolves the classic viewer rooted in Renaissance perspectivalism that privileged a self with a point of view outside the imaged object. An increasingly familiar example of what Rotman is describing occurs in our obsession with GIS maps, such as maps provided by Google Earth, with multiple (currently up to twelve) separate graphic layers overlaying different kinds of information that can be dynamically viewed as a co-present assemblage of images and proactively navigated by the user. GIS maps of this sort enact parallel seeing of images that previously had to be viewed side by side, serially; in the process they reshape the fixity of the viewing subject and promote a dynamic viewing body that bypasses a perspectival mode of viewing. In terms of Rotman's thesis, this dissolution of seriality impinges directly on the subject and the construction of the self, a falling away from a one-dimensional, singular consciousness into parallel, distributed co-presence. Rotman summarizes this transition eloquently:

> Once, not so long ago, there was an absolute opposition of self and other: an 'I,' identical to itself, wholly present as an autonomous, indivisible, interior psyche against an external, amorphous collectivity of third persons outside the skin. Now the I/me-unit is dissolving, the one who says or who writes 'I' is no longer a singular integrated whole, but multiple: a shifting plurality of distributed I-parts, I-roles, I-functions, and I-presences. Now the 'I' bleeds outward into the collective, and the collective introjects, insinuates, and internalizes itself within the me.

> What was privately interior and individual is invaded by the public, the historical, the social. What was the outside world of events enters (and reveals itself as having always entered) the individual soul in the mode of personal destiny (99).

As we spend more time in electronically mediated environments, engaging with massively parallel distributed computing processes that are merging ever more seamlessly with the material processes and technological affordances of our everyday world, we are, in Rotman's terms, becoming, literally evolving, as distributed machinic multiples, para-selves beside our selves.