Flesh and Metal: Reconfiguring the Mindbody in Virtual Environments

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Dualistic thinking is as difficult to avoid as the sticky clay that passes for topsoil where I live in Topanga Canyon. When it gets even a little wet, it attacks my feet so resolutely that I look as if I am wearing snowshoes. I try to avoid it, of course, but inevitably something lures me off the beaten path and there I am again, stomping around with elephant shoes. In similar fashion I struggled to avoid the Cartesian mind-body split in my recent book *How We Became Posthuman* when I made a distinction between the body and embodiment.[1] The body, I suggested, is an abstract concept that is always culturally constructed. Regardless of how it is imagined, "the body" generalizes from a group of samples and in this sense always misses someone's particular body, which necessarily departs in greater or lesser measure from the culturally constructed norm. At the other end of the spectrum lie our experiences of embodiment. While these experiences are also culturally constructed, they are not entirely so, for they emerge from the complex interactions between conscious mind and the physiological structures that are the result of millennia of biological evolution. The body is the human form seen from the outside, from a cultural perspective striving to make representations that can stand in for bodies in general. Embodiment is experienced from the inside, from the feelings, emotions, and sensations that constitute the vibrant living textures of our lives—all the more vi-

1. N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999).

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brant because we are only occasionally conscious of their humming vitality.[2] I tried to stay on the holistic path by insisting that the body and embodiment are always dynamically interacting with one another. But having made the analytical distinction between the body and embodiment, I could not escape the dualistic thinking that clung to me regardless of my efforts to avoid it.

I want now to construct the situation in a different way. This essay pushes beyond the position articulated at the end of *How We Became Posthuman,* where I argued that the erasure of embodiment characteristic of the history of cybernetics should not again be enacted as we move into the technoscientific formations I call the posthuman. Rather than beginning dualistically with body and embodiment, I propose instead to focus on the idea of relation and posit it as the dynamic flux from which both the body and embodiment emerge. Seeing entities emerging from specific kinds of interaction allows them to come into view not as static objects precoded and prevalued, but rather as the visible results of the dynamic ongoingness of the flux—which in itself can be neither good nor bad because it precedes these evaluations, serving as the source of everything that populates my perceived world, including the body and experiences of embodiment.[3]

Beginning with relation rather than preexisting entities changes everything. It enables us to see that embodied experience comes not only from the complex interplay between brain and viscera that Antonio R. Damasio compellingly describes in *Descartes' Error: Emotion, Reason, and the Human Brain,* but also from the constant engagement of our embodied interactions with the environment.[4] Abstract ideas of the body likewise arise from the interplay between prevailing cultural formations and the beliefs, observations, and experiences that count as empirical evidence in a given society. In this view, embodiment and the body are emergent phenomena arising from the dynamic flux that we try to understand analytically by parsing it into such concepts as biology and culture, evolution and technology.

2. For a sympathetic account of the importance of emotion to human cognition, see Antonio R. Damasio, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (New York: Harcourt, 1999).

3. I have been arguing for such a view for several years. See, for example, N. Katherine Hayles, "Constrained Constructivism: Locating Scientific Inquiry in the Theater of Representation," *New Orleans Review* 18 (1991): 76–85; reprinted in *Realism and Representation*: *Essays on the Problem of Realism in Relation to Science, Literature, and Culture,* ed. George Levine (Madison: University of Wisconsin Press, 1993), pp. 27–43.

4. Antonio R. Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: Putnam, 1994).

These categories always come after the fact, however, emerging from a flux too complex, interactive, and holistic to be grasped as a thing in itself. To signify this emergent quality of the body and embodiment, I will adopt the term proposed by Mark Hansen to denote a similar unity, the mindbody.[5]

While a study of anatomy textbooks written across the centuries will confirm that ideas of the body change as the culture changes, it is less obvious that our experiences of embodiment also change.[6] Refusing to grant embodiment a status prior to relation opens the possibility that changes in the environment (themselves emerging from systemic and organized changes in the flux) are deeply interrelated with changes in embodiment. Living in a technologically engineered and information-rich environment brings with it associated shifts in habits, postures, enactments, perceptions—in short, changes in the experiences that constitute the dynamic lifeworld we inhabit as embodied creatures. One story about these changes—a story I deeply want to resist—narrates them as what Donna Haraway calls a masculinist fantasy of second birthing, a transcendent union of the human and the technological that will enable us to download our consciousness into computers and live as disembodied information patterns, thereby escaping the frailties of the human body, especially mortality.[7] But one need not indulge in this fantasy to grant that embodied experiences are changing through interactions with information-rich environments, a point that Andy Clark tellingly makes when he argues that technologies have always coevolved with the human brain.[8]

What kinds of changes are bringing about these shifts in embodied experience? Space will not allow me to explore this question fully, but I can sketch a few possibilities to indicate what I have in mind. Consider first the force of habits to shape embodied responses—especially proprioception, the internal sense that gives us the feeling that we *occupy* our bodies rather than merely possess them.[9] Com-

5. Mark Hansen, "From Image to Affect: Making Sense of New Media Art," presentation at UCLA, May 2001.

6. See, for example, Thomas Laqueur, *Making Sex: Body and Gender from the Greeks to Freud* (Cambridge, Mass.: Harvard University Press, 1992).

7. Donna Haraway, "The Companion Animal Manifesto: Dogs, People, and Significant Otherness," presentation at UCLA, April 2003.

8. Andy Clark, *Natural Born Cyborgs (Why Minds and Technologies Are Made to Merge)* (New York/London: Oxford University Press, in press).

9. Oliver Sacks, in *The Man Who Mistook His Wife for a Hat* (New York: Harper Perennial, 1990), recounts the case of Christine, who had lost her proprioceptive sense through

puter video game players testify to feeling that they are projecting their proprioceptive sense into the simulated space of the game world; in fact, they eloquently insist that being a good player absolutely requires this kind of projection. Their body boundaries have fluidly intermingled with the technological affordances so that they feel the joystick as an unconscious extension of the hand. Simon Penny, acknowledging the power of these interactive computer games, discusses them as a bodily discipline that the military has been quick to appropriate.[10] Moreover, the interactions have the potential not only to condition, but actually to shape the central and peripheral nervous systems. Of species on earth, humans are among those with the longest period of neotony, extending at least into adolescence the capacity of the nervous system to change and evolve after birth. The flexibility of the human neural system enables new synaptic connections to form in response to embodied interactions. This implies that a youngster growing up in a medieval village in twelfth-century France would literally have different neural connections than a twenty-first-century American adolescent who has spent serious time with computer games.

In addition to these biological changes there are more intrusive interventions that join the biological with the technological. Sandro Mussa-Ivaldi and his research team at Northwestern University have successfully removed portions of a sea lamprey's brain, kept it alive in a bath of nutrients, and then connected wires to bring electrical signals from a mobile robot's optical sensors into the lamprey's vestibular system, the part of the brain that deals with up-down orientation in the water. The disembodied brain apparently interprets the robot's signals as denoting a certain orientation in the water and sends signals back that make the robot move toward the light (the most common response), or away; additional behaviors include wheeling in a circle and spinning in a spiral configuration.[11] This fusion of biological organism and cybernetic device is so striking that "cyborg" seems too innocuous a term to describe it. Experiments are under way at UCLA and elsewhere to use similar technologies to link the brain waves of paraplegics with remote actuators, thus enabling

neurological disorder and consequently felt that she operated her body as if it were a puppet.

10. Simon Penny, "Representation, Enaction and the Ethics of Simulation," in *First Person Plural*, ed. Pat Harrington and Noah Wardrip-Fruin (Cambridge, Mass.: MIT Press, in press).

11. Sid Perkins, "Lamprey Cyborg Sees the Light and Responds," *Science News* 158:20 (November 11, 2000): 309. See also the conference paper delivered at Artificial Life VII (Portland, Ore.: August 2000): *www.smpp.nwu.edu/~smpp pub/RegerEtAlv_2000.pdf*.

them to manipulate objects in their environment in ways that would otherwise be impossible; success depends on their ability to put their brains in intense feedback loops with the technology, thereby forming new neural patterns that can drive the actuators. Other interventions include implants such as those Kevin Warwick, professor of Cybernetics at the University of Reading in England, had inserted into his arm: His first implant was a passive device, communicating only with embedded sensors in the environment.[12] He advanced from that to a second implant that also sends signals to his nervous system, creating an integrated circuit linking his evolving neural patterns directly with environmentally embedded sensors and computer chips.[13]

The number of people who have implants is likely to remain minuscule, at least for the immediate future. Greater numbers will be affected by the continuing development and expansion of pervasive computing. The idea is to embed innumerable sensors and small computers in the environment capable of collecting, processing, storing, and transmitting information. Recent-model cars already have a module under the right front seat that collects more than two hundred different kinds of information; when the car is taken in for service, the mechanic downloads the information into his computer, where a diagnostic software program analyzes it and identifies malfunctioning parts. An article on telematics in the London *Financial Times* details further developments, including an eye-tracking system that analyzes a driver's eye motions to anticipate moves such as changing lanes; the system coordinates this information with images from a rear video camera and warns the driver if the move is unsafe.[14] Additional functionalities include analyzing eye motions to determine if a driver is getting sleepy, which also triggers a warning. Related to telematics within the car is the development of smart highways, with embedded sensors and computers capable of tracking a car's movement: the goal is to develop cars and highways with interlocking computer systems that will enable cars to drive themselves. Similarly, sensors are being embedded in smart buildings, enabling a building to sense the presence of human beings and activate

12. Kevin Warwick, "Cyborg 1.0," *Wired* 8:02 (February 2000), available on-line at *www.wired.com/wired/archive/8.02/warwick.html*.

13. Kevin Warwick describes this device and its function in *I, Cyborg* (London: Garnder's UK, 2003). The operation is also described on his website, *www.kevinwarwick.org,* as "Project Cyborg 2.0."

14. Mark Vernon, "Telematics Will Transform the Driving Experience," *Financial Times* June 6, 2001, FT-IT Review, pp. 7–12.

or shut down ventilation, lighting, heating, and cooling systems and a variety of other functionalities. While many information transactions will take place between embedded computers without the people who move in those spaces knowing about them, enough of the infrastructure will be visible to make experientially vivid the myriad ways in which our embodied interactions with the environment generate, direct, and change the information flows surging ceaselessly around us.

The development of smart environments makes even more persuasive the arguments of philosopher Andy Clark and anthropologist Edwin Hutchins that cognition should not be seen as taking place in the brain alone. Rather, cognition in their view is a systemic activity, distributed throughout the environments in which humans move and work. Indeed, Clark argues that the distinctive characteristic of humans has always been to enroll objects into their cognitive systems, creating a distributed functionality he calls "extended mind."[15] We are cyborgs, he wrote in a recent article, "not in the merely superficial sense of combining flesh and wires, but in the more profound sense of being human-technology symbiots: thinking and reasoning systems whose minds and selves are spread across biological brain and non-biological circuitry"; observing that the "extended mind" is a strategy almost as old as humans, he nevertheless points out that the joining of technology with biology has created a "cognitive machinery" that is "now intrinsically geared to transformation, technology-based expansion, and a snowballing and self-perpetuating process of computational and representational growth."[16] Although relatively small changes in human brains may have been sufficient to make us into the "symbolic species," as Terrence Deacon calls humans,[17] these incremental changes have now catapulted us "on the far side of a precipitous cliff in cognitive-architectural space."[18]

Following a similar line of thought, Edwin Hutchins argues that cognitive scientists made a fundamental mistake when they located cognition in the brain and then tried to model that cognition in ar-

15. Andy Clark, *Being There: Putting Brain, Body, and World Together Again* (Cambridge, Mass.: MIT Press, 1998).

16. Andy Clark, "Natural Born Cyborgs?" hosted at The Third Culture website maintained by John Brockman, *www.edge.org/3rd_culture/clark/clark_index.html*. This article is excerpted from his forthcoming book, *Natural Born Cyborgs* (above, n. 8).

17. Terrence W. Deacon, *The Symbolic Species: The Co-evolution of Language and the Brain* (New York: Norton, 1997).

18. Clark, "Natural Born Cyborgs?"

tificial intelligences.[19] They rather should have recognized that cognition is a systemic activity distributed throughout the environment and actuated by a variety of actors, only some of which are human. In his view it is not merely a metaphor to call drawing a line on a navigational chart "remembering" and erasing a line "forgetting," for if these objects are part of our extended mind, drawing and erasing are indeed functionally equivalent to remembering and forgetting. The extended-mind model indicates how cultural perceptions change in relation to the development of information-rich environments: Instead of the Cartesian subject who begins by cutting himself off from his environment and visualizing his thinking presence as the one thing he cannot doubt, the human who inhabits the information-rich environments of contemporary technological societies knows that the dynamic and fluctuating boundaries of her embodied cognitions develop in relation to other cognizing agents embedded throughout the environment, among which the most powerful are intelligent machines.

In these views the impact of information technologies on the mindbody is always understood as a two-way relation, a feedback loop between biologically evolved capabilities and a richly engineered technological environment. Such feedback loops may be reaching new levels of intensity as our environments become smarter and more information-rich, but the basic dynamic is as old as humans. Returning to *The Symbolic Species*, I take Deacon's point that while the evolution of language changed human brain structure, human brain structure affected the evolution of language. To emphasize the importance of this relationality, he proposes that we "imagine language as an independent life form that colonizes and parasitizes human brains, using them to reproduce."[20] The relationship is symbiotic: "modern humans need the language parasite in order to flourish and reproduce, just as much as it needs humans to reproduce. Consequently, each has evolved with respect to the other."[21] He draws an analogy with the evolution of computer interfaces: When interfaces were restricted to DOS commands, computers were seen as the special province of scientists, engineers, and other researchers. With the more intuitive interfaces pioneered at Xerox PARC and implemented by Apple, computers spread much more rapidly in the population, in part because they were better suited to

19. Edwin Hutchins, *Cognition in the Wild* (Cambridge, Mass.: MIT Press, 1996).

20. Deacon, *Symbolic Species* (above, n. 17), p. 111.

21. Ibid., p. 113.

brain processing.[22] This is the other side of adaptations in the brain to better accommodate computer dynamics. Relationality implies a deep and dynamic connection between the evolutionary pathways of computers and humans, each influencing and helping to configure the other.

My argument further implies that these coevolutionary dynamics are not only abstract propositions grasped by the conscious mind, but also emergent dynamic processes actualized through interactions with the environment. And here there is a problem. Especially in times of rapid technological innovation, there are many gaps and discontinuities between abstract concepts of the body, experiences of embodiment, and the dynamic interactions with the flux of which these are enculturated expressions. The environment changes and the flux shifts in correlated systemic and organized ways, but it takes time, thought, and experience for these changes to be registered in the mindbody.

Bridging these gaps and connecting these discontinuities is the task taken on by the three Virtual Reality artworks discussed here: "Traces," by Simon Penny and his collaborators; "Einstein's Brain," by Alan Dunning, Paul Woodrow, and their collaborators; and "nØtime," by Victoria Vesna and her collaborators. If art not only teaches us to understand our experiences in new ways but actually changes experience itself, these artworks engage us in ways that make vividly real the emergence of ideas of the body and experiences of embodiment from our interactions with increasingly information-rich environments. They teach us what it means to be posthuman in the best sense, in which the mindbody is experienced as an emergent phenomenon created in dynamic interaction with the ungraspable flux from which also emerge the cognitive agents we call intelligent machines. Central to all three artworks is the commitment to understanding the body and embodiment in relational terms, as processes emerging from complex recursive interactions rather than as preexisting entities. Because relationality can be seen through many lenses, I have chosen works that place the emphasis on different modes of relation. "Traces" foregrounds the relation of mindbody to the immediate surroundings by focusing on robust movement in a three-dimensional environment; "Einstein's Brain" foregrounds perception as the relation between mindbody and world that brings the

22. Of course there were also other factors, including faster processor speed, greater memory storage, and most importantly, the advent of the Internet and the World Wide Web.

flux into existence for us as a lived reality; and "nØtime" emphasizes relationality as cultural construction.

These configurations can also be understood in terms of the typology that Don Ihde proposes in *Technology and the Lifeworld: From Garden to Eden*.[23] Parsing the general situation as Human-technology-World Relations, he identifies three variants. The first, which he calls "embodiment relations," bundles the human and the technological into one component and emphasizes the relationality between this component and the world: (Human-technology)→World. This corresponds to the situation in "Traces," in which the technology reproduces the human form in a simulation (thereby bundling together the technology and the human) and emphasizes the movement of the simulated techno-human through space. The second variant, identified by Ihde as "hermeneutic relations," bundles together technology and the world and emphasizes the relationality with the human: Human→(technology-World). This parsing is performed in "nØtime," which leaves the human body unencumbered to experience an installation space permeated by sensors, actuators, and display technologies, which bundle together the world and technology. The third parsing, "alterity relations," is parsed as Human→technology-(-World), where the brackets around World indicate that the bundling of technology and world is achieved through the creation of a simulated world, which is then put into relation with the human. Although the three emphases of enactment, perception, and enculturation (corresponding to embodiment, hermeneutic, and alterity relations in Ihde's schema) by no means exhaust the ways in which relationality brings the mind-body and the world into the realm of human experience, they are capacious enough in their differences to convey a sense of what is at stake in shifting the focus from entity to relation.

Relation as Enactment

In *The Embodied Mind: Cognitive Science and Human Experience*, Francisco Varela, Evan Thompson, and Elanor Rosch articulate a vision of relationality that has much in common with "Traces." They write: "living beings and their environments stand in relation to each other through *mutual specification* or *codetermination*."[24] Coin-

23. Don Ihde, *Technology and the Lifeworld: From Garden to Eden* (Bloomington: Indiana University Press, 1990), p. 106 and passim.

24. Francisco Varela, Evan Thompson, and Eleanor Rosch, *The Embodied Mind: Cognitive Science and Human Experience* (Cambridge, Mass.: MIT Press, 1991), p. 198.

ing the term "enaction" to describe this dynamic interplay between self and world, they envision mindbody and environment coming into existence through a mutual process of "codependent arising."[25]

It is precisely this kind of relationality that Simon Penny wanted to implement in a Virtual Reality (VR) environment. As early as 1994 he articulated a desire to depart from the usual VR model that, in his assessment, "blithely reifies a mind/body split that is essentially patriarchal and a paradigm of viewing that is phallic, colonizing, and panoptic."[26] In "Traces," Penny along with collaborators Jeffrey Smith, Phoebe Sengers, Andre Bernhardt, and Jamieson Shulte created an interactive artwork designed to bring the body more fully into the virtual space. Reacting against the VR rhetoric of disembodiment, they critique this rhetoric as deriving from "an essentially uninterrogated Cartesian value system, which privileges the abstract and disembodied over the embodied and concrete."[27] They proposed, by contrast, to build "an unencumbering sensing system which modeled the entire body of the user" (p. 3). Working with a three-dimensional CAVE environment that displays simulated visual images along four surfaces (three walls and the floor) as well as in the goggles of the user, they implemented a visual tracking system that computes the volume of the user's body by modeling its movement in space and time through three-dimensional cubes called "voxels" (volumetric units named by analogy to two-dimensional pixels). From this computation they created "traces," simulated images of volumetric residues that trail behind the rendered model of the user's body, gradually fading through time as continued movement creates new traces that also fade in turn. The body model and residues are comprised of lilac-colored voxels 5 cm on a side, rendered in a simulation space 60 × 60 × 45 voxels in three dimensions, with computational time steps of 15 fps. Since the time-step interval falls below the threshold of 24 fps at which successive frames appear to human viewers as continuous motion, the computational process manifests itself to the user and outside viewers as somewhat jerky in its motion. This effect, although in one sense a constraint imposed

25. Ibid., p. 110.

26. Simon Penny, "Virtual Reality as the Completion of the Enlightenment Project," in *Culture on the Brink: Ideologies of Technology*, ed. Gretchen Bender and Timothy Druckrey (Seattle: Bay Press, 1994), pp. 231–263, on p. 238.

27. Simon Penny, Jeffrey Smith, Phoebe Sengers, Andre Bernhardt, and Jamieson Schulte, "Traces: Embodied Immersive Interaction with Semi-Autonomous Avatars," unpublished essay, p. 2. I am grateful to Simon Penny for giving me permission to quote from this essay prior to its publication. (Subsequent parenthetical references in this section are to this work.)

by the amount of computation required for each updating, is embraced by Penny and his collaborators as part of a larger aesthetic strategy to "avoid any pretense of organic form. There was a desire to be up-front about the fact that this was a computational environment, not some cinematic or hallucinatory pastoral scene" (p. 13). For the same reason, the collaborative team renounced what they regarded as the "eye candy" of virtual worlds ready for exploration, using texture-mapping only for the virtual room projected on the CAVE walls, about twice the size of the CAVE's dimensions of three meters on a side. Instead of a graphically rendered virtual world, the user "simply sees graphical entities spawned by various parts of their [sic] body when in motion" (p. 10).

The avatar interface is designed, in Penny's terminology, to be "autopedagogical," teaching the user how to interact with it through its evolution through the three phases of Passive Trace, Active Trace, and Behaving Trace. In the Passive Trace the simulated volume passively follows the user's motions, creating the impression that the user "'dances' a 'sculpture'" (p. 4), though a transitory one that gradually fades into transparency as it moves away from the viewer into the simulated space on the front wall of the CAVE. With its time-sensitive evolving transparency, the Passive Trace would seem to have more in common with Henri Bergson's vision of flowing time than with the enduring static form that sculpture usually implies. As the user continues to move in the space, the trace transforms from a passively following cloud to active entities that can be "spun off" the user's body through rapid motion or acceleration, for example by flicking one's hand rapidly down one's arm as if shaking off water droplets. At first these entities follow the user, but gradually they become more autonomous as their motions are guided by autonomous agent software. As they make the transition into the Behaving Trace, they exhibit behaviors characteristic of such artificial life programs as Craig Reynolds's "Boids," simulated forms that exhibit flocking behavior when programmed with a relatively simple set of rules such as "always fly toward the center of where the other objects are." The simulated objects in the Behaving Trace may follow the user, for example, or they may break off and head in other directions, moving as a flock following its own artificial life dynamics.

Although the immediate meaning of "autopedagogical" for Penny is the progression whereby "Traces" teaches the user how to interact with it, the term evocatively points toward other realizations as well. By incorporating a temporal dimension into the work, and especially by having the duration of the trace visibly fade away as it ages, the artwork resists the fantasy that information technologies will allow us to escape our bodies and move into transcendent spaces where we can avoid the ravages of time. Another realization emerges from the "traces" metaphor, which suggests new kinds of possibilities for interactions between humans and intelligent machines. As Penny and his collaborators point out, the "Traces" simulation, considered as an avatar, occupies a middle ground between avatars that mirror the user's motions and autonomous agents that behave independently of their human interlocutors. As the "trace" avatar transforms from mirroring the user's actions to engaging in autonomous behaviors, it enacts a borderland where the boundaries of the self diffuse into the immediate environment and then differentiate into independent agents. This performance, registered by the user visually and also kinesthetically as she moves energetically within the space to generate the entities of the Active and Behaving Traces, makes vividly clear that the simulated entities she calls "her body" and the "trace" are emergent phenomena arising from their dynamic and creative interactions.

Moreover, the elegant simplicity of the simulation—the refusal to add "eye candy" to the visual effects—helps to make real to the user that the avatar is in effect indistinguishable from her interface with the computer. The trace avatar, Penny and his collaborators write, "must be thought of as the part of the system which is intimately connected to the user. In this way, the line between system, avatar, and interface also becomes blurred; the avatar becomes the interface, the point at which the computational system and the user make contact" (p. 22). The aesthetic strategy of refusing to conceal the computational nature of the simulation resists the fantasy of transcendent second-birthing by grounding the work in the constraints of real-life computational and sensing devices. As the "Traces" article explaining the construction of the work makes clear, this is no illusory world of limitless possibilities, but a carefully engineered artwork in which numerous trade-offs and "workarounds" are required to make the project feasible. The ingenuity, creativity and skill of the designers and programmers are repeatedly tested as they confront a variety of problems, from devising a workable camera tracking system to balancing the graininess of the voxelated image against increased latency times as the computational load increases. Coming to grip with these problems, they achieve the key insight that constraints can function as opportunities as well as problems. This approach led them to see that the problems involved in having the avatar exactly track the user's body could be used constructively if they switched metaphors: rather than regarding the avatar as a mirroring puppet, they think of it as a trace emerging from the borderlands created by the energetic body in motion. What was a tracking problem is thus transformed into the possibility of creative play between user and avatar.

The net result of these compromises, creative solutions, and transformations is to make real for us the insight that the artwork is not simply the instantiation of an abstract concept, but an artifact that emerged from the dynamic relation between the vision of the designers, the constraints imposed by the situation, and the powerful but still limited capabilities of the intelligent machines that perform the sensing, computational, and rendering tasks that make the project a reality. In its form, construction, and functionality, "Traces" testifies to this relationality at the same time that it also performs relationality for the user. Far from the fantasy of disembodied information and transcendent immortality, "Traces" bespeaks the playful and creative possibilities of a body with fuzzy boundaries, experiences of embodiment that transform and evolve through time, connections to intelligent machines that enact the human-machine boundary as mutual emergence, and the joy that comes when we realize we are not isolated from the flux but rather enact our mind-bodies through our deep and continuous communion with it.

Relation as Perception

In "The Brightness Confound," Brian Massumi reminds us of Wittgenstein's puzzlement as he stares at his sunlit table and realizes that he cannot say what color the table is, for his perception fuses luminosity, radiance, and color into a unity that defies tidy categorization. Following Marc Bornstein, Massumi calls this unity "the brightness confound" and makes the simple but elegant point that the perception is a "singular confound of what are described empirically as separate dimensions of vision."[28] In this sense the confound is absolute:

> Absoluteness is an attribute to any and all elements of a relational whole. Except, as absolute, they are not "elements." They are parts or elements before they fuse into the relational whole by entering indissociably into each other's company; and they are parts or elements afterwards, if they are dissociated or extracted from their congregation by a follow-up operation dedicated to that purpose. In the seeing, they are absolute.[29]

28. Brian Massumi, "The Brightness Confound," in *Body Mécanique: Artistic Explorations of Digital Realms*, ed. Sarah J. Rogers (Columbus, Ohio: Wexner Center for the Arts, 1998), pp. 81–94, on p. 81.

29. Ibid., p. 82.

Insisting on this absoluteness, Massumi nevertheless writes as if the elements of the confound have a prior existence as separate entities. Humberto Maturana expunges this vestige of realism when, in developing the theory of autopoiesis, he makes the point that someone experiencing a hallucination would be unable to distinguish the hallucination from reality.[30] In Maturana's view, what we perceive *is* reality for us.

In the "Einstein's Brain" project, Canadian artists Alan Dunning and Paul Woodrow stage what we might think of as Maturana's claim (although they come to this view via their own independent paths, and not necessarily through Maturana). They are keenly conscious of the ironic overtones of their chosen title, referencing Roland Barthes's essay by a similar title. Commenting on Einstein's brain as a fetishized object, they write: "His brain has passed into the world of myth, cut up and minutely examined but revealing little."[31] The title points up the fact that the brain as fetishized physical object, considered in isolation from the world, cannot possibly account for the richness of human experience. In his meditation on the subject, Barthes related the duality of physical brain and prodigious mind to a split between Einstein as the researcher and Einstein the knower of the world's innermost secrets.[32] Rooted in the physical brain, Einstein's mind nevertheless seemed to have nearly occult powers of insight, at least in the popular imagination. This oscillation between ordinary physical reality and occult power translates in the "Einstein's Brain" project into a desire to use advanced technology to reveal the constructedness of our everyday world.

30. Humberto R. Maturana, "Biology of Language: The Epistemology of Reality," in *Psychology and Biology of Language and Thought: Essays in Honor of Eric Lenneberg*, ed. George A. Miller and Elizabeth Lenneberg (New York: Academic Press, 1978), p. 46. In my view, this claim needs to be modified. Some people who experience migraine headaches see visual auras but are quite conscious that these auras are not reality. Other visions, such as those inscribed by Hildegard in *Scivias*, are taken by the perceiver as real but are distinguished from ordinary reality—in this case, by being identified with the divine. A similar case is presented by the auditory hallucinations experienced by the science fiction writer Philip K. Dick near the end of his life, which he finally decided were communications from an extraterrestrial intelligence. Oliver Sacks, in *The Man Who Mistook His Wife for a Hat* (above, n. 9), reports auditory and visual hallucinations that seemed very real to the patient but were also understood by the patient as coming from somewhere other than consensual reality, in one case as replayed memories (pp. 132–155).

31. Alan Dunning and Paul Woodrow, "Einstein's Brain," at *wwwl.acs.ucalgary.ca/~einbrain/EBessay.htm*, p. 2. (Subsequent parenthetical references in this section are to this work.)

32. Roland Barthes, "The Brain of Einstein," in idem, *Mythologies* (New York: Hill and Wang, 1971), pp. 68–70.

The "Einstein's Brain" project has been in process for five years and has taken a variety of forms in different installations, but a common idea unites all the instantiations.[33] The artists (like Maturana) are committed to the realization that the world of consensual reality does not in any sense exist "out there" in the forms in which we perceive it. Rather, the world we know is an active and dynamic construction that emerges from our interactions with the flux:

> We think of the body as separate from the world—our skin as the limit of ourselves. This is the ego boundary—the point at which here is not there. Yet, the body is pierced with myriad openings. Each opening admits the world—stardust gathers in our lungs, gases exchange, viruses move through our blood vessels. We are continually linked to the world and other bodies by these strings of matter. We project our bodies into the world—we speak, we breathe, we write, we leave a trail of cells and absorb the trails of others. The body enfolds the world and the world enfolds the body—the notion of the skin as the boundary to the body falls apart. (p. 7)

The artists self-consciously position their work in opposition to military and corporate uses of Virtual Reality, which continually aim for greater and greater realism. They point out that when Virtual Reality illusions are engineered with the goal of seamlessly reproducing the "real" world, the effect (wittingly or not) is to reinforce existing structures of authority and domination—structures that, in their desire to preserve the status quo, find it in their interest to foreclose alternative constructions of reality, and moreover to keep them from coming to mind as possibilities. By contrast, Dunning and Woodrow conceive of the simulation technologies as deliberately imperfect, so as to make clear their construction as "reality engines connected not to the generation of a reality but as a means of attending to a consciousness that in turn fashions a reality" (p. 7).

To resist the domination in VR of a "realism rid of expression, symbol or metaphor" that is "sustained by the authorities of homogeneity and seamlessness" (p. 1), Dunning and Woodrow create a "cranial landscape" merging symbolic and semiotic markers with the landscape of experience (p. 5). Their work often has a somewhat idiosyncratic range of reference overlying the consistency of their vision, rather as if a magpie had collected shiny bits from here and

33. Collaborators vary from project to project but include, among others, Martin Raff of the MRC Laboratory for Cell Biology, University College, London; Pauline van Mourik Broekman, *Mute* magazine, London; Hideaki Kuzuoka, Department of Engineering, University of Tzukuba, Japan; Nick Dalton, Bartlett School of Architecture, University College, London; and Arthur Clark, Department of Neurology Health Sciences, University of Calgary, Calgary, Alberta, Canada.

there because they attracted her attention and had then woven them into a nest of breathtaking coherence and careful design. Dunning and Woodrow create a semiotically marked landscape that exists for the user as a negotiable surface, and also as a changing landmass tied in with the user's responses as they are registered through reading her brain waves and other physiological indicators. Thus the inspiration for the cranial landscape comes partly from the *Carte du tendre*, in Madeleine de Scudéry's seventeenth-century novel, *Clélie: Histoire Romaine*. The *Carte du tendre* is a romantic narrative map inscribing onto a landscape names indicating the predictable heating up and cooling off of a love affair.[34] Another source of inspiration is the "dérive" of the Situationists, a random walk through the city governed by the principle that every turn and meander should be taken at random rather than with the intent to arrive somewhere. Guy Debord's 1957 map of Paris with arrows marking the course of a dérive suggested to Dunning and Woodrow that even something as apparently static and durable as city architecture might be reimagined as emerging in complex interplay with human enactments—so their plan for the "Forest of Vowels," a site inspired also, according to the artists, by Rimbaud's poetry, calls for the association of external events in the real world with the landscape of the virtual world. These associations include feeding in the moon's changing gravitational forces so they alter the form of the virtual world's landmasses, tying fluctuations in the stock market to the growth patterns of trees and plants, and connecting the daily attendance figures at Graceland to the changing cultural paradigms of the virtual world (p. 6).

Another idiosyncratic influence is "The Stone Tapes," a story produced by Nigel Kneale on BBC Television on December 25, 1972. The story takes the form of a mystery centered on an apparently haunted building, which has somehow recorded in its inorganic stone traumatic events that happened there; the building has the capacity to play these recordings back by transferring them directly to the brains of people who come inside the building, so that it appears to the people as if they are spectators of the original events. The story appeals to Dunning and Woodrow on multiple levels. The building displays qualities that make it appear as if it can operate as a subject, thus blurring the boundary between an exterior static architecture and the dynamic interior world of human emotion. Moreover, the humans haunted by the building must confront the apparent reality of an illusion generated from inside their own

34. Madeleine de Scudèry, *Clélie: Histoire romaine*, 10 vols. (Geneva: Slatkine Reprints, 1973; reprint of Paris 1660 edition).

brains, blurring the boundary between their perceptions of the real world and the illusions activated for them by the stone building.

The incongruities between a Virtual Reality experienced by those who are "haunted" and the consensual reality experienced by onlookers are dramatically staged in Dunning and Woodrow's installation "The Madhouse," in which participants wearing VR goggles engage in behaviors that can only appear strange and bizarre from the viewpoint of those who do not see or hear the simulations. In a similar mode is their plan for an artwork that would force participants to question consensual reality by creating deliberately unstable and deficient renderings of the virtual world. In this projected work vision is blurred, detail is shifting and inconstant, slower or faster frame rates suggest a rendering engine behind the scenes, left- or right-hand sides of stereoscopic vision blink out, depth perception is lost, objects appear only when one is in motion, the edges of the worlds visibly reinvent themselves. They write of their motivation for these strategies:

> As western artists, we developed from a world where we learned to objectify our bodies, to separate our minds from our bodies and viscera, where we learned to distinguish matter from mind and where the construction and placement of objects was the focus and culmination of our intentions and desires. Developments in cultural and social theory and in technology have suggested that we and other artists shift their attention away from a graspable, predominantly corporeal world to one which is increasingly slippery, elusive and immaterial. Mind and matter, combining in the cognitive body, are interdependent. The world we inhabit is in flux, comprised of increasingly complex connections and interactions. In this world there are no fixed objects, no unchanging contexts. There are only coexistent, nested multiplicities. (p. 8).

In the "unbroken field of transformations" that for them constitute the emergent dynamic we call reality, Virtual Reality art can play a vital role in shaking the belief that our bodies and the world exist independent of relation. They intend their art to enact engagements that make vividly real the fact that everything in our world, including (or rather especially) the human mindbody, emerges from our relation with the ongoing flux.

These ideas and strategies come together in the installation exhibited at the TechnOboro Gallery in Montreal in September 2001 and demonstrated in prototype at the Digital Arts Conference at Brown University in April 2001, which is where I saw it. The centerpiece of the installation is the ALIBI, the "anatomically lifelike interactive biological interface": an anatomically correct life-size model of the human body stuffed with a wide variety of sensors, including theramin proximity sensors, touch sensors, aroma sniffers, pressure sensors, sound sensors, and carbon dioxide sensors. Participants wear goggles that can be arranged to show only the simulated world or (by removing the blinders from the lens area) to convert the scene to a "mixed reality" in which both the simulation and the real room are visible. They are thus able to see simultaneously the Virtual Reality projection and the artifactual body, which lies on a light table in the center of a room. Made from a cast of a male model, the body is painted with thermochromic paint that appears as a lovely dark blue when cool but turns white when warmed by someone's touch, fading again to blue as the area cools to the ambient temperature. Participants can interact with the body by touching it on the thigh, abdomen, legs, etc., by whispering in its ear, or even by breathing into its mouth. These interactions, when sensed by the system, activate and change the simulated worlds being imaged in the goggles. The blue body thus acts as a navigational interface, opening portals to a variety of simulated worlds as different body areas are touched, massaged, and otherwise manipulated. One user wears a helmet capable of sensing her electroencephalic activity, including alpha, beta, theta, and delta brain waves. These data are fed into the simulation, along with other biological data collected from the user such as blood pressure, pulse rate, and galvanic skin response. The data trigger the performance of simulated images, with sunbursts, polygons, and flashes of light appearing in response to the user's reactions. Moreover, the amplitude and frequency of the participant's brain waves are converted to MIDI files and used to create a soundscape for the simulation, which serves as an acoustic transform of her ongoing physiological responses.

Two other components add to the complexity of this work. First, on the back wall are projected images of revolutionary historical events, including authentic footage of statues being pulled down during the Russian Revolution and speeches by Mao. This corresponds to the "Stone Tapes" motif, establishing a visual connection between past and present, and "haunting" participants with events that have changed the course of history and that continue to be remembered as dramatic instantiations of the revolutionary impulses. Second, there is a "viewing room," in which other visitors can see the artifactual body being manipulated by users who engage in actions and behaviors that remain inexplicable to those who cannot see the virtual worlds. The effect, once again, is to call into question consensual reality by fragmenting the space so that different versions of "reality," virtual and actual, compete and conflict in their representational stimuli.

The most striking part of the installation, from my point of view, are the feedback loops between the user's responses, her interactions with the artifactual body, and the production of the simulated world. Imagine the scene: You are in some initial brain state that generates images and sounds in the simulated world you see. While watching these displays, you begin to touch the body in its sensitive areas, opening portals to other simulated worlds, which trigger new responses in you, which feed back into the simulation to change it, which makes you want to touch the body in new ways, which further changes the simulated images and sounds, which in turn generate yet more responses from you. The loop is endless, and endlessly fascinating, forming, as the authors say, a "single intelligent symbiotic system."[35] Commenting on a different artwork, Dunning and Woodrow explain the relation of the body to the VR world in ways that apply with special force to this installation:

> These worlds are not external to the body, but, are properly thought of as being inside the body. This accounts for the apparent invisibility of the body in a virtual space. The body disappears because it is turned in on itself. The ego-boundary is no longer the point at which the body begins and ends in relation to an external environment, but is, rather, . . . the very limit of the world. (p. 5)

Using a different metaphor in "The Stone Tape, the Dérive, the Madhouse," they comment: "It is as if we are inside ourselves, like a three-dimensional eye which constructs itself as it moves through internal haptic space."[36] Relationality here is not beside the point; it *is* the point of a mindbody that realizes itself through its playful and intense interactions with evolving virtual worlds, which in the view of these artists include our perceptions of both real simulated worlds. In this sense all human experience is a "mixed reality," emerging from another kind of brightness confound in which technology, the world, and human embodiment all play a role.

Relation as Enculturation

A notable characteristic of "nØtime" is its collaborative nature, as is the case with "Traces" and "Einstein's Brain" as well. The human collaborators, listed by name and sometimes by affiliation, indicate the range of expertise necessary to construct the installations, including such skilled contributors as computer scientist and cultural critic Phoebe Sengers for the "Traces" project, software designer and

35. Alan Dunning and Paul Woodrow, "The Stone Tape, the Dérive, the Madhouse," presented at the New Media Institute at the Banff Centre, September 2000, p. 6.

36. Ibid., p. 3.

CSCW engineer Hideaki Kuzuoka for the "Einstein's Brain" project, and software designer Gerald Jong for the nØtime project. For convenience I have referred to works using the names of the artists who had the initial idea as creator, but these artists more than anyone else realize how deeply their collaborators have shaped the projects and how essential their contributions have been. Less prominently featured and usually identified by model name and technical capacity are the silicon collaborators, the intelligent machines and software packages without which these works would have been impossible to create. It is not merely whimsical to refer to the machines as collaborators, for their capabilities and limitations are as important to the project's shape as are the capabilities and limitations of the human designers. These silicon collaborators include computers, software programs, sensing systems, music synthesizers, tracking systems, motion detectors, and a host of other processors, interfaces, and actuators. The complexity of the collaborations between many different humans and intelligent machines indicates that in a deep sense all of these projects are distributed cognitive systems. Moreover, cognition takes place not just in the minds of the artists and the logic gates of the machines, but also in the participants who interact with the artworks. As "Einstein's Brain" in particular makes clear, the user's interactions in the installations are not merely passive viewing of preexisting works but active components in the work's construction. Among these three artworks, nØtime insists most visibly and interactively on the distributed cognitive collaborations that construct it, and especially on the role played by the global community of intelligent machines we call the Internet. It also locates the arena of relationality with which it is concerned in the broadest geographic terms. Whereas "Traces" focused on the immediate proximity of the body, and "Einstein's Brain" on the room-sized spaces where the artifacts were placed and the simulations projected, the reach of "nØtime's" enactments is global, although it simultaneously insists as well on the importance of local interactions and proximity.

Victoria Vesna originally conceived of nØtime as a response to the common postmodern condition of having no time, living amid the multiple conflicting commitments and stresses that people negotiating complex urban environments find to be an inevitability of contemporary life. Her playfully paradoxical idea was to create avatars that could take over portions of our lives and live them for us while we were busy doing other things. As the project evolved, the idea of collaborative interactions that together create a "person" or "life" took a somewhat different turn, focusing on a nested series of relations between the local and the remote, the individual and the collective, the proximate and the distributed, the immediate and the long-term. As with “Traces” and “Einstein’s Brain,” the effect is to create a space of intense interaction and feedback in which the subject experiences herself as emerging from relational dynamics rather than existing as a pregiven and static self.

The artwork consists of a distributed cognitive system that includes a physical installation located in a gallery space and a remote component played out over the Internet. The physical installation consists of a gridwork of five supporting legs and four trusses that, draped with cream-colored spandex fabric, forms a beautifully translucent three-dimensional spiral thirteen feet high, which the visitor enters with the dawning delight of a snail discovering a shell of palatial dimensions. When the visitor positions herself at the center of the installation, the translucent sheeting functions as a borderland between inside and outside, for it creates a sense of enclosure at the same time that it allows shapes and sounds to be discernible through the fabric.[37] On the wall is a projection flashing the names of participants who have previously created “bodies” in nØtime; when the visitor sees a name she recognizes or likes, she steps forward and the “body” corresponding to that name is displayed on another wall.

Like Penny, Dunning, and Woodrow, Vesna is critical of the tendency in military and corporate VR to move toward greater realism. Rather than participate in this tendency by creating an anthropomorphic avatar, Vesna prefers to break with realistic representation and visualize the information/energetic “body” as a tetrahedron consisting initially of the six lines and four apices required to outline the tetrahedral shape. The tetrahedron, as messages flashing on the walls explain, is privileged because of all polygons it has the greatest resistance to an applied load. When the load exceeds the critical tolerance, a tretrahedron will not dimple or bend like other polyhedral structures; rather, it turns inside out, thus making it “unique in being its own dual.” These characteristics were why Buckminster Fuller chose the tetrahedron as the basic unit of construction for geodesic domes. They also relate to the tetrahedral shape of carbon stereochemistry, which makes the tetrahedron the essential shape for all carbon-based life on earth. The six edges of the tetrahedron Vesna calls “intervals,” and she associates them with the components

37. Don Ihde, in *Technology and the Lifeworld,* pp. 72 ff., remarks that many people want the advantages of technology without having it intrude into their lives—a contradictory desire made manifest in the wish that powerful technologies exist but that they also be transparent. The translucent enclosure seems to acknowledge this wish and also to resist it by evoking transparency and simultaneously denying it.

essential to human life as identified by the Indian chakra system—adding color coding so that the family interval appears red, the finances interval orange, the creativity interval yellow, the love interval green, the communication interval blue, and the spirituality interval purple.

The apices are also named, but here the naming scheme focuses on the cultural constructions that Richard Dawkins called "memes": ideas, bits of song, and other concepts that propagate rapidly through the culture, acting as ideational viruses that use humans as their conceptual replication system, much as Dawkins envisioned the "selfish gene" as doing through the physical body.[38] When a user creates a body as tetrahedron, she chooses the length of the intervals, which reflects the relative importance she gives to the six components and determines the shape of that particular tetrahedron. In addition, this initial choice affects the overall shape as other tetrahedrons are added onto the virtual "body." To complete the body, the user names the four apices with words or short phrases representing the memes she wants to circulate through the virtual space of her "body." Once the body is complete, it is correlated with a three-dimensional soundscape that the on-site visitor can navigate by changing position within the installation. Gerald Jong's custom software, entitled "fluidiom," coordinates the visitor's position as registered by motion sensors with this soundscape, creating an acoustic experience unique to the interactions between a specific virtual body and a user's unique movements within the space.

Once the basic body is constructed, it can grow only through collaborators who are willing to spend time in the physical space. The longer an on-site visitor stays gazing at someone's tetrahedron, the more intervals are added to the figure. The body's owner can then add more memes, allow friends to add them, or distribute cards that enable visitors to add them at an on-site Internet connection. In keeping with the installation's theme, however, growth cannot continue indefinitely. Enacting the finitude that makes time, space, and life span limited commodities for all humans, a body deconstructs when it reaches a size of 150 intervals. The event is announced in advance at the website, and people are invited to witness the virtual collapse. At that point the overgrown body is archived in a file accessible only to the owner, who has the option to start the growth process again with the same basic tetrahedron, or to craft another one.

Through its distributed architecture, collaborative procedures, and sculpturally striking on-site installation, "nØtime" enacts the

38. Richard Dawkins, *The Selfish Gene* (New York: Oxford University Press, 1990).

human body as an emergent phenomenon coming into existence through multiple agencies, including the owner's desires, the cultural formations within which identities can be enacted and performed, and the social interactions that circulate through the global networks of the World Wide Web. The phenomenon of "no time" is thus transformed from an indicator of a declining quality of life into a site for creative play and collaborative interaction. But only, of course, if we make the time to visit the installation, participate in the website, and extend the bodies of our fellow humans by physically committing ourselves to relational interactions that last longer than the thirty seconds usually accorded a gallery installation. Relationality requires care, attention, and dynamic interaction, all of which take the time that "nØtime" paradoxically insists we have after all.

Relation as the Posthuman

In *How We Became Posthuman*, I argued that a range of developments in such fields as cognitive science, artificial life, evolutionary psychology, and robotics were bringing about a shift in what it means to be human. The new formation differs so significantly from the liberal humanist subject it could appropriately be called posthuman. Among the qualities of the liberal humanist subject displaced by technoscientific articulations of the posthuman are autonomy, free will, rationality, individual agency, and the identification of consciousness as the seat of identity. The posthuman, whether understood as a biological organism or a cyborg seamlessly joined with intelligent machines, is seen as a construction that participates in distributed cognition dispersed throughout the body and the environment. Agency still exists, but for the posthuman it becomes a distributed function. Consciousness for the posthuman ceases to be seen as the seat of identity and becomes instead an epiphenomenon, a late evolutionary add-on whose principal function is to narrate just-so stories that often have little to do with what is actually happening. In the crises precipitated by the deconstruction of the liberal humanist subject, one kind of response is represented by attempts to reinstate the lost qualities through the mastery of increasingly powerful computational and informational technologies. If consciousness is reduced to an epiphenomenon, perhaps its sovereign role can be reinstated by losing the body and resituating the mind within a computer. If agency is distributed, perhaps it can be regained by creating more-powerful prostheses, more-extensive implants, more smart weapons. These responses share a reluctance to accept human finitude; they remain intent on imposing the will of the individual onto the world seen as an object to dominate. In these constructions, the subject remains inviolate even while losing the body, and the boundaries of the subject continue to be clearly delineated from an objective world. In an important sense, these responses carry on the worst aspects of the liberal humanist subject even as they turn toward the posthuman.

Another kind of response is enacted by the Virtual Reality artworks discussed above. Here the posthuman is embraced as the occasion to rethink the mind/body split and the premise that mind and body, like the rest of the world, preexist our experiences of them. As we have seen, the relational stance enacted by these works puts the emphasis instead on dynamic interactive processes from which both mindbody and world emerge together. The significance of these works in this posthuman moment is profound, for they operate with a performative intensity that makes us realize the importance of emergent relationality in mind and body, transforming these two "elements" into the mindbody that in turn is embedded in our relations with the techno-world. Speaking to more than conscious mind, these artworks provide our mindbodies with rich experiential fields that invest the relational stance with meanings that work on multiple levels, including the neocortex but reaching below and beyond it as well. They vividly demonstrate the promise of the posthuman, which despite all its problems and dangers may open us to the realization that without relation, existence (if it is conceivable at all) would be a mean and miserable thing. We do not exist in order to relate; rather, we relate in order that we may exist as fully realized human beings.

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