FCJ-129 Ubiquity Editorial (Cont.) – Interaction Designs for Ubicomp Cultures

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[Abstract]

I. Ubicomp Cultures: Hyperbolic Vision, Factual Developments

This is a journal issue invested in remarking more than once upon the undecidability hovering today around our getting into contact with 'ubiquity' or 'pervasiveness' as a potential to be further actualized in the fields of human-computer interaction (HCI), interaction design, and the cultural life worlds of information societies more generally. It could well be that you have not yet heard of ubiquitous or pervasive computing, or that you have heard of these but still remain in doubt whether there actually is or will be such a thing, in interaction designs or elsewhere. It could also very well be the case, however, that you both know a great deal about this as a rather momentous shift, qua a third wave in computing and associated disciplines, and find yourself engaging with it all around you in your practical life: at work, at home, in leisure activities and games, in the media art at the museum, or in the everyday culture of the public sphere. Affirming this undecidability is a necessity – since both of these alternatives are currently at stake, and since 'ubiquity' and ubicomp remain potentialities of whose actualization we are not yet sure. This undecidability may be a matter of the explicit articulation of principal ideas. At the same time, it may concern the concrete lines of development and research that make of this so many hands-on facts inherent in the interactions in our contemporary life worlds. In other words, the focus and special merit of this issue is not least to enter into the set of questions surrounding the notion of 'interaction designs for ubicomp cultures' – as something partaking of that which Michel Foucault would have called 'a history of the present.' This issue engages with an altogether contemporary field of research in order to make a difference that makes a difference while the cultural and technical developments at stake are still undecidable, multiple, and emergent – at a fast pace, too.

Even now, 20 years after Mark Weiser's initial coinage of 'ubiquitous computing' as a term (1988), and 15 years or so after his seminal papers (Weiser, 1991, 1993, 1994, 1995, 1996, 1997, 1999; Weiser and Brown; Weiser, Gold and Brown), there is not yet a general consensus as regards the definition of 'ubicomp.' However, perhaps one might, as do the contributors here, proceed on the assumption that the field of inquiry involves in particular a third epoch of computing (after the mainframe and the personal computer), one preoccupied with the question whether and how computing is, should be, or could be moving on from existing primarily as distinctly recognizable units so as to be multiplicitously and pervasively integrated into our living and working environments and perhaps altogether invisibly embedded in our life world and life form. In that case, a working definition of 'ubiquitous computing' would be a socio-cultural *and* technical thrust to integrate and/or embed computing pervasively, to have information processing thoroughly integrated with or embedded into everyday objects and activities, including those pertaining to human bodies and their bodily parts. Thus, if somebody is living with ubiquitous computing, it does not concern or only marginally concerns engaging consciously with a single device or application for some definite purpose. Rather, it concerns engaging with multiple computational devices and systems simultaneously during more or less ordinary activities, without necessarily being aware of doing so. This is also to say that the models and practical implementations of ubiquitous computing investigated here largely adhere to something like Weiser's vision of a myriad of small, inexpensive, robust, networked information processing devices, perhaps mobile but certainly distributed at all scales throughout everyday life and culture, most often turned towards distinctly mundane, commonsensical, and commonplace ends. When this sort of extensive distribution is referred to as a development of 'out-of-the-box computing,' it is due not least to Weiser's suggestive notion of a process of drawing computers out of their electronic shells so as to have the 'virtuality' of computer-readable data and 'all the different ways in which it can be altered, processed and analyzed… brought into the physical world' (Weiser, 1991: 98).

During these last two decades, we have had a number of conferences concerning the technics of ubiquitous and pervasive computing, many of which have resulted in the publication of conference proceedings, and these conferences now continue on a regular basis (Dourish and Friday; Krumm; Indulska; LaMarca, Langheinrich and Truong). Likewise, the interested reader will today be able to

find at least a dozen books treating of quite a few of the pertinent issues in the hardware-engineering and the software- or middleware-development for ubicomp (Adelstein; Cook and Das; Szymanski and Yener). In addition, the first more substantial and useful anthologies in computer science studies have now appeared (Symonds, 2010, 2011). Nonetheless, a major part of the technical research issues are far from resolved. Device components, networks, as well as the different layers of protocols and applications remain in multiple strands of basic development rather than already being involved in undertaking a broader and higher level abstraction from a shared consensus or standard. Non-resolved computer science issues that are still common to most research projects at work on ubiquitous and pervasive computing include, among other things: the sensation and collection of meaningful data on 'human' activities; building models for real-world 'human' activity; application of software agent technology, many of them only loosely integrated; appropriate unobtrusive interfaces; taking the right kind of care of security, privacy, ownership, and trust; appraising 'human' factors and social impact; implementing, maintaining, and developing dynamic communications networks; managing the scales and heterogeneities of ad hoc networks in non-hierarchical ways; modeling collective failure modes; appropriate consideration and design of energy consumption when many of the systems depend on batteries (Steventon and Wright: 12; Crowcroft).

In the human and social sciences, moreover, the field of research is characterized by a very noticeable delay in the development of cultural theoretical, sociological, psychological, and aesthetic approaches to ubicomp and its implications for our form of life. Some conferences have now been held, however, in Yokohama, New York, Weimar, London, and Copenhagen, mostly by culture and art organizations, a few by universities. In addition, an initial set of interesting book-length studies have begun to emerge. Malcolm McCullough and Adam Greenfield's individual studies provide a quite detailed account of what is at stake culturally and architecturally in the emergence of ubiquitous and pervasive computing, while drawing each in their own way on a sound, vocal skepticism so as to point towards a first set of critical evaluations (McCullough; Greenfield, 2006). The *Throughout* volume edited by Ulrik Ekman presents the first relatively comprehensive anthology engaging in an explicit treatment of a considerable subset of the socio-cultural, ethico-political, media-specific, aesthetic, and philosophical aspects and implications of the contemporary development of ubiquitous computing (Ekman).

Something analogous to this delay is at stake for the disciplines and fields more sharply in focus in this journal issue, i.e., interaction design, HCI, CHI, and human factors. In spite of the undeniable general rise of interaction design since the early 1990s (after Bill Moggridge and Bill Verplank's introduction of the term, and after the emergence of the first corresponding disciplinary institutes), one cannot but notice a certain slowness and several lacunae in the engagement with an ever more extensive actualization of ubicomp cultures and their associated technics, software, as well as medial interfaces.

As recent a book as *About Face 3: The Essentials of Interaction Design* (Cooper, Reimann and Cronin) illustrates with abundant clarity that the very vast majority of practitioners today still generally subscribe to a view of this discipline as a matter of defining the behavior of products and systems that users can interact with visually, specifically via a graphical user interface (GUI) appearing on a screen – and this typically by engaging peripherally via a mouse and a keyboard belonging to a very recognizable personal computer with Internet access. Along that path, the keystones of work on interaction design notably include a distinct (personal) computer, a screen, a GUI, and WWW networking. If questions of 'ubiquity' and 'pervasiveness' present themselves at all, these appear matters of marginal import.

However, one would also want to argue that this state of affairs is to be approached as a question of a hegemonic and predominant disciplinary paradigm for the second wave of computing (personal computing and distinct PCs overtly demanding our attention) that is currently very much in the process of being revised. For in parallel, and simultaneously, you also find, for example, Jay David Bolter and Diane Gromala participating in the SIGGRAPH 2000 digital art show only to write a book that argues in favor of establishing as the goal of interaction design the appropriate rhythmic oscillation between transparency and reflection, and between the invisible computer and the visible computer (Bolter and Gromala: 2-6). Notably, Bolter and Gromala wish to see this oscillation unfolding as a matter of a contextual design that is informed by the new paradigm of

relations between the virtual and physical. That is rather precisely what one finds in the current developments of augmentation (AR and AV), mixed reality (MR) (Milgram and Kishino), and a kind of ubicomp that includes not least an embodied experience of decidedly social and cultural settings in the real environment (Bolter and Gromala: 114-40). From this other perspective, more traditional approaches in interaction design could well be supplemented not only by such efforts found in the early *T-Garden* project examined by Bolter and Gromala, but also, for example, by the many later interaction designs that have been evolving for tangible AR applications and for embodied sociocultural MR interactivity.

An analogous set of more traditional conventions can be observed at play in the field of HCI, whenever computer science and the behavioral sciences are brought to meet in visual design, or whenever computers, operating systems, plus programming languages are brought to meet social sciences, cognitive psychology, plus linguistics in a relation of computer graphics and communication theory. The enormous impact on interaction designs for personal computing made by ocularcentrism, transparency, as well as GUI and WIMP paradigms is evidently still with us, hegemonically too. Nonetheless, the pursuit of actual developments of ubicomp qua an out-of-the-box 'calm' computing (Weiser and Brown, 1996) has also had its effects on HCI during the last period. Witness the responses to the remarkable de facto expansion of embedded computing found in the EEC 'disappearing computer' research initiative (Streitz, Kameas and Mavrommati), Donald Norman's work on the invisible computer (Norman, 1998), as well as Paul Dourish's still seminal work on a notion of interaction design for ubicomp cultures that would draw upon key insights from HCI, an existential phenomenology of the body, and a phenomenology of the social world (Dourish, 2001).

Given such developments, perhaps it is not altogether surprising to find that already the first part of the massive work from HCI International edited by Julie Jacko and Andrew Sears, deriving from conferences in 2003, came to include a substantial prospective section on virtual, mixed, and augmented environments which very evidently involve, at least to some extent, innovative post-PC, post-desktop, and post-GUI notions of interactivity and interaction designs which might draw upon invisible processes of computation (Jacko and Sears: 1103-1308). Two years later, the ubicomp conference in Tokyo already bespeaks a deep engagement with the challenges inherent in developing fast and robust interfaces for ubiquitous applications operating in context-aware mixed-reality systems (Gajos et al.). Here, shifts from interaction to participation become much more explicit, along with a reconfiguration of space as partaking of mixed reality, not least as a matter of a mobile, embodied interaction rather than a more or less virtually abstract, primarily sedentary, and positionally fixed immersion.

Perhaps the year of 2005 can be considered a minor turning point, as Mike Kuniavsky has also observed in his study concerning experience design for ubicomp (Kuniavsky), for the later editions of the key disciplinary works from HCI International (Jacko, 2007, 2009, 2011; Sears and Jacko) bespeak a growing concern with HCI for ubicomp cultures. Witness the expanded general treatment of multimodal interfaces, adaptive interfaces and agents, mobile interaction design, tangible user interfaces, and information-intensive environments – and, more specifically, the devotion of book-length studies to issues of ambient, ubiquitous, and intelligent interaction (Jacko, 2009).

Evidently, the kinds and degrees of actualization of interaction designs for ubicomp cultures are not least affected by the ideas and forces which shape computing during the final years of the 1990s and the first decade of the new millennium. Interaction designs for ubicomp cultures become more than a potential and a much more pressing factual concern in tandem with: decreasing general hardware costs, reduction in power requirements, implementation of ubiquitous ad hoc networking (including high speed and/or wireless LAN and WAN), increasing development of mobile and distributed computing, widening of the ongoing deployment of embedded computation to include networked communications among units, deployment of materials for miniaturization and further specialization of sensors and actuators, increased portability of computational devices, thin and large new display technologies, pursuit of high-bandwidth interaction and innovative multimodal input techniques, presentation of group interfaces on organizational and socio-cultural levels, as well as extensions of user-tailorability to include user-innovation in more domains. However, these interaction designs concern a co-

evolution of culture and technics. Thus, such interaction designs develop in tandem with the broad cultural integration in everyday practices of digital identity systems, social media and web 2.0, mobile communications, GPS and locative media, things that think (RFIDs), tagging of the life world, information intensive environments, context-aware installations, responsive architectures and smart homes, security systems, surveillance, and more.

Since projects are currently unfolding along such multiple lines of innovation, ubicomp cultures cannot simply be termed an actual fact or process, but necessarily retain a considerable potential dimension, still undecidable and in emergence. Nonetheless, already in 2005 this third wave in computing has established enough of a cultural presence empirically as well as in research and development that educational textbooks for designers operating with and alongside the computation of the 21st century take as a point of departure a number of the traits and challenges of ubicomp.

In this special issue of *Fibreculture* and in the contributors' research articles it is taken for granted that the relation between the potential of ubicomp culture and its actualization is today still undecided but also a matter of a very dynamic and energetic set of ongoing research projects and concrete technocultural developments which call for quite some descriptive, analytical, and critically evaluative efforts. The articles in this issue thus proceed after having acknowledged what one might wish to call a certain ambiguity. First, the contributors acknowledge that a fully developed, robust, pervasively distributed, relatively smart, context-aware, and innovatively ad-hoc networked ubiquitous computing has yet to emerge as a cultural and technical fact, whether in an invisibly embedded infrastructural variant or an overtly attention-getting personalized portable one.[1] Secondly, the contributors affirm, at the same time, that the actual technical developments as well as our modes of interactivity (socio-culturally medial and communicational, psychological, and aesthetic) have already changed enough to warrant the recognition that in a number of ways we *are* living in a ubicomp epoch and world.

However, this ambiguity is not simply acknowledged in a neutral fashion. The contributions can be read as a constellation of statements to the effect that at this point in time the discourses and practices relating to interaction designs for 'ubiquity' call for a first set of critical distinctions. Preferably, one would distinguish between 'ubiquitous computing,' as a historically specific term denoting certain actual socio-cultural and technological developments during the last two decades relating in the main to computer science, software engineering, interaction design, media studies, media art, and their supports in the human and social sciences, and, on the other hand, the more metaphorically slanted terms 'ubiquity' and 'pervasiveness' which appear consistently as idealities, not least in the hyperbolic form of philosophical tropes with metaphysical and/or ontological remainders that display quite some traditional capacity to survive.

Efforts to begin delimiting the latter are evident, for example, in Anders Michelsen's insistence – in 'Pervasive Computing and Prosopopoietic Modeling' – that we must recognize a certain 'cybernetic metaphoricity' within existing claims, more or less explicit, that computing and its mediations can 'pervade' realms of the real so as to really be or become 'ubiquitous.' Michelsen suggests that we first undertake a more detailed rehistorization to see how this metaphoricity displays intrinsic relations to the heritage of cybernetics and systems theory from the mid-20th century onward. On that background Michelsen suggests that we address 'ubiquitous computing' as partaking of more than half a century of computational imagination, specifically engaged in a reworking of what one might call, echoing the thoughts of Herbert Simon and Ezio Manzini, 'an imaginary of the artificial' (Simon; Manzini). At this altogether general level, interaction designs for ubiquity would then best be approached as a matter of a creative human articulation, Michelsen argues, in which one may distinguish between a novel form of our computational modeling of the real via the artificial (approximating the world as design) and, on the other hand, the more radical address of the artificial as being computational per se (approximating a radical computational imagination or a process of artificialization).

Whether in cultural theoretical or technical discourses, the terms of 'ubiquity,' 'pervasiveness,' and 'ambience' come silently freighted with a notion of totalizing universality or even certain ontological and metaphysical remainders (altogether abstract idealizations and/or excessively essential or substantial extensions). Both the editors and the authors contributing to this special issue approach this as a call for ongoing deconstruction and reconstruction, not least in the sense

that remainders and implications of onto-theological and sovereign ideological notions must be questioned reasonably so as to be put under critical erasure in one or more ways. The articles thus include an implicit orientation towards rather unconditional critique of the idea that ubicomp is, should, or could be 'ubiquitous,' that pervasive computing is, should, or could be 'pervasive,' that ambience is, should, or could be 'all around,' or that the discourses, practices, and inventions involved extend, penetrate, and invade 'throughout,' or are always already at stake all over as an omnipresence. Instead, one would like to put the emphasis on the multiple actual ways in which interaction designs for 'ubiquity' partake of infinite finitude. Perhaps a reminder of our myriad on-off relations of interactivity with and within mobile cultures is one of the easiest and best ways to illustrate that the problematics of cultures of ubiquitous information exist not as a totality or infinity but rather as so many matters of immanent complexity. In this actual but still emergent third wave of computing, its mobile devices and co-developing cultural practices might be one of the best foci. This because all our everyday engagements with mobile phones, handhelds, and small tech make felt a culture of ubiquitous information qua the dynamics and energies of ad hoc network theories and practices – live as organized inorganicity, inorganically and organically live. Mobile computational entities and their cultural enfoldment are such good foci because they make felt the ways in which complexity arises from a vast number of distinguishable relational regimes and their associated state spaces, promising a defined system of interactivity for 'ubiquity' (to come).

II. Interaction Designs: Technical and Human Co-Developments in Question

In the main, then, the contributions to this issue proceed on the assumption that an uneven and uncertain but nevertheless quite recognizable developmental trend is already a fact, something which involves ubicomp cultures as actual harbingers of a third wave of computing as well as a gradual factual articulation of a paradigm for those many interaction designs now arriving which are in a number of respects different from those we already know very well and continue to live with, i.e., those pertaining to engagements with a predominantly personal kind of desktop computers, their GUIs, windows, icons, menus, and pointing devices (WIMP).[2] In the new millennium, and notably after 2005, as a citizen of more or less massively networked information societies, one has already been interacting enough beyond command-lines, menus, desktops, and GUIs to have realized that another set of models is operative, and that there is at this point an obvious need to pursue analyses and critical evaluations of these models. Along with a great many innovative artistic explorations in new media art installations, you may witness this development, as do the contributors here, on a larger socio-cultural scale.

One meets it, for example, via the signals and vibrations from mobile phones, when drawing upon the services afforded by the massive development of wireless devices and overlapping networks (including WPAN, WLAN, and WMAN or WiMax), when engaging with the tangible interfaces and auditory culture of MP3 players (iPods), when you partake of the reading anywhere of e-books on your networked iPad or Kindle, via the RFID tagging of your library or supermarket, when getting upset by the locative and navigational practices unfolding along with GPS, via the entry into your workplace of interactive whiteboards, during your increasingly frequent architectural encounter with smart buildings and environments, via the experience of augmented museum tours, and not least in the rapid and extensive widening of effects from the technics of surveillance (CCTV, webcams, security video cameras, sensor networks, profiling and behavioral recognition, as well as biometrics and digital identity systems). Along with the rise of wearable computing, prosthetics, and implants, perhaps one can best appraise the entire contour of this actual development, i.e., its serpent-like and environmental recoiling in and around the life of the *anthropos* as such, by considering the integrative and embedding efforts characteristic of pervasive healthcare, in the hospital, of course, but certainly also in the milieu of city and the context of the home (Orwat, Graefe and Faulwasser; 'Centre for Pervasive Healthcare'; 'Center of Excellence for Ubiquitous Systems').

Accordingly, in such a work as *Designing Interactive Systems,* appearing in the year 2005 (Benyon, Turner and Turner), it is taken for granted that interactive systems design is now primarily a question of contextual design, much as Bolter and Gromala, Dourish, and others have begun to suggest. This is also to say that perhaps context-awareness has become one of the major traits of interactive ubicomp systems. Now HCI also concerns information spaces whose architecture,

design, navigation, and agents must be considered, as when undertaking interaction design for the dynamics of computer-supported cooperative working (CSCW) or social mingling in an airport or on a public square. Moreover, then, such interaction designs for ubicomp cultures not only draw, as did earlier HCI, on cognitive psychology to understand and support single-user interaction with a computer. They also extend this psychologically and behavioristically to begin encompassing multi-user interaction involving many computational units in physical and socio-cultural settings for AR as well as virtual environments with AV. Thus, one must assume interaction design to include not only a single individual's abstract, virtual, and sedentary interactions with a personal computer, but also embodied, distributed, locative, and mobile cognition on the side of many human users and systems both.

This is also to remark that the context-awareness at stake in interaction designs for ubicomp cultures slowly tends towards operating with the entire span of mixed realities, now notably including the real environment and interactants' embodiment. In that respect, the 2000s might well be distinct from the 1990s fascination with a transcendent virtuality, as Lev Manovich has also observed, in that the period after the millennial turn turns out to be about the physical – physical space filled with electronic and visual information. Along with the pursuit of ubicomp augmentations and mixes, computation and network technics actively enter our real physical spaces, replacing the well-known cognitive model of a VR interactant traveling in a virtual space by an embodied model of a person checking her email or making a phone call using her PDA / cell phone combo while in the airport, the street, a car, or in any other actually existing space (Manovich).

The arrival of interaction designs for more fully mixed realities is still quite delayed and deferred in several ways, and our notions of 'mixed reality' remain varied.[3] When MR is pursued, the 'mix' at stake is hardly ever addressed explicitly but understood as a matter of augmentation, which thus tends to be treated as medial overlays or spatiotemporal superimpositions rather than 'mixes' involving conversions of the digital and the analog. Likewise, when augmentation is pursued in current interaction designs, it is likely to be understood as 'improvement' just as augmented reality seems to have the upper hand (perhaps due to the wish to counter more than a decade of privileging of VR). Currently, one must observe a tendential parenthesizing not only of the exploration of interactions with a virtual environment including augmented virtuality, but also of any critical engagements with the notion of more or less teleological 'progression' and 'improvement' assumed to be at play.

Context-awareness can only be termed a chief goal for ubiquitous and pervasive computing and projects within both do display significant efforts to meet this. Developers, interaction designers, and users of ubicomp have so far tended to grant a certain primacy to the physical environment and a rather empirical notion of 'context,' as in almost all locative projects drawing upon GPS, for example. This kind of focus still in the main ignores or parenthesizes the human users and their context-awareness. It bespeaks a keeping to key decisions made in early cybernetics (Shannon and Weaver) as regards marginalizing or altogether excluding the exploration of 'context' as a matter of meaning, i.e., in general any approaches stemming from linguistics, discourse analysis, hermeneutics, semantics, semiotics and, quite specifically, the early alternative cybernetic theories trying to work integrally with aspects of this (MacKay; Ruyer). This bracketing is, however, not unilateral and also seems to be changing over time as research interests now begin to accrue to the role in ubicomp of human awareness, meaningful embodied action and response, as well as language. Hence it is of some interest to keep on tracing this development. Nonetheless, although context-aware ubicomp systems are already quite advanced as regards human user profiling on biophysical, perceptual, and some limited habitual action planes, it is still a challenging and open issue, to put it mildly, how to have context-aware systems try to make relatively well-informed or even intelligent assumptions about users' current situations. We still await, then, an *in actu* and proactive demonstration of cybernetic systems that incorporate and interact with well-interpreted human intention, individually and socially. It seems clear today that a Pandora's box for cybernetics has been reopened once more with this call for establishing and engaging with meaningful contextual relations. That is, an approximation to meeting human context-awareness still remains a formidable challenge (for technics, interaction designs, and new media), and the hindrances and misunderstandings remain many as soon as a move is made from a systemic

awareness of physical location and movement in positional terms to an awareness of human affect, passion, intention, action, emotion, perception, or semantics.[4]

Even if interaction designs involving 'mixed realities' and 'context-awareness' today still explore the polysemia of both, it is quite evident that these two notions have become key traits because they represent attempts to actualize a central heritage from Weiser's early vision of ubiquitous computing. For the current efforts to develop and engage with mixed reality interaction designs include not least a response to Weiser's call for a remarkable expansion or widening of the field of research. Ubicomp should become an out-of-the-box computing, i.e., it should draw 'computers out of their electronic shells' and into the physical world so as to 'become part of the environment,' or become integrated 'seamlessly into the world.' This move towards 'embodied virtuality' cannot but involve a notion of mixed reality, just as it remains almost diametrically opposed to the virtual reality paradigm of trying to make a world inside the computer (Weiser, 1991: 94-96). Likewise, the very intense pursuit of interaction designs involving context-awareness echoes part of the heritage from Weiser and his colleagues at Xerox Parc. In this case, the disciplines of interaction design and HCI try to respond to the call for a human-centered and 'calm' computing. This would entail development of interaction designs for computational processes that have become an integral, invisible part of the way people live their lives, processes that may 'calmly' vanish into the background because having taken into account the natural human environment (Weiser, 1991; Weiser and Brown, 1996). As revealed by Weiser's explicit aims to have computers free us to use them without thinking and so focus beyond them on new goals, to have computing free us to be more fully human, the pursuit of both these parts of the heritage either assumes or demands a very thorough systemic grasp and knowledge of the human being, its notion of reality and its practical mode of being aware of or attentive to its situation and context. It is relatively safe to say that neither computer science nor interaction design and HCI has so far been able to live up to this, leaving us with a great many interesting de facto research projects over the last two decades, a set of unresolved and perhaps unfeasible technical aims as well as an equally important set of critical discussions respecting not only the cultural desirability of these aims but also what might present alternatives to be considered.

In principle, the vision for ubicomp signals a complete out-of-the-box expansion that would entail the development of interaction designs for all human interactivity in mixed realities presumably present anywhere and at all times. In fact, this is neither technically feasible nor culturally desirable, and thus one would perhaps do better to put in parenthesis the hyperbole – so as to observe the need for further concrete delimitations. Generally speaking, mixed ubicomp realities are rather few and far between, not least because the massive infrastructural demands for high-speed wired net connections as well as many more wired or wireless nets of sensors and actuators have not been met. Interaction designs for these mixed realities so far tend to appear in rather strictly delimited or specialized areas such as technical research departments, pervasive healthcare, singular architectural projects, office environments for large corporations, large stores or archival institutions, and new media art installations. Interesting and notably exceptions would be the much broader technocultural developments associated with our interactions with mobile communication and ICT (Goggin and Hjorth; Ito, Okabe and Matsuda; Jacko, 2011; Webb), security and surveillance after 9/11 (Frohne et al.; Haggerty and Samatas; Tennenhouse; Want and Pering), and digital identity systems (Wren and Reynolds; Michelis et al.; Waller and Johnston). While a great many researchers acknowledge the general trend towards an expansion or widening of the research field and its practical aims, we are still missing any first overview of the concrete areas of interactivity being addressed, not to mention their relationships and the priority granted to each.

With respect to the pursuit of context-awareness, we are much further in certain actual developments of this, but we do not entirely agree on how and whether this can or should be human-centered, whether it can or should be intelligent, proactive, and self-adaptive. In spite of the work by Beigl, Dey, Dourish, Gellersen, Loke, Schilit, and several others, we do not even have one generally accepted definition of this notion, not least due to difficulties as regards answering the question of contextual interpretation and semantics (Dourish, 2001; Dourish, 2004; Schmidt, Beigl and Gellersen; Loke; Schilit, Adams and Want; Dey). It is still far from easy, even now in the day and age of a semantic web on the rise, to see how meaning and interpretation are to be handled so as to make a relatively smooth translation from 'information' in computer science to

the kind of semiotics and hermeneutics most often taken for granted in cultural studies and the human or social sciences more generally.

It remains an issue of quite some debate, in the articles in this issue as well as more broadly in the research community, whether or not we are to pursue mixed reality out-of-the-box computing and context-awareness as part and parcel of the kind of human-centered computational integration and embeddedness at stake in Weiser's original vision for a 'calm' computing. First, as Manovich also remarks in his contribution to this journal issue, the notion of an altogether invisible computing and an equally imperceptible interaction design is now to a large extent discredited or problematized, in spite of work on this by Donald Norman as well as in the EEC disappearing computer initiative (Norman, 1998; Streitz, Kameas and Mavrommati). According to Manovich's argument in 'Interaction as a Designed Experience,' the shift during the 1995 to 2008 period consists in abandoning the ideal of invisibility in favor of treating interaction explicitly as an event while designing aesthetic interfaces for a carefully orchestrated or dramatized experience. While embedded computing will continue to be on the rise for quite some time, along with infrastructural projects (in Europe not least),[5] strict invisibility and human unawareness also remain problematic as aims and values for technical, ethico-political, and mundane practical reasons (e.g., situations of repair, infringements of rights, or everyday workability as well as minimal recognizability of interaction designs).

Then, one would like to remark that this is also a rather slanted understanding of the vision for ubicomp, since Weiser's 'calm' computing only here and there could be read as a call for strict invisibility and complete embeddedness. In their more interesting and convincing passages, Weiser's texts first of all remarked that not all computing or interaction had to be calm, just as 'calmness' is here to be understood as referring to a varied and dynamic engagement with human economies of attention, oscillating between center and periphery. Interaction designs would thus be at work on a technology that may move easily from the periphery of human attention to the center, and back. When interaction designs become peripheral, they would arguably permit interactants to attune to many more things by drawing upon the large part of the brain devoted to peripheral and sensory processing – i.e., by informing without overloading. Centering or recentering something from peripheral interactivity would then permit both a more focused awareness and a series of interactions aimed at increased control or correction (Weiser and Brown, 1995).

Read in this way, interaction designs for ubicomp cultures would not be post-desktop, post-GUI, post-WIMP in any revolutionary sense, but would leave most of existing efforts in HCI intact and useful, only to aim at a certain supplement in the form of an expanded *and* more finely differentiated treatment of kinds and degrees of situated attention. Still, this is by no means a simple matter, witness the fact that we do still not have any one agreed upon standard for interaction designs for ubicomp cultures. No little part of the difficulty stems from the extensive implications of this vision for interaction design. For, as Weiser was well aware, interactivity with a 'calm' dynamics calls for interfaces characterized by something akin to a visual invariance (J. J. Gibson), a tacit dimension (Michael Polanyi), a vague and unobtrusive peripheral reach (John Seely Brown), a heuristic compiling (Herbert Simon), a horizontality (Hans-Georg Gadamer), or a being ready-to-hand (Martin Heidegger). In other words, what is at stake here involves interaction designs endowed with a practical and sensate intuition, i.e., designs for situated and lived experience that not least grant a new and major privilege to the more passive and perpetually open dimensions of human sensation, and hence to the proximate and affective dimensions of our embodied activity and form of life.

One line of response to this consists in pursuing a more nuanced and balanced understanding of Weiser's vision of an embedded and calm ubicomp – something making itself felt today in the area of interaction design research and development. For example, Vivienne Waller and Robert Johnston draw upon Heideggerian notions of availability to argue that ubicomp will support our everyday activities only when designed so as to be physically and cognitively available both – not altogether embedded, nor invisible (Waller and Johnston). Christopher Wren and Carson Reynolds refer to Ishii's important work on tangible user interfaces and describe specific ways in which minimalism – not invisibility – in ubicomp interface design will allow computational augmentations to coexist with physical artifacts and the task behaviors surrounding them (Wren and Reynolds;

Ishii, 1997, 2008). Likewise, Hyunjung Kim and Woohun Lee present concrete projects for everyday ubicomp objects and practices for which physical plasticity and minimalist design may provide unobtrusive interfaces that shift between invisible and visible states (the concealed interface appears when put into use, and disappears after use) (Kim and Lee).

Benyon and others emphasize that the cognitive and psychological foundations for interaction design will continue to draw to some extent on transparent presence, a consciously clear vision, and an explicitly focused practical understanding. However, another privilege is now to be granted to the role of largely silent memory traces, subtly peripheral attention, and an inclusive approach to the process of making of mistakes and corrections. Likewise, with the unfolding of multimodal interaction designs hearing and haptics would become vastly more important, as would the roles of affectivity and degrees of being pleased or unsettled (Benyon, Turner and Turner: 352-447). Perhaps one of the most obvious changes heralded here is the relative and gradual downplaying of the digital visual culture of the screen (not the outright disappearance proclaimed by Manovich as the historical outcome of the arrival of embodied virtuality after the three main phases of the classic, the dynamic, and the real-time screen, or by Michelis), since the more implicit modalities of haptic, auditory, and ambient interaction will be granted another priority (Michelis et al.). Albrecht Schmidt and others point out that the traditional focus in HCI on interfaces for explicit use (visible GUIs and widgets on screens) remains but a small part of the expanded design space for interactive systems from a ubicomp perspective – which would include not only tangible and physical user interfaces that go across explicit and implicit modes of interaction but also (and not least) implicit modes of interaction via movement, posture, facial expression, gesture, direct manipulation, GUIs, command lines, and speech. An examination of this expanded design space will show that embeddedness or invisibility does not necessarily determine how a system is used. Something perfectly embedded and hidden can still be used explicitly – and non-embedded or visible technology which is used often can very well be used implicitly and without the user being aware of it. This goes quite some way towards pointing out the limited use of adopting any simple concepts of physical embeddedness and invisible computing in this field – since the question is not least one of degrees of experienced invisibility and interactions embedded into a user's task or more or less habitual situated action (Schmidt, Kranz and Holleis).

It might be that William Edmondson and Russell Beale sum up a significant part of our current, more nuanced understanding of Weiser's notions of a 'calm' computing when they claim that in our environment today we find not one seamless, invisible computational mesh but rather a grouping of at least four kinds of ubicomp – many computers; people using computers much of the time; embedded computers; 'invisible' computational systems – with the two former gradually undermining the two latter and more specialized notions (Edmondson and Beale). Insofar as this is correct, we are in a specific sense witnessing a relatively strong but gradual disembedding of computers — as they appear more overtly in our everyday cultural practices. This is still only one point of view, though, and in more general terms we are still not done discussing how and whether interaction designs for ubicomp cultures are to draw upon invisible, visible, peripherally attention-getting, or peripherally vague processes of computation. At best, we have a first general understanding that a mix of all four of these will be called upon for the interactive parts of ubicomp to function as expanded out-of-the-box computation in and as our life world. Robert Jacob and others are no doubt right when rejecting the idea that the numerous actual moves towards post-WIMP interaction styles (such as VR, MR, AR, TUI, handheld, mobile, lightweight, tacit, or passive) during the last two decades are not to be seen as disparate innovations proceeding on unrelated fronts, but rather as sharing important commonalities. The ongoing realizations of ubicomp are at one in reality-based interaction, according to Jacob et al, and build on users' pre-existing knowledge of the everyday non-digital world to a much greater extent than before, notably by drawing upon users' understanding of naïve physics, their own bodies, the surrounding environment, and other people (Jacob et al.).

In more ways than one, this echoes Simon Penny's claim in his contribution to this issue that the kinds of interactivity we encounter today in the media art projects engaging with ubiquitous computing partake of a general historical development towards a performative ontology and aesthetics of interactivity. Penny provides a much needed and quite detailed historical account of 60 years of intersections between technological development and artistic experimentation,

including a critical reconsideration of the lack of non-instrumental theorizations of interactivity. In this rehistorization, Penny is generally at pains to demonstrate that throughout the period of pioneering interactive art up to this point in time one can, and should, trace the moments of a development moving towards a synthesis of performance theory and neurocognitive studies which forms the base of that performative ontology on which current aesthetics of interaction and interaction design is to be constructed. Within this broader historical tapestry interaction designs for ubicomp cultures are woven as relatively mature latecomers – in the sense that their integrations of materiality and computation, technology and culture, or control and action bypass any dualist approach. Penny's double claim is thus first that in the current epoch of ubiquitous computation, the universe of live data is increasingly anchored in physical and social contexts via a variety of digital entities and, secondly, that the technics, the techno-social strutures, as well as the modalities of interaction we now see permitting of such (re)unions were essentially worked out and prototypes in media art research during the past quarter century.

However, having acknowledged all of this, one must also recognize and affirm another main line of response, for enough time has passed since Weiser's untimely death that more explicitly critical arguments respecting his ideas begin to appear in tandem with that ongoing realization of the ubicomp vision which is in a number of respects different from what the researchers at Xerox Parc imagined early on. Yvonne Rogers suggests that we now step aside from the intractable computer science problems and the considerable ethical problems lurking in Weiser's vision in order to explore alternatives to 'calmness,' such as designing for explicitly engaging user experiences, designing so as to extend creatively, excitedly, and constructively what people currently do, or designing in order to support personal, cognitive, and social processes of habit-changing, problem-solving, creativity, learning or performing a skill (Rogers).

In 'Affective Experience in Interactive Environments' in this issue, Jonas Fritsch assumes, to begin with, that Rogers is right in proposing as an agenda for working with ubicomp that interaction designs had better focus on the creation of engaging user experiences, just as objects or environments with embedded interactive technics now should tend towards becoming remarkable lifestyle objects or places with which we engage in identity formations. In that case, designing for living with ubicomp must imply considerations of the experiental qualities brought into play to form our concrete experiences of interactive objects and environments. Accordingly, Fritsch singles out the question of affectivity as the primary focus of interaction designs for ubicomp cultures. For interaction design now needs to develop an understanding as well as means to describe how interactive environments and technics may shape our situated affective experiences. Via an exemplary case study and analysis of the experiental field of the interactive installation *City Voices*, Fritsch seeks to confirm and flesh out his hypothesis that Brian Massumi's concept of affect is particularly useful for investigating the ways in which ubicomp environments engage their human users affectively by creating fields of experience. Arguably, this concept will permit the needed kind of focus on such affective tonalities and such relational events as might emerge through interactions in these environments.

Bo Kampmann Walther's contribution to this issue, 'Reflections on the Philosophy of Pervasive Gaming,' focuses on the phenomenon of pervasive gaming still on the rise, not least in urban settings, as attested to by *SuperFly*, by the Swedish game company It's Alive Mobile, for example, or by projects such as *Can You See Me Now?* and *Uncle Roy All Around You* by the UK performance group Blast Theory. Thus Walther seems to agree with both Rogers and Fritsch that experiences of play, creativity, problem solving, learning, and skillful performance are at the heart of living with ubicomp cultures and their interaction designs. Walther's text not only contributes to discussions of new (post-GUI, post-screen) pervasive interfaces but also seeks to legitimize and flesh out significant parts of 'pervasive ludology' as the field of pervasive gaming theory. Generally speaking, Walther's inquiry concerns a certain meta-ludic architecture of pervasive games, or that which constitutes the playability and epistemology of post-screen pervasive games. This entails a reexamination of the notion of 'gameplay' in terms of rules, tactics, exploration, and level-orientation as well as acts of playing vs. acts of gaming. Quite specifically, Walther seeks to reflect on Deleuze's claim that the virtual is not opposed to the real but must be understood as the condition for actuality. Here Walther argues that the Deleuzian concept of virtuality is precisely

what can be used to explain the relational structure of play that connects and yet remains irreducible to gaming.

Malcolm McCullough's work on the digital ground for architecture, place, and out-of-the-box computing draws more explicitly and affirmatively upon the early visions for ubiquitous and pervasive computing than do Fritsch and Walther. However, McCullough's extended and quite detailed account of how embodied virtuality is to be inscribed into the social and environmental complexity of the existing physical environment nonetheless insistently gives voice to a number critical issues. It is far from certain that such situated technology will help us manage the protocols, flows, ecologies, and systems that secure valued places. Without drawing upon very rich cultural foundations, McCullough argues, it is quite likely that layers of distrust, information glut, and experiental uniformity will be the result. Acknowledging the rise of interaction design, in this field too, McCullough agrees that digital systems which are carried, worn, and embedded into physical situations can alter how people interact. Nonetheless, it is uncertain that the new remote, asynchronous, and indirect modes of interaction will come to serve an environmental knowing and our need for 'getting into place,' since software engineers have pursued the accumulation rather than the integration of technical features, since interface designers have so far focused on first-time usability at the expense of more satisfying long-term practices, and since psychologists, ethnographers, architects, and cultural theorists barely understand the consequences of all this mediation (McCullough: xiii-xiv). In his article for this issue, McCullough further expands on his critique concerning the lacunae still left in current research and development of ubicomp cultures and their interaction designs. The text 'Toward Environmental Criticism' can perhaps best be read as an urgent call to have information history and environmental history merge enough so that a phrase such as 'environmental history of information' will yield a good deal more than null in our search engines (as opposed to now). McCullough rightly observes that the actualization of ubicomp mediation and interfaces has already blurred separations of environment and information, environment and nature, environment and culture – without the accompaniment of any critical consideration of the taggings, annotations, operations, linkings, recordings, fillings, and pollutions at stake in the upsurge of information intensive environments. One might well contend, then, that an environmental criticism is lacking that would not least address the physical embedding of certain environmental sensibilities outside the efficiency of computational tasks. Here McCullough would like to have us reconsider the ways in which ambient and inhabitable information advances or obstructs larger changes in worldview, and the ways in which specific concerns of interaction design imply active responsibility or a neglect of that question.

In this journal issue, Søren Pold and Christian Ulrik Andersen's contribution, 'The Scripted Spaces of Urban Ubiquitous Computing,' continues and further develops such a line of critical thinking respecting the implications of ubicomp for our engagements with spaces and places. Andersen and Pold argue that contemporary urban environments with ubicomp could be approached as so many 'scripted spaces' qua spaces in which ubicomp literally has added coded and meaningful scripts to our surroundings by programming smart things, architectural equipment, infrastructural devices, and PDAs that all link up wirelessly. As the authors demonstrate via a case study of the Swedish city of Lund, such scripted spaces not only have a non-visual, coded, and encrypted side but also in some ways go beyond the uneasy, anxious, or paranoid experience of computational control structures and transactions behind the façade, the surface, or the interface of the city. For the coded and essentially written character can and should be highlighted as yet another layer in the spectacular city, perhaps first as a hieroglyphic sense of concealed meaning or as a sign of signs, but then perhaps also as a more or less critical recognition of the ways in which the scriptings reorganize perception, teach understandable structures of thought, and tend to internalize the logic of the programs. According to Pold and Andersen, the distinctly political level of scripted spaces remains subject to overt debate as well as internal critique: they can be used in unintended ways, be reconfigured, or even hacked. In certain, rather marginal cases, the city dweller may be dissatisfied enough by the urban scripts to experience this as a call for action, a call to become 'writerly' in the sense of hacking, rewriting, or creating the city, something which will also mean a return of an urban public domain as well as the arrival of a paradigm of computing remarkably different from that of the disappearing computer.

In 'Embedding Response: Self-production as a Model for an Actuated Architecture,' Mette Ramsgard Thomsen and Karin Bech are equally concerned with the relation of ubicomp and the built environment but this time approached from within architecture as a practice-based research discipline. Presenting *Breathing Room* and *Slow Furl*, two of their recent installations, the authors explore worlds in which the built environment has strata of embedded computation and presents a readiness towards the digital and the mediated. Notably, Bech and Thomsen seek with these two installations to challenge in at least two ways the prevalent approaches to ubicomp and architecture. In the first place, they develop a model of interactivity that does not focus on engaging a human user in a situation of apparent control but rather invests the built environment as a whole with systemic qualities of self-production and recursiveness that grant a new privilege to a semi-autonomous pulsation and mobile responsiveness of architectural self-invigoration. Second, *Breathing Room* and *Slow Furl* introduce dynamic textiles as transitive materials as well as sensing and actuating computational processes embedded so as to have become integral parts of the built environment. This contributes to a new architectural language of responsive design that integrates both temporality and movement and thus instability as challenges to prevalent material practices of architecture which grant a privilege to the permanent and the static in their tectonics. In effect, Thomsen and Bech's contribution begin to raise questions respecting what it means for ubicomp architecture to become interactive in ways that query traditional spatial conceptualization and architectural values such as stability and structure, or what happens to our material practices as the ability to sense and actuate become properties of architectures of change.

Adam Greenfield's easily readable book on 'everyware' not only nods in the direction of the becoming actual of ubicomp and pervasive computing (as do McCullough, Pold and Andersen, as well as Ramsgard and Bech) but in fact offers an explicit argument to the effect that it is an inevitable development (Greenfield, 2006: 91-92). In many ways it is still the best broadly accessible treatment from a technically and culturally informed author of ubicomp user experience, associated interface modes, and techno-social implications. However, this does not preclude quite extensive critical treatments of issues such as information overload, invisibility and seamlessness, unpredictable and emergent kinds of interconnections, as well as the risk that human agency, judgment, and will progressively become supplanted by compliance with external, algorithmically applied standards and norms. Greenfield's frank identification of limiting and critical factors is refreshing, as when he states that: broad standards for the interoperability of heterogeneous devices and interfaces do not exist; the network infrastructure deployed in most places is insufficient to support ubiquitous applications; the appropriate design documents and conventions simply do not exist, nor is there a community consciously devoted to the design of ubiquitous systems; there is hardly any awareness on the part of users as to the existence of ubicomp systems, nor any agreement as to their value or utility (180). In a later, short research article, Greenfield makes his main critical focus on social and ethical questions quite clear. If issues such as privacy, security, robustness, surveillance, power, the environment, social sorting and control remain, then a set of minimal ethical guidelines is one missing resource. In view of this, Greenfield proffers the argument that ubicomp developments should: default to harmlessness; be self-disclosing; be conservative of face; and be deniable (Greenfield, 2008).

Moving across both these main lines of response, it becomes increasingly clear that quite careful balances will have to be struck between implicit and explicit interaction, almost always with the option to enter into the latter, as pointed out by Christina Brodersen and Jannie Kristensen, for instance (Brodersen and Kristensen). Their wish to approach interaction designs for ubicomp cultures via a concept of 'negotiation' is also quite interesting since it manages to highlight the key problem at stake for Weiser as well as for Rogers and many others, i.e., the question concerning the relation between the human and the technical potential in a given context or situation of interactivity. Whereas the latter are quite explicitly human-centered in their approaches, Brodersen and Kristensen take another tack which promises to continue the long, slow deconstruction elsewhere of the recurring tendency to get caught in the opposition between technological determinism and its inverse (ingenious human mastery or orchestration). For, defining 'negotiation' as the mediating process relating human users and technological possibilities in a given situation, they wish to emphasize the *mutual* translation process taking place in HCI

situations, 'taking into account the strengths of the computer as a computer and the human as human' (262).

In spite of the lack here of a definition of either term (human, computer), perhaps this call for interactive co-developments or co-evolutions of technics and the human, at the limit of any asymmetric relations, provides the most interesting challenge for the mixed reality ubicomp cultures and their interaction designs to come. It is perhaps really not simple to say with respect to this interactivity whether and how human context-awareness will become technically other, whether and how technical context-awareness will become otherwise human. Probably, this interactivity will be concerned only very little with further developments of linear processing according to pre-established arrays or hierarchical trees of possibilities, just as it seems unlikely that it will come to involve thoroughly autonomous, self-adaptive, self-reproducing, or even mutant artificial life forms. If interaction designs for ubicomp will not be or become a matter of simplicity, however, this is because the mutual translation among machinic and human processes of interactivity is emergent – something which presupposes complexity.

III. Emergent Interaction Designs?

If ubicomp cultures are not a utopian imaginary but in some sense 'real,' it is a guiding hypothesis for the contributions to this journal issue that they constitute a remarkable reconfiguration of our mode of living with modern computing and a considerable expansion of the fields of interaction design and HCI. In addition, the contributors assume that this realization of ubicomp as a cultural and technical fact, already at the stage at which we are today, brings with it some quite pressing theoretical and practical concerns for the human, the social, as well as the technical sciences. For the actualization of ubicomp cultures must be approached as renewed engagements with an emergence arising from cultural and technical complexity. One key wager here is, then, that we need to revisit notions of complexity and emergence both. This is not only because most of us are not yet particularly good at working through with these in mind, even though we have to — because only a few of us have the requisite methodologies – since these tend to go across physics, chemistry, biology, network topology, dynamic systems theory, and social or cultural theory. A renewed encounter with complexity and emergence is also a necessity because ubicomp cultures cannot but involve the movements, dynamics, more or less ad hoc relations, and modes of organization or self-organization pertaining to multiplicities of computational entities as well as humans.

As a researcher in the human and social sciences concerned with finding or developing an adequate set of tools in sociocultural theory this is a tall order. For even after having read, for instance, Gilbert Simondon and others on relational ontologies, Gilles Deleuze and others on assemblages, Michel Serres on translation without a metalanguage, Humberto Maturana and Francisco Varela on self-organization, and various kinds of STS or actor-network theory from early Bruno Latour onward, one is still not convinced that one would have the right kind of tools to describe, analyze, and critically evaluate 'complexity' and 'emergence' as two key implications of ubicomp for our forms or life. What kind of sociocultural theoretical approach would you mobilize in the face of an innovative developmental phenomenon like the new technical and human movements and relations appearing and disappearing as interactivity in a smart building with a vast set of networks of sensors and actuators? What kind of sociocultural theoretical approach would you suggest when encountering the technical and human movements and relations forthcoming and dwindling as interactivity in and around your national library, involving hundreds of thousands of human interactants on the move along with several million entities tagged with RFIDs? What kind of sociocultural theoretical approach would you adopt in the face of the multiplicities of technical and human movements and relations coming together and withdrawing interactively in and around JFK, LAX, or Frankfurt Airport, including those of human individuals and social groupings, mobiles, heating, ventilation, and lighting systems, transport systems, security systems, and airplanes?

As a researcher in hardware engineering, software development, or interaction design, would you be quite sure that your current studies of network topology, dynamic systems theory, along with certain recent sources treating of swarm intelligence, flocking, ant colonization, and a-life would be adequate to the kinds of complexity and emergence on the horizon for ubicomp cultures? The task at hand could be given a first delineation or set of contours by looking at some of the qualities of a

ubicomp system listed by Chalmers et al: it will be fluid; its structure will varyin the short term and evolve in the long term; each non-human entity will be purposivevaguely or formally; it will be partly autonomous– some of its interactions are determined by its purpose and its interactive experience rather than by invocation from a higher authority; it will be reflective – subsystems can report experiences to higher systems and perhaps humans to permit intervention or guidance(Chalmers et al.: 2.From this approach it seems to follow that what takes place through interactivity in ubicomp cultures will not just involve complexity but will do so in a strong sense, i.e., irreducibly, and so interaction designs or not only to be engaged with as dynamic but as evolving (and decaying or dying out). This is closely related to the claims made by Matthew Fuller and Sónia Matos in their contribution to this issue. In 'Feral Computing: From Ubiquitous Calculation to Wild Interactions' the readers will find not only an explicit critique of the tendency to develop ubicomp as seamless and invisible by overemphasizing the machine and keeping the deployed human component stable and unexcited, thus replicating the military and AI strands of the computational heritage from WWII onward so as to risk once again an obfuscation of the potential for a different reworking of interrelations with the dynamics of thought, computational subjects, societies, as well as modes of life. The readers will also find a pursuit of a deeper understanding of human-computer symbiosis that will engage with a wider notion of systems and ecologies. Notably, Matos and Fuller will seek to substantiate their claim that the complex and feral potential of ubicomp now (to be) actualized consists in a renewed and expanded context for computing, shifting from 'calculation' to 'interaction.' A environmentally distributed, situated, and embedded ubicomp is thus to be approached as an opening of new spaces for variable kinds of users, cognitions, and contextualizations that echoes a number of central aims of the second-order cybernetics worked out by Heinz von Foerster and others. This is not least a matter of an attempt to study complex systems, including humans and machines, while attending to their formation of patterns of reflexivity, to their generation of a recursive sense of self, and to the wider processes in and with which that self co-composed. Fuller and Matos thus also acknowledge ubicomp cultures and their interaction designs as a question of complexity – with a certain emphasis, perhaps, upon a strong version. For the authors' attempt to affirm a 'feral' ubicomp draws upon a notion of systems as analytically indecomposable (although they also mention systems qua a growth by partaking of an expanded conversation, as well as different forms of structural couplings). Feral ubicomp would, then, be a matter of interactivity qua connectivist composition and decomposition involving dynamic relations among the entities and interactants in a wider and quite multiplicitous ecology. Interaction design for ubicomp cultures would here correspond to think with things, or to start finding means of generating rigor in the chaotic, but doing so recursively, promising to produce something that renders the complexity of these ubicomp cultures sensible and open. This is by no means the only kind of approach, however, as one might surmise by looking at Shin'ichi Konomi and George Roussos' treatment of the ways in which ubicomp technics are finding their way into large scale real world commercial information systems (rather than small scale research simulations):

The core enabler for ubiquitous computing is technology that makes the physical and digital worlds interlinked and thus intimately related. Every object in the world we live in has a digital representation that follows the situation of its real self and vice versa. This unique linking of bits and atoms opens up numerous possibilities for new computing interactions which are currently explored by ubiquitous computing research. One of the main implications of this interlinking is that people, places and things acquire unique machine readable identities within systems of very large scale that must be accommodated within inflexible physical constraints and constantly changing usage context. To be sure, auto-identification capability opens up membership to ubiquitous computing systems for numerous entities and potentially results in massive increases to the number of constituent elements and system complexity. Understanding the issues raised by this increased complexity and exploring solutions can be hard to carry out in lab-based studies or case studies of limited scale. Such understanding often requires that experiments are carried out at scale, a fact that invariably implies high costs that are almost certainly prohibitive in a research context. Nor is it possible to identify and address such issues using large scale simulations, as these are limited by the simplified assumptions involved, and cannot take into account the emerging behaviors caused by real users.(Konomi and Roussos: 508)

One observes that no matter which way one goes about it, one will have to draw upon notions of 'complexity' and 'emergence,' neither of which is so far readily available in a clearly defined sense. While Konomi and Roussos also identify and acknowledge the question concerning complexity and emergence, their project does not embrace strong nor irreducible complexity but remains explicitly devoted to a version of reductionism – something allegedly necessary to meet the economico-practical limits and needs of the real (commercial) world. In fact, reductionism is both by far the most traditional response and a highly justifiable and respectable one, since otherwise most standards of scientific research and practical development are put in quite some doubt.

Hence one can understand John Thackara's reaction in his book on designing in a complex world (Thackara). In the name of a biomimicry of the lightness and seeming simplicity of natural phenomena and evolution, Thackara proposes that we reject and put aside the complexity of ubicomp cultures. He is quite plausible when criticizing some of the stronger claims made for ubicomp – that it will be seamlessly embedded in our environment, fully personalized, altogether self-adaptive, fully anticipatory of our needs, and deliver only information rich with contextually relevant meaning. But, however uncomfortable this is, I do not think the complexity of ubicomp can be reduced away easily, as Thackara implicitly calls for when remarking on the claims made for ubicomp: '…maybe I am missing something, but to me this translates as: Build systems that are too complicated to understand and then, after they are deployed, find ways to master their complexity. Hmmm' (204). He is no doubt right in his contemporary historical diagnosis: 'Trillions of smart tags, sensors, smart materials, connected appliances, wearable computing, and body implants are now being unleashed upon the world all at once. It is by no means clear to what question they are an answer – or who is going to look after them, and how' (198). He is also undoubtedly right that very few of us need to interact with an electronic toothbrush that harbors 3,000 lines of hard code. This does not entail, however, that one can avoid addressing interactions with the complexity of ubicomp culture as such, as complex.

Maybe there is a sound ethical insight and point to be found in Thackara's treatment. In that case he shares that insight with Donald Norman who insists in his recent book on making a distinction between 'complexity' and something 'complicated' (Norman, 2011). 'Complexity' has to do with a state of the world, suggesting things with many intricate and interrelated parts, Norman argues. 'Complicated' has to do with a state of mind, including not least the secondary meaning of that which is 'confusing.' Maybe the two authors could be brought to agree, then, to Norman's suggestion that we forget about the complaints against complexity, only to complain against confusion, against whatever makes us feel helpless or powerless in the face of mysterious forces that take away control and understanding. On this view, bad interaction design for ubicomp cultures has no excuse, whereas good design can help tame the complexity, a complexity which is required but should be managed and be made understandable, according to Norman. This type of argument will not be helpful enough – assuming that it will not do to militate against complexity in the most traditional way, i.e., by insisting on granting priority to some version of reductionism (in this case Norman's insistence upon reduction to the understandable). This will be insufficient in case an affirmative pursuit of the complexity of ubicomp cultures is called for, and this will certainly be the case each time their emergent traits are to be addressed, no matter how uncomfortable it might be to admit of contingency and the spontaneously unpredictable.

In fact, a more affirmative way to approximate a theoretical set of resources for dealing with complexity and emergence in this context can be found in a source as early as Warren Weaver's 1948 article on science and complexity (Weaver). This text might be said to present several forward steps in that respect with its double distinction, first between 'problems of simplicity' (largely concerned with two variables) and 'problems of complexity'; then between problems of 'disorganized complexity' on the one hand (billions of variables as in physics and math, to be handled by probability theory and statistical mechanics), and, on the other, problems of 'organized complexity' (the middle region concerning ways to deal simultaneously with a sizable number of factors which are interrelated into an organic whole). Perhaps Weaver's now classic article is particularly useful because it would allow us to see that almost all of our questions concerning the complexity of ubicomp culture and their interaction designs belong to such problems of 'organized complexity,' as are similar problems in biology, medicine, psychology, economics, and political science. Reduction to simply two variable problems is not possible, but it is also not a matter of

applying a mathematics of averages to a huge number of factors. Not least, an approach via this middle kingdom of organized complexity might permit us to acknowledge the occurrence of emergence, i.e., that which Weaver already pointed to when saying that members of diverse groups can work together to form a unit which is much greater than the mere sum of its parts (542).

Even though the contributors to this issue of the Fibreculture Journalhave different approaches to this, the issue as a whole can be read as an insistent voicing of a concern with complexities of ubicomp cultures whose bundled relations of interactivity display emergent traits. The wager is that a great many kinds of interactivity in ubicomp cultures can be modeled or simulated as so many complex systems qua a non-linear coming together and dispersal of diverse interactants and components. This necessarily means that interaction designs for ubicomp cultures are to quite some degree unpredictable and uncontrollable, not least for cybernetics as a science of control. But perhaps they are also positively emergent qua tendentially self-organizational (i.e., 'designing' means to afford local dynamics of interactions so as to eventually produce global coordination and synergy). Perhaps this remains at the heart of interaction designs for ubicomp cultures: they must be and remain a complexly moving target. One will have to engage with the existing interaction designs and those to come so as to find out whether their interactive networkings are emergent in a strong and/or a weak sense. One will have to explore whether and how their spontaneous ordering of complex systems and patterns out of a multiplicity of relatively simple interactions do and do not go beyond the qualities of their components. It will be of some interest to see whether and how one might approach interaction designs for a ubicomp culture by thinking of and working with its interactive complexity in terms of scale-free networks or small world networks, as thought by Albert-László Barabási and others (Barabási, 2002, 2009; Newman, Barabási and Watts) as well as by Duncan Watts and Steven Strogatz (Watts and Strogatz). This is not least of interest because it already amounts to affirming a belief in a complexity of interaction design that cannot be strictly defined, only momentarily and locally placed as fluctuations somewhere between ordering of structures and dissipating into disorder (Nicolis and Prigogine; Prigogine and Stengers).

Biographical Note

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Notes

- [1]For one good, short, and relatively early account of the status quo of ubicomp research, including its limits and unresolved issues, see the article written by two computer scientists from Intel (Want and Pering).
- [2]Gregory Abowd and Elizabeth Mynatt provide one good, short historical overview from 2000 of the implications for HCI of ubiquitous computing, such as natural interfaces, context-aware applications, and automated capture and access (Abowd and Mynatt). Jonathan Grudin's more recent introduction for the third edition of the *Human-Computer Interaction Handbook* (2011) offers a much broader and more detailed rehistorization of HCI whose closing part engages with ubiquitous computing under the rubric of discretion and invisible HCI (Grudin).
- [3] For a more extensive treatment of the notions of mixed reality at stake in current cultural theory along with research and development, see my introduction in *Throughout* (Ekman).

- [4] A more detailed account of engagements with context-awareness can be found in my introduction to *Throughout* (Ekman).
- [5] See also David Tennenhouse's useful insistence on delimiting any traditional human-centered vision focused on interactive computing now that we are approaching the networking of thousands of embedded processors per person on the planet (Tennenhouse).

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