Trying to be Calm:

Ubiquity, Cognitivism, and Embodiment

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Introduction

Mark Weiser and John Seely Brown proposed a 'calm' backgrounded technology as a reaction to the laborious and foregrounded nature of '90s computer systems and the techno-fetishism exemplified by mid 90's Virtual Reality (Weiser and Seely Brown, 1995). This paper traces discursive and technological transitions between the decade of 'virtuality' (1990s) and the decade of ubiquity (2000s). The paper proposes that the notion of virtuality was in part a product of an incomplete technology. The paper outlines the role of the cognitivist paradigm in shaping notions of computation and virtuality through the 90s and draws attention to the increasing importance of discourses of embodiment in both HCI and media arts since the early 90s. The key role of media artists in proposing and developing new modalities of embodied interaction is observed. Two quite different classes of technology which are often grouped under the rubric of 'ubiquitous computing' are distinguished. It is argued that the ongoing paradigm shift toward embodied and performative cognitive perspectives is critical to resolving theoretical and (interaction) design challenges inherent in the development of ubiquitous technology.

After Virtuality

I propose that discourses of technological 'virtuality' during the 1990s are attributable in large part to the vestigal condition of interface technologies during that decade, a condition which was theoretically supported by the prevailing cogntivism. In their new roles as interactive multimedia systems, computers were inadequately supplied with interfaces to the physical world –

the previously ‘normal’ roles of computers did not call for such interfaces. This disjunction between comparative sophistication of computational capabilities and the relative paucity of interface capabilities led, I would argue, to the notion of the (computational) virtual, and the confused rhetorics of virtuality. In hindsight we might say that the 90’s furor around the ‘virtual’ was symptomatic of this technological imbalance, that much of the research work and grass-roots development of the 90’s was directed at correcting that imbalance, and that the current era of ubicomp evidences the effectiveness of that correction.

The 1990’s saw an explosion of creative research in interactive and immersive art, catalysed by increasing availability of domestic and prosumer computer-based media technologies, and fueled by burgeoning rhetorics of cyberculture. The realm of the arts was a highly charged vortex for this work as the traditional commitment to material immediacy and finely crafted sensorial effect abruptly confronted a technology framed as abstract immaterial manipulation of information. Over that decade, media arts practitioners played a key and vigorous role in diagnosing, imagining and developing interface technologies and new modalities of engagement. Capabilities of real time interaction and databasing made questions of the aesthetics of (hyper) narrative and of embodied experience of the digital central. A desire to reconcile the sensibilities of arts practices and the capabilities and constraints of emerging computational media technologies, was as important as an exploration of the potential of the new technologies themselves. It was a radically interdisciplinary moment, bringing together artists, computer scientists, critical and media theorists and others, and driven by the traditions of open intellectual inquiry and interdisciplinarity in the Arts and the previous thirty years of ‘art and technology’ practice.

El bal de Fanalet/ Lightpools. Naric Pares, Roc Pares and Perry Hoberman, 1998. El bal de Fanalet/ Lightpools combined sonar-based tracking and interactive artificial life-based graphics with artifacts derived from Catalan popular culture.

The transition from the period of virtuality to the period of ubiquity was a result of the maturation of interface technologies absent from the technological

palette of the 90s. Since then a variety of technologies linking the dataworld with the lived physical world: sensing and tracking technologies (such as MEMS accelerometers, machine vision, laserscanners, GPS, RFID) and mobile communications technologies have been developed and deployed. This has had the effect of nesting the 'virtual' back into the lived physical world, revealing it to be a panic around an explosive and messy technological transition period. This belated integration of data with the world caused 'the Virtual' to evaporate. The transition from VR to more nuanced augmented and mixed-reality modes deploying VR's stock-in-trade tracking and simulation techniques indicates that ubiquitous computing is less the kind of antithesis of VR which Weiser envisaged, and more of a continuity.

Petit Mal - Autonomous Robotic Artwork. Simon Penny, 1993-95. Shown here in the Smile Machines Exhibition (curator Anne-Marie Duguet), Transmediale 2006, Berlin.

At the same time that human computer interaction moved out beyond the research lab, human interaction with the world and with technology was addressed more intensively – as is evidenced by the rapid expansion of HCI, CSCW and related areas of research. HCI became increasingly interdisciplinary as psychologists, anthropologists and sociologists became involved. As recognition of the shortcomings of the cognitivist paradigm became more widespread, new modes of cognitive science grappled with the embodied, enactive, situated and social dimensions of cognition (Varela, Thompson and Rosch, Suchman, Hutchins). Neuroscience research revealed new dimensions of the mind-body relation (Edelman, Ramachanran, Sacks, etc). Conventional philosophy of mind has been challenged on these bases by Lakoff and Johnson, Clark, Thompson and others. This movement met media artists coming the other way, as it were – exploring the application of computational technologies to embodied, material and situated cultural practices. The crafting of embodied, sensorial experience is a fundamental expertise of the arts, an expertise which is as old as human culture itself. Various topics of critical discourse which had been lumped-in with discussion of the virtual have persisted, and in particular, it has become clear that many of the aesthetic projects of 'media-artists' are inherently concerned with the central issues of ubiquity.

Ubiquity : figure and ground

Mark Weiser, John Seely Brown and others made clear their motivations for a 'calm technology' that recedes from attention, but the term 'Ubiquitous computing' is applied to two quite different types of technology. One is industrial and embedded, effectively invisible and accessed by experts. The other is consumer commodity, very visible and demanding of attention, while nonetheless affording sophisticated data-gathering available to paying customers. Although the two categories have much in common technologically, they are very different in their relation to the social.

Intelligent buildings, augmented spaces and complex machines, as well as communications networks themselves involve distributed and networked 'embedded' technologies composed of small, low power units – in practice invisible, with no (immediate) human interface - no screen, no keyboards (perhaps an LED). These systems have been integrated into existing technologies, edging them a little further along the mechanically causal - homeostatic - adaptive trajectory, quasi-organisms with digital nervous systems. Cars, planes, refineries, hospitals, bridges, utility infrastructures, seismic faultlines and national borders are now increasingly digitally instrumented. Engines run a little smoother and cleaner, industrial workplaces have fewer workers and fewer accidents due to human error, illegal immigrants are intercepted more efficiently.

In consumer goods, the obsession with the interface does not seem to have abated, the ecstasy of computation - if not the ecstasy of communication - seems to have become a fixture of popular culture. While miniaturisation and wireless networking have indeed moved 'out into the physical world', it has not resulted in 'repositioning it in the environmental background' (Ekman, this volume). Rather, the miniaturised but intensified interface, attention demanding and insistent, is foregrounded. While the technological infrastructure (cell phone reception, etc) has indeed become ubiquitous, on the level of human experience, many technologies reinforce a discontinuity between the dataworld and the physical world.

Mobile wireless technology has certainly become ubiquitous, but perhaps not in the way Weiser hoped. These words ‘ubiquitous’, ‘pervasive’, ‘embedded’ all have an ominous ring, they carry negative connotations of an oppressive informational monoculture or monopolistic order, perhaps because of their deployment in military jargon. While the technical modalities of the technology are novel, the purposes to which they are put retain functions of surveillance and control. It is not just a question of to what ends the technology is deployed and whom it is working for or against, but of to whom the systems are visible and to whom they are invisible.

Skeuemorphs Rule, OK?

David Mindell reminds us: “Our computers retain traces of earlier technologies, from telephones and mechanical analogs to directorscopes and tracking to radars.” (Mindell 321) The physical conformation and functionality of the machine we use is determined by the history of technologies from which it arose. Interactive multimedia, we must recall, is the child of Cold War computing research. The SAGE (Semi Automatic Ground Environment) system put soldiers with keyboards and lightpens in front of monitors, to accomplish the complex pattern recognition functions which the system could not autonomously achieve. This constellation of technologies was the model for the keyboard-mouse-monitor paradigm. The fact that this harnessing of flesh to machine was later clad in the rhetoric of liberation in the heyday of interactive multimedia remains deeply ironic.

Why did the computer, which once was a basement sized machine staffed by attendants, morph into a desktop machine? The historical answer is that it was applied the kinds of tasks which people who sit at desks do when sitting at desks. Functionally, the desktop computer was an enhanced typewriter and calculator with added filing-cabinet functionality. It follows then that it is particularly useful and relevant for activities which resemble office desk activities, such as record management, accountancy and letter writing, and is decreasingly appropriate for activities whose social and architectural placement diverges from that scenario. Many human activities, including

cultural and artmaking activities, do not resemble office work in their physical contexts, methodologies or goals.

For the last generation, we have managed with computer technology which, for all its touted user-friendliness, has continued to demand that we preprocess our thoughts and experiences into a kind of keystroke mush which is easily amenable to the limited a-d capability of these machines. If we are to pursue the fundamental goals of Weiser's ubiquity, it means developing computational technology past the stage that we and it appear to have got co-dependently stuck in - tolerating a technology which must be spoon-fed with little alphanumeric streams. Mercifully, after thirty years of personal computing I no longer have to always position myself in work-position at my work-station, from which I cannot move even a few feet without breaking my connection with the machine by losing contact with screen and keyboard. But why, having finally freed ourselves from the bondage of the desktop, do we tolerate having to poke unidigitally at a miniature QWERTY on our mobile devices? What a profound failure of imagination!

Trying to Be Calm

There is a significant difference between enhancing the control systems of existing machine complexes and the enmeshing of computational processes with human cultural and biological processes. I've distinguished between, on the one hand, clandestine, faceless technologies which involve distributed units in a larger control array which itself is embedded in a larger machine complex; and on the other hand, garrulous, clingy technologies close to the body. Neither of these seems particularly *calm*. Beyond embedded miniaturization (microcontrollers), location (tracking) and transmission (internet and wireless communication), how far have we come along the trajectory to *calmness*? Is automated processing of logical operations is necessarily applicable and an asset in every aspect of life? Are there aspects of our lives where digital intrusion might be utterly undesirable? (Do I need 'blueteeth' that notify my dentist directly when they sense decay? Probably not. I certainly don't feel the need for pop-up ads on the periphery of my vision when I'm wearing my sunglasses.) To ask this question is to challenge the marketing

rhetoric of the computer industry, to challenge the assumption of the desirability of the intrusion of computation everywhere: that automated processing of logical operations is necessarily applicable and an asset in every aspect of life. Computation is not value-free cognitive bedrock. There is nothing ‘neutral’ about the culture of computation, even if we are naturalized to it.

While such issues are not necessarily foregrounded in everyday use of consumer devices, we should review the aspirations of ubi-comp and its current implementations, and consider the desirability of the current trajectory. In what more or less subtle or insidious ways does the bending of human activities to the needs of a not entirely calm technology stain or perturb the richness of those practices? I am thinking here of skilled embodied practices in particular; practices which have developed organically over generations, subtly adapted to the complex richness of human formation, where artifacts have co-evolved in ways which adapt and optimize subtleties of human sensori-motoric capabilities, which may never have been, nor have had to be, made explicit. Consider two examples, one high, one low: the culture of the violin and the culture of the household kitchen. What makes a Stradivarius so much more of a violin than a cigar box with a rubber band stretched over it? The special quality of such an instrument is that it has been formed through an extended period of interplay between artisans and players. A history of co-evolution between the material specificities of the artifact and the repertoire, an increasingly refined atunement between the embodied intelligences of the artisan and the musician. A Kitchen likewise evolves as a workplace through use - chains of intuitive design tweaks - a subtle interplay between the ingredients, artifacts and procedures of specific cuisines, spatial layouts and the physical capabilities of its users.

In such contexts the application of digital technologies almost always has the effect of ‘thinning out’ the experience in question, and this is due in part to a preoccupation with problem-solving on the symbolic plane and the ensuing elision of the situated, embodied action. This syndrome maps onto imperatives of computer engineering – modularity/reductivism, standardization/generality,

optimality/efficiency – instrumentality generally. These criteria are valid in their 'home territory' – I want my laptop battery to have maximum life, I want my file to be compatible, I do not want anyone taking aesthetic liberties with the shape of an airplane wing. But the validity of these criteria wanes as they are applied in territories further from home. Optimisation of *King Lear* or Beethoven's 5^{th} by elimination of redundancy is an inherently ludicrous proposition.

The Profundity of Material Being

The term 'Human factors' speaks volumes about the engineering mindset - as if the qualities of human embodiment were peripheral, 'implementation details'. This is veiled cognitivitism, in the sense that thinking is conceived of as abstract symbol manipulation and is taken to be an end in itself, rather than part of the process of ongoing lived being. Combined with a rather Victorian characterization of human perception and action, inflected with dualism, serial processing (input-output) and cognitivism informs much computational thinking. The crisis of the cognitivist model, (heralded, ironically, by the faltering of Artificial Intelligence) led to renewed attention to embodied, situated and material aspects of cognition. This new cognitive science is immediately relevant to the still-vexed 'human factors' aspect of ubiquitous computing, precisely because it addresses aspects of human experience pertinent to the development of richer and more subtle, if not calmer technologies of interaction.

Escape from the cognitivist cul-de-sac demands a wholesale paradigm-shift and a new set of axiomatic assumptions: mind and body are not separate or separable; self and world is likewise an invidious distinction; intelligence is making sense of the world; thinking occurs at the fingertips and in the soles of the feet, in the process of interaction with the world. Calm, embedded, context aware technology implies a phenomenological understanding of being-in-the-world, or, rather of a performative 'doing-in-the- world', of situated sensori-motor action. Coming to understand the emergence of meaning through a temporal process of bodily interaction with things and people in the world is to engage what Andy Pickering has called *The Mangle of Practice* (1995). In this work, Pickering captures a key aspect of the paradigm shift I am arguing for in

his distinction between what he called the representational idiom and the performative idiom. In these terms, the cognitivist paradigm is firmly rooted in the representational idiom. I propose that the pursuit of ubiquity demands a post-cognitivist approach attending to embodiment, to the performative relation to artifacts and the world, and to the relation of cognition to social and cultural formations. In what follows, I give an introduction to such perspectives via a discussion of the work of Edwin Hutchins.

Cognition Distributed and Embodied

In 1995, Edwin Hutchins published a remarkable work of interdisciplinary scholarship which combined anthropological field work with cognitive science and computational theory. He analysed the group activity of navigation on a ships bridge as a case of 'distributed cognition,' in which a group of people performing specific roles and communicating to each other in specific ways, using a highly developed set of tools perform computational tasks. In a more recent paper,"Imagining the Cognitive Life of Things", Hutchins makes some remarkable observations on cognition in the wild, which warrant quotation at length:

> "In the last chapter of *cognition in the wild* … I argue that cognitive science made a fundamental category error when it mistook the properties of a person in interaction with a social and material world for the cognitive properties of whatever is inside the person. One enduring problem with this claim is that it demands a description of how cognitive properties arise from the interaction of person with social and material world. *Cognition in the Wild* provides a profoundly incomplete answer to this question…For the most part, the cognitive processes described in *Cognition in the Wild,* and in other treatments of distributed cognition, are presented without reference to the role of the body in thinking. That is, in spite of the fact that distributed cognition claims that the interaction of people with things is a central phenomenon of cognition, the approach has remained oddly disembodied." (Hutchins)

I want to dwell upon Hutchins' laudable self-criticism because is it a useful example of the slow process of de-naturalising axiomatic assumptions (in general and) in cognitive science, and is exemplary of the paradigm shift

which is occurring in cognitive studies. *Cognition in the Wild* can be read as an attempt to recuperate a functioning and historically coherent system to computationalism. As Philip agre puts it: “A computer… does not simply have an instrumental use in a given site of practice; the computer is frequently about that site in its very design. In this sense computing has been constituted as a kind of imperialism; it aims to reinvent virtually every other site of practice in its own image” (Agre 2003). When Hutchins translates one activity into the terms of another, explaining navigation in terms of computation; the authority of this translation is given by the (presumed) authority of the discourse of computation. The ability of the crew, their training and process, tools and artifacts, was demonstrably effective long before computational explanation – recall that the expressed purpose of Babbage’s difference engine was to calculate tide tables for the British navy – aids to precisely the kind of navigation Hutchins observed.

In what way and for whom did *Cognition in the Wild* ‘explain’ the procedures of coastal navigation, or to put it another way: what is the power of the computational explanation? An unreconstructed computational explanation would necessarily explain observed phemonema in functionalist terms (Putnam 1967- since recanted). Functionalism asserts that a mental state is constituted by the causal relations that it bears to sensory inputs, behavioral outputs and other mental states. Cognitivism is just one (computational) version of functionalism. Functionalism has a rather industrial if not von Neumannesque cast in its reliance on the idea of serial processing, inputs and outputs. The cognitivism of *Cognition in the Wild* is more nuanced. Cognition, for Hutchins, is embedded in artifacts and practices and shared among actors – but it is still understood as computation. As cognitive science reaches out further and further into cultural realms where computation is an increasingly alien concept, distinctions between technical and popular usages become increasingly hazy, the imperializing project of computer culture insidiously persists.

Hutchins’ recognition that “Interactions between the body and cultural artifacts constitute an important form of thinking. These interactions are not taken as

‘indications’ of invisible mental processes, rather they are taken as the thinking processes themselves” (Hutchins, 2006) are reminiscent of remarks made by Hubert Dreyfus many years earlier in his phenomenological critique of AI: “My personal plans and my memories are inscribed in the things around me just as are the public goals of men in general.” (Dreyfus, 1992, 266) More recently John Sutton has similarly noted that “…thought is not an inner realm behind practical skill, but itself an intrinsic and worldly aspect of real-time engagement with the tricky material and social world.” (Sutton 2008, 50) To permit that bodily motion may constitute the medium of thinking itself is a radical assertion for a rehabilitated cognitivist, but will come as no surprise to the dancer or practitioner of martial arts, nor to any thoughtful person while rock climbing or hanging out the laundry. But we must not underestimate the profundity of this sea-change in cognitive science, it indicates a hard-won emancipation from naturalization to the tenets of AI. Philip Agre lucidly documents his won such emanciption. He credits his reading of Foucault’s *The Archeology of Knowledge* specifically and poststructural writing generally as an epiphany: “…they were utterly practical instruments by which I first became able to think clearly and to comprehend ideas that had not been hollowed out through the false precision of formalism.” (Agre 1997, “Towards a Critical Technical Practice.”)·

It is precisely this ‘false precision of formalism’ that hollows-out embodied knowledge.

As Aldous Huxley observed long ago, “[i]n a world where education is predominantly verbal, highly educated people find it all but impossible to pay serious attention to anything but words and notions.” Numerous students of embodied cognition, from Michael Polyani to Evan Thompson, have stated what practitioners and teachers of embodied cultures have always known: the skills of bodily know-how are notoriously hard to document: such thinking is inherently non textual and non-intersecting with textual representation and text-based reasoning. Dreyfus, after Polyani, refers to such knowledge as “muscular gestalts.” (249) John Sutton notes in regard to the skill of the potter: “Because this kind of expertise relies on an immense reservoir of practical skill memory, embodied somehow in the fibres (*sic*) and in the sedimented ability to

sequence technical gestures appropriately, verbal descriptions of it (by either actors or observers) will be inadequate…what the expert remembers is in large part consciously inaccessible as well as linguistically inarticulable." (Sutton, 2008, 49) Philip Agre puts the complementary point when he observes that computational fields "concentrate on the aspects of representation that writing normally captures. As a result, theories will naturally tend to lean on distinctions that writing captures and not on the many distinctions that it doesn't." (Agre 2003, 290) It is precisely this discontinuity which creates a deep tension in the modern academy between the pedagogy of the textuo-symbolic regime and the pedagogy of the arts and other embodied practices – accounting for the failure of interdisciplinarity noted above.

Such (embodied) thinking is not computational in the usual sense, so any attempt to recuperate it to the world of computation has to force it through several transmogrifications to fit a linear, atemporal, Boolean mode of representation. The framing of group performance on a ships navigation bridge as distributed computation in a computational-cognitivist world-view was a tour de force by Hutchins. Yet, as he himself notes, the bodily dimensions of thinking such analysis rendered irrelevant or invisible:

> The processes that underlie the 'Aha!' insight remain invisible to a computational perspective in part because that perspective represents everything in a single mono-modal (or even a-modal) system. A careful examination of the way the body engages the tools in the setting, however, helps solve the mystery of how the discovery was made, and why it happened when it did. The insight was achieved in and emerged out of the navigators bodily engagement with the tool. (Hutchins, 2006)

Hutchins comes close to the work of Mark Johnson (1987) and also Lakoff and Johnson (1999) regarding the origins of abstract concepts in embodied experience when he notes: "Motion in space acquires conceptual meaning and reasoning can be performed by moving the body." (Hutchins, 2006) Here is revealed a fundamental cognitive cauterisation amongst all but the most sensitively designed interfaces and interactive systems – a situation which has

beleaguered digital arts practices: they ignore and erase bodily engagement of the sort that complement material artefacts and tools developed over years or generations and which, taken together, facilitate bodily reasoning. The navigators hoey, the engineers slide rule, the machinists caliper, the carpenters square, are amenable to computational explanation, because (loosely) what is involved is a relatively simple translation of geometry to algebra. The painters brush, the violinists bow, the harvesters scythe, and so many other artefacts, are complex and sophisticated devices for thinking with because they have evolved in a deep structural coupling with the basic rhythms and modalities of neural circuits and sensori-motor loops. They are prosthetics which integrate with the user at a deep and more organic level precisely because they do not involve a translation into and out of mathematico-logical computation. On the subject of artifacts, Hutchins notes: “By interacting with particular kinds of cultural things, we can produce complex cognitive accomplishments while employing simple cognitive processes.” (Hutchins 2006) Aspects of the environment are deployed as off-board memory, and consistent with Hutchins’ notion of distributed cognition, computation is offloaded too.

But are we not, in framing the situation in this way, reinstating precisely the computationalist bifurcations we sought to avoid? Not simply of storage and processing, but of the world and representation? Lambros Malafouris asserts that it makes little sense to speak of one system representing the other: “Although we may be well able to construct a mental representation of anything in the world, the efficacy of material culture in the cognitive system lies primarily in the fact that it makes it possible for the mind to operate without having to do so, ie, to think through things, in action, without the need of mental representation.” (Malafouris, 2004, 58) Micronesian canoeists gather knowledge about undersea geography, colloquially ‘through the seat of their pants’ (if they’re wearing any), but more accurately through a subtle integration of proprioceptive and vestibular cues related to the movement of their craft (canoe, catamaran) as a prosthetic extension of their embodiment. Hutchins goes on rightly to observe: “From the perspective of formal representation of the task, the means by which the tools are manipulated by the body appear as

mere implementation details." (Hutchins, 2006)

The phrase "implementation details" tells the score before the game begins. It belies a commitment to dualism that will automatically render invisible or irrelevant aspects of embodiment. Explanation of a group human activity in terms of computation will inevitably render invisible the significance of embodied practice because the irrelevance of embodiment is axiomatic to the rationale of the discipline. "Implementation details" is a phrase which stands in for an entire corpus of disciplinary rationalizations to justify the disembodiment of AI, as first articulated by Herbert Simon: "Instead of trying to consider the 'whole man', fully equipped with glands and viscera, I should like to limit my discussion to Homo Sapiens, 'thinking man.'" (Simon 1969, 65) This arbitrary and convenient 'limit' in the 'root document' of cogntivism is a veritable Pandoras box, which permitted the excision of embodied situated materiality from AI and cognitive science for a generation. The devil is not so much in the (implementation) details as in the desire to ignore them. "Implementation details" cannot be swept under the rug. Like 'human factors', the term has allowed technical community to sidestep the overarching importance of human culture – engagement of which would of course demand a challenging interdisciplinarity which always has the awkward potential of destabilizing axiomatic assumptions.

Conclusion.

Two decades ago, at the emergence of the 'reactive robotics' movement, Rodney Brooks critiqued the reigning representationalism in his pithy assertion that: "the world is its own best model," (Brooks 1991, 15) a sentiment which was sympathetic to emerging paradigms of embodied, situated and distributed cognition, and also with Hubert Dreyfus' phenomenological critique of AI. By virtue of evolutionary selection, there is direct cognitive correlation between the world and the bodily experience of it. This results in a kind of (performative) knowledge and (non-)cogitation irreconcilable with the cogntivist 'physical symbol system hypothesis.' But it is this embodied, situated knowledge which provides the basis for precisely such cogitation, and for introspection. This is the lived solution to the symbol grounding problem.

(Harnad) This double - that the world is its own best model, and that there is direct (non)cognitive correlation between the world and the bodily experience of it - is the core of the post-cognitivist position. It is a true paradigm shift, which must be thoroughly internalized if real progress is to be made in the development of 'calm' technology.

The period of development of (ubiquitous/consumer/computer/digital) technology in which it could be (and needed to be) developed in vacuo, in the lab, is resoundingly over. It must now be considered for what it demonstrably is, an integrated component of social and cultural fabric, like automobiles and telephones. In my opinion, a rigorous engagement of post-cognitive perspectives offers the prospect of new approaches to 'calmness', context awareness, and other murky 'human factors' which have to date stymied the project of ubiquity.

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