The specter of a postbiological and posthuman future has haunted cultural studies of technoscience and other disciplines for two decades. 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. 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.

But these are deflationary times, and some of the techno-optimism of the pundits of Singularity—Ray Kurzweil, Hans Moravec and others—has been brought to bay by the efforts of a generation of neuroscientists and roboticists to understand and replicate human intelligence in humanoid robotic systems. Eminent scientists such as Christof Koch, Giulio Tononi, John Horgan, Rodney Brooks, and others argue that despite significant recent advances in brain-machine interfaces and the development of neural prosthetics, even if it were possible to simulate the architecture of the human brain, neuroscientists are far from understanding the neural codes, the sets of rules or algorithms that transform neural spikes into perceptions, memories, meanings, sensations, and intentions. Even if we could replicate the machine, we couldn’t program it.
Still, most researchers agree that there is no reason in principle why we will not eventually develop conscious machines that rival or surpass human intelligence. Rather than pursuing the goal of replicating human intelligence in a computer-based medium, researchers like Christof Koch and Giulio Tononi advocate starting with a suitably abstracted mammal-like architecture and evolving it into a conscious entity through the rapidly developing field of evolutionary robotics. (Koch, 2008) Similarly Rodney Brooks believes that standard economic and social forces will gradually shape the mildly intelligent systems we have today into more intelligent machines. The singularity will be a period, not an event:

   Eventually, we will create truly artificial intelligences, with cognition and consciousness recognizably similar to our own... At the same time, we humans will transform ourselves...We will incorporate a wide range of advanced sensory devices and prosthetics to enhance our bodies. As our machines become more like us, we will become more like them.(Brooks, 2008: 73).

Brooks' admonition that we are machines on a continuous path of co-evolution 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 her two recent books, *How We Became Posthuman* and *My Mother Was a Computer*. Hayles considers it possible that machines and humans may someday interpenetrate. 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. 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.”(204) The narratives of the computational universe woven by Wolfram and others 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. By intermediation Hayles refers to a complex entanglement of bodies of texts and digital subjects as well as between different forms of media.(207) In 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.
Hayles’ theory of intermediation alerts us to the 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 techno-scientific 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?

I propose to circumvent the issue of an apocalyptic end of the human and our replacement by a new form of Robo Sapiens by drawing upon the work of anthropologists, philosophers, language theorists, and more recently cognitive scientists shaping the results of their researches into a 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.” (Clark, 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. The materiality of media rather than their content is what matters. Communicational media are machines operating at the heart of subject formation. Like Deleuze and Guattari, and like Andy Clark, I view consciousness and mind as emergent phenomena based in assemblages of machinic operations; and I am sympathetic to Deleuze 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 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 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.

Materialist semiotics in concert with recent work in cognitive neuroscience, studies in evolutionary ethology, and a variety of recent developments in the computational sciences may point the way. Also central to my argument is 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.” (Guattari, 1995: 4) For media philosophers the question is whether Deleuze 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.” At the conclusion of this essay I explore current work in the field of reality mining that aims to access the corporeal axiomatics of the affective domain.

The thesis I am developing here presupposes that each media regime and each system of signification project a specific configuration of the subject and a horizon of agency as a consequence of its normal operation. 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 (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. Moreover, 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
language, 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.

Is there any foundation for relating this approach to the biological evolution of human cognition to a theory of signification and the notions of media machines? Terrence Deacon, Merlin Donald and others have pursued this question deep into the structure of symbolic communication and its embodiment in the neural architecture of evolving human brains. Their work on the evolution of language is suggestive 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 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 pressure 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 and 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.(Deacon, 1997: 401) In short, symbolic culture was a response to a reproductive problem that only symbols could solve: the imperative of representing a proto-social contract. What was at stake here was not the more historically advanced 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 had been crossed to symbolic communication 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; 1902) 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. 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.(Deacon, 1997: 436) 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 animate 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 carried by communication systems and examine the effects of media, including electronic media, more broadly.

For Deacon, the most important feature to recognize about 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. 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 facilitated 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. …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.(345)

In Deacon’s theory evolutionary selection on the prefrontal cortex was crucial in constructing the distributed mnemonic architecture that supports learning and analysis of higher-order associative relationships that constitute 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, 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. Deacon bases his theory of reference on (arguably a modified version of) Charles Sanders 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. This “meta” character of symbolic reference has wide-reaching consequences for subject formation.

For Deacon symbolic reference is virtual, unreal, and rests on the 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 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. This virtual character of symbolic reference is the source of its power and of its interest for our concerns with subject formation. For Deacon symbols are neurological tokens. Like buoys indicating an otherwise invisible best course, they mark a specific associative path, which we reconstruct by following the implicit symbolic reference. 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. (300)

Three points about symbolic reference are relevant to our present discussion. The power of symbolic reference is due to its shared character; it is largely external to the individual mind, being located in cultural systems and artifacts; and, as discussed above, it is virtual. Unlike the interpretation of icons and indices (a process uniquely personal and insular within each brain), symbolic representations are in part externally interpreted. 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. 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, shared, and virtual. These aspects of symbolic reference thus lead to some provocative and counter-intuitive peculiarities of subject formation:

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. (452)

Supported by the evidence of contemporary neuroscience on the plasticity of the neocortex and its capacity to adapt to intricate challenges of a changing cognitive environment, Deacon argues that rather than being rigidly hardwired 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 whose properties are constantly changing. 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. (Vygotsky, 1986) A number of theorists, including Andy Clark, have been interested in expanding this analysis to include media other than speech and writing, especially technologically mediated and computer-based forms of communication. It is to that argument I want to turn now.

In several books and pathbreaking articles Andy Clark has developed a compelling thesis about what he calls “extended mind” that provides the perfect bridge between Deacon’s work on the evolution of symbolic reference and our considerations of media in the posthuman singularity. Clark radicalizes much of recent work in cognitive science that emphasizes the embodied character of cognition. While agreeing with these new wave cognitive scientists that mind is not simply a device to manipulate symbols in terms of formal rules and that higher cognition is built on a substrate of embodied perceptuomotor capacities, Clark takes the position of embodied cognition in quite radical directions. While proponents of distributed cognition defend the embodied character of cognition and support the notion that cognition makes heavy use of external props in the world, for the most part, Clark argues, the world, and even to a certain extent the human senses are treated as instruments of the brain. In this account all genuinely cognitive activity, however richly supported by external material and social supports and bodily input, goes on inside the brain and central nervous system. Clark radicalizes this idea in moving from embodiment to cognitive extension. In the Extended model of cognition, thinking and cognition depend directly and noninstrumentally upon the ongoing work of the body and/the extraorganismic environment. According to Clark:
According to EXTENDED, the actual local operations that realize certain forms of human cognizing include inextricable tangles of feedback, feed-forward, and feed-around loops: loops that promiscuously crisscross the boundaries of brain, body, and world. The local mechanisms of mind, if this is correct, are not all in the head. Cognition leaks out into body and the world. (Clark, 2008: xxviii)

In discussing the parity principle at the basis of their important paper on the extended mind Clark and David Chalmers argue when the human organism is linked with an external entity creating a two-way interaction, the coupled system consisting of components both external and internal to the brain should be seen as a cognitive system in its own right. All the components, including the external components, play an active causal role and jointly govern behavior in the same way that cognition usually does. If by removing the external component the behavioral competence of the system drops, the external component should be viewed as much a causal factor in the cognitive process whether or not it is wholly in the head. (Clark and Chalmers, 1998: 8-9) In Clark and Chalmers' vision of cognition the boundary between external and internal perception and action disappears, so that iPhones, calculators, computational aids and less exotic cultural props such as the tray of letters in a game of Scrabble become components of the extended mind. In the years since they first published their paper (1998) Chalmers has become convinced that the extended mind is most likely even more widely extended than to the domain of beliefs and specifically cognitive processes. What about extended desires, extended reasoning, extended perception, imagination and emotions?

I think there is no principled reason why the physical basis of consciousness could not be extended in a similar way. It is probably so extended in some possible worlds: one could imagine that some of the neuronal correlates of consciousness are replaced by a module
on one’s belt, for example. There may even be worlds where what is perceived in the
environment is itself a direct element of consciousness.(Chalmers, 2008: xiv;
Chalmers, 2006: 49-125)

Brain-machine interfaces such as cochlear implants, artificial prosthetic hippocampus chips,
retinal implants and DARPA’s “brain-in-the-loop” imaging systems for its Cognitive Threat
Awareness Program are all examples of where the extended mind might be heading.(Clark, 2007)
But less invasive socially networked pervasive computing systems are likely to have even more
profound effects in creating the extended mind.

The extended mind thesis treats human cognition as distributed and multiply hybrid, involving a
complex interplay between internal biological and external non-biological resources. On this
model, then, thinking itself is deeply hybrid, involving internal biological resources as well as
external agent/artifacts annexed and scaffolded as parts of cognitive processes. Included in these
external elements are sociocultural artifacts, such as gestures, diagrams, external text, software
applications and more. But chief among these resources is language itself, which Clark and
Chalmers consider the ultimate artifact.(Clark, 2004) Language in this view is an external public
code organized around arbitrary material symbols. Its primary role is to facilitate a coordinated
coupling between the internal biological structures and processes of the brain and external non-
biological resources. Language, according to the Clark-Chalmers Extended Mind model, is a
crucial hybrid structure: It straddles the internal-external borderline, looking one moment like any
other piece of the biological equipment, and at the next like a particularly potent piece of external
cognitive scaffolding.(Clark, 2006: 293) Language in this view is not a mirror of internal states but
rather a complementary external structure that carries the major burden of coordinating coupling
between external cognitive artifacts and processes and the brain’s internal representational regime.
Drawing on a variety of recent studies in cognitive science, such as (Barsalou, 1999), (Elman,
2004), (Clowes, 2007a; 2007b), and others, Clark argues that the symbolic environment impacts thought by activating internal representational resources and by allowing the stable structures of public language with its rich set of material symbols to act as a fulcrum for attention, memory and control and as an anchor in the fluid stream of active thought and conceptualization.

The Extended Mind treatment of language in terms of hybrid representational forms, coordination dynamics and complementarity between biological and artifactual contributions provides an account of how the “entanglement” Hayles describes of media with the formation of human subjects might take place in the new inscription practices of pervasively mediated computer environments. The key point in Clark’s model is that language is fundamentally an external resource, and even processes of internal thought, silent rehearsal, and other forms of “off-line” linguaform representation for problem-solving are internal recapitulations of the relevant external vehicles. Of course, there are internal representations in this model, but Clark-Chalmers part company with defenders of neural mentalese (Churchland) or a hardwired language of thought (Fodor). Stressing hybrid representational forms and coordination dynamics of a brain that is fundamentally a pattern-completing engine, they propose that external artifactual resources of the symbolic environment are co-opted without being replicated by special biological structures or translated into another internal code. Exposure to external material symbols and epistemic artifacts does not result in the installation of new internal representational forms in the brain, or as Dennett proposed, by installing a new virtual serial machine via “myriad microsettings in the plasticity of the brain.” (Dennett, 218-219) Rather words, sentences, and other stable public symbolic forms are used without radically altering the brain’s basic modes of representation and computation. External public symbol structures, in this view, complement the basic modes of operation and representation endemic to the biological brain. Clark notes that “The brain represents these structures, of course. But it does so in the same way it represents anything else. They do not
reorganize neural routines in any way that is deeper or more profound than might occur, say, when we first learn to swim, or to play volleyball.” (Clark, 2004: 720)

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 200,000 to 100,000 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 *Sapiens* and has continued at an ever increasing pace since is the development of supplements to individual internal biological memory in the form of visuographic systems and external memory media, especially written records and other forms of symbolic storage. (Donald, 1991: 308-312) Rather than being limited by our neural architecture these external material supports have only enhanced the symbolizing power of the mind. My point is that the recent development of the Web and the rise of ubiquitous computing happening in our own day 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, Brian Rotman argues that the medium of alphabetic writing introduced as silent collateral machinic effects an entire apparatus enabling practices, routines, patterns of movement and gestures, 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.
(Rotman, 2008: 92) This model of the mind and of thinking is being challenged and displaced by the researches of contemporary cognitive science, which is demonstrating that thinking is not only 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. According to Rotman the parallelization of multiple computational media resources 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. 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, a new parallelist radically different self is in the process of displacing the single, serial, alphabeticized psyche: “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’ 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.” (99-100)

The infrastructure of ubiquitous computing envisioned two decades ago by Mark Weiser and John Seely Brown offers the nutrient matrix for Clark’s posthuman extended mind and Rotman’s collective paraselves (Weiser: 1991, 1994; Weiser and Brown: 1996); namely, a world in which computation would disappear from the desktop and merge with the objects and surfaces of our ambient environment. (Greenfield: 2006) Rather than taking work to a desktop computer, many
tiny computing devices would be spread throughout the environment, in computationally enhanced walls, floors, pens and desks seamlessly integrated into everyday life. As Ulrik Ekman cautions in the introduction to this volume, we are still far from realizing Weiser’s vision of computing for the twenty-first century. Apart from the fact that nearly every piece of technology we use has one or more processors in it, we are far from reaching the transition point to ubiquitous computing when the majority of those processors are networked and addressable. But we are getting there. There have already been a number of milestones along the road to ubiquitous computing. Inspired by efforts from 1989-1995 at Olivetti and Xerox PARC to develop invisible interfaces interlinking coworkers with electronic badges and early RFID tags (Want, 1992,1995,1999), the Hewlett Packard Cooltown project (2000-2005) offered a prototype architecture for linking everyday physical objects to Web pages by tagging them with infrared beacons, RFID tags, and bar codes. Users carrying PDAs, tablets, and other mobile devices could read those tags to view Web pages about the world around them and engage services, such as printers, radios, automatic call forwarding and continually updated maps for finding like-minded colleagues in locations such as conference settings. (Barton, 2001; Kindberg, 2002)

While systematically constructed ubiquitous cities based on the Cooltown model have yet to take hold, many of the enabling features of ubiquitous computing environments are arising in ad hoc fashion fuelled primarily by growing mass consumption worldwide of social networking applications and the wildly popular new generation smart phones with advanced computing capabilities, cameras, accelerometers, and a variety of readers and sensors. In response to this trend and building on a decade of Japanese experience with Quick Response (QR) barcodes, in December 2009 Google dispatched approximately 200,000 stickers with bar codes for the windows of its “Favorite Places” in the US, so that people can use their smart phones to find out about them. Besides such consumer-oriented uses, companies like Wal-Mart and other global
retailers now routinely use RFID tags to manage industrial supply chains. These practices are now indispensable for hospital and other medical environments. Such examples are the tip of the iceberg of increasingly pervasive computing applications for the masses. Consumer demand for electronically mediated pervasive “brand zones” such as Apple Stores, Prada Epicenters, and the interior of your BMW where movement, symbols, sound, and smell all reinforce the brand message turning shopping spaces/driving experiences into engineered synesthetic environments are powerful aphrodisiacs for pervasive computing.

Even these pathbreaking developments fall short of Weiser’s vision which was to engage multiple computational devices and systems simultaneously during ordinary activities without having to interact with a computer through mouse, keyboard and desktop monitor and without necessarily being aware of doing so. In the years since these first experimental systems rapid advances have taken place in mobile computing, including: new smart materials capable of supporting small, light weight, wearable mobile cameras and communications devices; many varieties of sensor technologies; RFID tags; physical storage on “motes” or “mu-chips”, such as HP’s Memory Spot system which permits storage of large media files on tiny chips instantly accessible by a PDA (McDonnell, 2010); Bluetooth; numerous sorts of GIS applications for location logging (eg., Sony’s PlaceEngine and LifeTagging system); wearable biometric sensors (eg., BodyMedia, SenseWear).

To realize Weiser’s vision though, we must further augment these sorts of breakthroughs by getting the attention-grabbing gadgets, smart phones and tablets out of our hands and begin interacting within computer-mediated environments the way we normally do with other persons and things. Here, too, recent advancements have been enormous, particularly advances in gesture and voice recognition technologies coupled with new forms of tangible interface and information displays. (Rekimoto, 2008)
Two prominent examples are the stunning gesture and voice recognition capabilities in the Microsoft Natal system for the Xbox 360 to be commercially available in 2010, which dispenses with a game controller altogether in favor of gesture recognition as game interface. But for our purposes the SixthSense prototype developed by Pranav Mistry and Pattie Maes at MIT points even more dramatically to an untethered fusion of the virtual and the real central to Weiser’s vision. (Mistry, 2009a; 2009b; 2009c) The SixthSense prototype is comprised of a pocket projector, a mirror and a camera built into a small mobile wearable device. Both the projector and the camera are connected to a mobile computing device in the user’s pocket. The camera recognizes objects instantly, with the micro-projector overlaying the information on any surface, including the object itself or the user’s hand. Then the user can access or manipulate the information using his/her fingers. The movements and arrangements of markers on the user’s hands and fingers are interpreted into gestures that activate instructions for a wide variety of applications projected as application interfaces—search, video, social networking, basically the entire Web. SixthSense also supports multi-touch and multi-user interaction. [See Figure 1: a, b, c]

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<th>Figure 1: Pranav Mistry and Pattie Maes, SixthSense. The system is comprised of a pocket projector, a mirror and a camera built into a wearable device connected to a mobile computing platform in the user’s pocket. The camera recognizes objects instantly, with the micro-projector overlaying the information on any surface, including the object itself or the user’s hand. (Photos courtesy of Pranav Mistry)</th>
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Thus far we have emphasized technologies that are enabling the rise of pervasive computing, but, as Ulrik Ekman cautioned in his introduction, ‘ubiquitous computing’ not only denotes a technical thrust; it is equally a socio-cultural formation, an imaginary and, as I have tried to indicate, a source of desire. From our perspective its power becomes transformative in permeating the affective domain, the machinic unconscious. Perhaps the most significant development driving this reconfiguration of affect are the phenomena of social networking and the use of “smart phones”. More people are not only spending more time online; they are seeking to do it together with other wired “friends”. Surveys by the Pew Internet & American Life Project report that between 2005-2008 use of social networking sites by online American adults 18 and older quadrupled from 8%-46% and that 65% of teens 12-17 used social networking sites like Facebook, MySpace, or LinkedIn. The Nielsin Company reports that 22 % of all time spent online is devoted to social network sites. (NielsenWire, June 15) Moreover, the new internet generation wants to connect up in order to share: the Pew Internet & American Life Project has found that 64% of online teens ages 12-17 have participated in a wide range of content-creating and sharing activities on the internet, 39% of online teens share their own artistic creations online, such as artwork, photos, stories, or videos, while 26% remix content they find online into their own creations.(Lenhart, 2010, “Social Media”) The desire to share is not limited to text and video, but is extending to data sharing of all sorts. Sleep, exercise, sex, food, mood, location, alertness, productivity, even spiritual well-being are being tracked and measured, shared and displayed. On MedHelp, one of the largest Internet forums for health information, more than 30,000 new personal tracking projects are started by users every month. Foursquare, a geo-tracking application with about one million users, keeps a running tally of how many times players “check in” at every locale, automatically building a detailed diary of movements and habits; many users publish these data widely.(Wolf, 2010) Indeed, most internet users are not concerned about the amount of
information available about them online, and most do not take steps to limit that information. Fully 60% of internet users say they are not worried about how much information is available about them online. Similarly, the majority of online adults (61%) do not feel compelled to limit the amount of information that can be found about them online. Just 38% say they have taken steps to limit the amount of online information that is available about them. (Madden: 2007, 4) As Kevin Kelly points out we are witnessing a feedback loop between new technologies and the creation of desire. The explosive development of mobile, wireless communications, widespread use of RFID tags, Bluetooth, embedded sensors, QR addressing, applications like Shazam for snatching a link and downloading music in your ambient environment, GIS applications of all sorts, social phones such as numerous types of Android phones and the iPhone4 that emphasize social networking are creating desire for open sharing, collaboration, even communalism, and above all a new kind of mind. (Kelly: 2009a, 2009b) [See Figure 2: a, b, c]

Insert Figure 2: a, b, c about here]

| Figure 2: 3D mapping, location aware applications, and augmented reality browsers. (Photos courtesy of Earthmine.com and Layer.com) |
|---|---|---|
| ![a](earthmine_flash.png) | ![b](earthmine_flash.png) | ![c](layar.png) |
| a. Earthmine attaches location aware apps (in this case streaming video) to specific real-world locations. | b. Earthmine enables 3D objects to be overlaid on specific locations. | c. Layar augmented reality browser overlays information, graphics, and animation on specific locations. |
The reconfiguration of the human currently underway is not just about developing new technologies and applications that facilitate information management in pervasive computing. Our new collective minds are deeply rooted in an emerging corporeal axiomatic, the domain identified by Guattari as the machinic unconscious—a wide range of media ecologies, material practices, social apparatuses for encoding and enforcing ways of behaving through routines, patterns of movement and gestures, as well as haptic and even neurological patterning/re-patterning that facilitate specific behaviors and modes of action. (Guattari, 2009) In this model technological media are conjoined with unconscious and preconscious cognitive activity to constitute subjects in particular, medium-specific directions. A body of empirical research spanning the past decade, too large to discuss here, has documented the range and extent of complex psychological functions that can transpire automatically, triggered by environmental events and without an intervening act of conscious will or subsequent conscious guidance. (Bargh, 1999; 2000; Hassin, 2005)

The affective domain is being reshaped by electronic media. Core elements of the domain of affect are unconscious social signals, primarily consisting of body language, facial expressions, and tone of voice. These social signals are not just a complement to conscious language; they form a separate communication network that influences behavior, and can provide a window into our intentions, goals, and values. Much contemporary research in cognitive science and other areas of social psychology is reaffirming that humans are intensely social animals and that our behavior is much more a function of our social networks than anyone has previously imagined. The social circuits formed by the back-and-forth pattern of unconscious signaling between people shapes much of our behavior in families, work groups and larger organizations. (Pentland, 2007, “Collective Nature of Human Intelligence”) By paying careful attention to the patterns of signaling within a social network, Pentland and others are demonstrating that it is possible to harvest tacit
knowledge that is spread across the network’s individuals. While our hominid ancestors communicated face-to-face through voice, face, and hand gestures, our communications today are increasingly electronically mediated, our social groups dispersed and distributed. But this does not mean that affect has disappeared or somehow been stripped away. On the contrary, as the “glue” of social life, affect is present in the electronic social signals that link us together. The domain of affect is embedded within and deeply intertwined with these pervasive computing networks. The question is, as we become more socially interlinked than ever through electronic media can the domain of affect be accessed, measured, perhaps understood and possibly manipulated for better or worse?

A number of researchers are developing systems to access, record and map the domain of affect, including a suite of applications by Sony Interaction Laboratory director Jun Rekimoto (Rekimoto, 2006; 2007a; 2007b; 2010) and a multiperson awareness medium for connecting distant friends and family developed by Pattie Maes’ group at MIT. For the past five years Sandy Pentland and his students at the MIT Media Lab have been working on what they call a socioscope for accessing the affective domain in order to make new social networked media smarter by analyzing prosody, gesture, and social context. The socioscope consists of three main parts: “smart” phones programmed to keep track of their owners’ locations and their proximity to other people by sensing cell tower and Bluetooth IDs; electronic badges that record the wearers’ locations, ambient audio, and upper body movement via a two-dimensional accelerometer; and a microphone with body-worn camera to record the wearers’ context, and software that is used to extract audio “signals”, specifically, the exact timing of individuals’ vocalizations and the amount of modulation (in both pitch and amplitude) of those vocalizations. Unlike most speech or gesture research, the goal is to measure and classify speaker interaction rather than trying to puzzle out the speakers’ meanings or intentions.
One implementation of this technology is the Serendipity system, which is implemented on Bluetooth-enabled mobile phones and built on BlueAware, an application that scans for other Bluetooth devices in the user’s proximity. (Eagle, 2005) When Serendipity discovers a new device nearby, it automatically sends a message to a social gateway server with the discovered device’s ID. If it finds a match, it sends a customized picture message to each user, introducing them to one another. The phone extracts the social signaling features as a background process so that it can provide feedback to the user about how that person sounded and to build a profile of the interactions the user had with the other person. The power of this system is that it can be used to create, verify, and better characterize relationships in online social network systems, such as Facebook, MySpace, and LinkedIn. A commercial application of this technology is Citysense, which acquires millions of data points to analyze aggregate human behavior and to develop a live map of city activity, learns about where each user likes to spend time and processes the movements of other users with similar patterns. Citysense displays not only "where is everyone right now" on the user’s PDA but "where is everyone like me right now." (Sense Networks, 2008)

There are a number of implications of this technology for quantifying the machinic unconscious of social signals. Enabling machines to know social context will enhance many forms of socially aware communication, and indeed, the idea is to overcome some of the major drawbacks in our current use of computationally mediated forms of communication. For example, having a quantifiable model of social context will permit the mapping of group structures, information flows identification of enabling nodes and bottlenecks, and provide feedback on group interactions: Did you sound forceful during a negotiation? Did you sound interested when you were talking to your spouse? Did you sound like a good team member during the teleconference?
Conclusion

Brian Rotman and Brian Massumi are both optimistic about what access to the affective domain might occasion for our emerging posthuman communal mind. For Massumi, better grasping the domain of affect will provide a basis for resistance and counter tactics to the political-cultural functioning of the media. (Massumi, 43-44) For Rotman the grammaticalization of gesture holds the prospect of a new order of body mediation opening it to other desires and other semiotics. Pentland is equally optimistic. But his reflections on what quantification of the affective domain may offer sound more like a recipe for assimilation than resistance. Pentland writes:

> By designing systems that are aware of human social signaling, and that adapt themselves to human social context, we may be able to remove the medium’s message and replace it with the traditional messaging of face-to-face communication. Just as computers are disappearing into clothing and walls, the otherness of communications technology might disappear as well, leaving us with organizations that are not only more efficient, but that also better balance our formal, informal, and personal lives. Assimilation into the Borg Collective might be inevitable, but we can still make it a more human place to live. (2005, 39)

Computer scientist/novelist Vernor Vinge first outlined the notion that humans and intelligent machines are headed toward convergence, which he predicted would occur by 2030. (Vinge, 1993) In his essay for this volume, John Johnston points out that Vinge also predicted a stage en route to the Singularity where networked, embedded, and location aware microprocessors provide the basis for a global panopticon, (Vinge, 2000; Wallace, 2006) and that Vinge has remained steadfastly positive about the possibilities presaged in this era: “...collaborations will thrive. Remote helping flourishes; wherever you go, local experts can make you as effective as a native. We experiment with a thousand new forms of teamwork and intimacy.” (Johnston, this volume;
Vinge, 2000) Such systems are not only on the immediate horizon; they are patented and commercially available in the prototypes coming from the labs and companies founded by scientists such as Pentland, Maes and Rekimoto, each of whom is emphatic about the need to implement and insure privacy in the potentially panoptic systems they have developed. (Sense Networks, “Principles”). We need not fear the singularity; but beware the panopticon.
Works Cited


