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INTIMATIONS OF EVERYDAY LIFE
Ubiquitous computing and the city

Ubiquitous computing seeks to embed computers into our everyday lives in such ways as to render them invisible and allow them to be taken for granted, while social and cultural theories of everyday life have always been interested in rendering the invisible visible and exposing the mundane. Despite these related concerns, social and cultural studies have been almost entirely absent in discussions of the design of ubiquitous technologies. This essay seeks to introduce researchers in both fields to each other, and begin to explore the ways in which collaboration might proceed. By exploring mobile and ubiquitous technologies currently being used to augment our experiences of the city, this paper investigates notions of sociality, spatialization and temporalization as central to our experiences of everyday life, and therefore of interest to the design of ubiquitous computing.

Keywords control society; embodiment flow; spatialization; temporalization; ubiquitous computing

> [E]veryday life consists of a multiplicity of rhythms. Everyday life thus entails a range of flows, each with their own 'proper time' (e.g., duration, pace, frequency). Likewise, we could argue that everyday life consists of a multiplicity of spatializations, including forms of embodiment. If we were to use 'space of places', we would have to bear in mind the inherently dynamic, volatile, contested, unstable, and *multiplicitous* (rather than duplicitous) nature of 'place'.
>
> (van Loon 2002, p. 93)

> The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.
>
> (Weiser 1991, p. 1)

Introduction

Ubiquitous computing seeks to embed computers into our everyday lives in such ways as to render them invisible and allow them to be taken for granted, while

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social and cultural theories of everyday life have always been interested in rendering the invisible visible and exposing the mundane. Despite these related concerns, social and cultural studies remain in the background of discussions of ubiquitous technology design. This essay seeks to bring together researchers in both fields, and begin to explore the ways in which collaboration might proceed. Of course, this is a large project, and this essay is only a first and tentative step in that direction. My strategy involves asking more questions than posing answers so that other researchers may begin to locate their own interests and make their own connections.

For the purpose of this special issue, and in the interests of critiques of everyday life, this essay explores ubiquitous computing in terms of sociality, spatialization and temporalization. The first part looks at the origins of ubiquitous computing and its concern with social and cultural practices. The second part of the essay addresses current ubiquitous computing, context-aware technologies, and particular projects explicitly using notions of space, time and embodiment to augment our experiences of the city.

The third and final part of the essay examines the centrality of spatialization, temporalization and embodiment in the performativity of everyday life, and further connects these concerns to ubiquitous computing. The primary goal of this essay is to draw out ways in which social and cultural theories of everyday life may begin to contribute to discussions of the design of ubiquitous computing, and how critiques of everyday life will increasingly need to account for emerging ubiquitous technologies.

The social origins of ubiquitous computing

In 1991, *Scientific American* published Weiser's article 'The computer for the 21st century' and planted the seed for a new paradigm in computing that is arguably set to dominate the coming decades. In the late 1980s, researchers at Xerox Palo Alto Research Center (PARC) moved away from personal computing – which they understood as forcing computers to the centre of our attention – and towards what they called ubiquitous computing, or Ubicomp, which 'takes into account the natural human environment and allows the computers themselves to vanish into the background' (Weiser 1991, p. 1). In other words, they were interested in 'invisible' computers that would allow us to focus on life beyond computational devices. According to Weiser, not only would ubiquitous computing liberate us from the constraints of desktop computing, it would free us from equally isolating immersive and simulated virtual reality environments. From the perspective of design, ubiquitous computing was also novel because Weiser's inspiration came from the social and cultural realms more than from the technological (Weiser 1993a).

Weiser began with an explicit interest in the role of computers in everyday

life, and a desire to build computers that did not interfere with our everyday activities:

> A good tool is an invisible tool. By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good tool – you look at the world, not the eyeglasses. The blind man tapping the cane feels the street, not the cane.
>
> (Weiser 1993b, p. 7)

Rheingold visited PARC for an article he was writing for *Wired Magazine*, and interviewed Weiser:

> The lab's new direction, Weiser says, 'recognizes even more that people are social creatures'. He referred to his ideas as a form of 'postmodern computing', in that he wants to 'return to letting things in the world be what they are, instead of reducing them' to data or virtualizing them into illusions. 'Ubicomp honors the complexity of human relationships, the fact that we have bodies, are mobile', he said.
>
> (Rheingold 1994a, p. 3)

The degree to which Weiser was able to convince fellow computer scientists of the importance of social and cultural issues in the development of ubiquitous computing varied. In 1999, Weiser was diagnosed with cancer and given 18 months to live; he died after six weeks. An obituary from the Department of Electrical Engineering and Computer Sciences, University of California, Berkeley (1999) recalled that,

> When he was diagnosed with cancer, he decided to spend his remaining time writing a book clearing up some of the confusion around ubiquitous computing. Weiser wanted to sit by the seaside and write the book on the real essence of ubiquitous computing. 'They've completely missed the non-technical part of what ubiquitous computing is all about', he told Xerox's chief scientist and PARC's director, John Seely Brown.

Unfortunately, Weiser died before he could write his book and now, four years later, while many Ubicomp research projects conduct ethnographic evaluations of technology in use, we could still make the case that the 'non-technical' or broader social and cultural aspects of ubiquitous computing remain insufficiently explored and represented in the design process.

Ubiquitous computing vs. virtual reality

From the beginning, Weiser was concerned not only with describing what Ubicomp was, but also what it was *not*. Most importantly, ubiquitous computing

was seen to be fundamentally different from the virtual reality technologies that dominated the popular consciousness of the time.

> [V]irtual reality is only a map, not a territory. It . . . focuses an enormous apparatus on simulating the world rather than on invisibly enhancing the world that already exists. Indeed, the opposition between the notion of virtual reality and ubiquitous, invisible computing is so strong that some of us use the term 'embodied virtuality' to refer to the process of drawing computers out of their electronic shells. The 'virtuality' of computer-readable data – all the different ways in which it can be altered, processed and analysed – is brought into the physical world . . . By pushing computers into the background, embodied virtuality will make individuals more aware of the people on the other ends of their computer links.
>
> (Weiser 1991, p. 2)

The corporate Xerox PARC researchers had positioned themselves against virtual reality, when VR represented a unique mix of military, university and counter-culture values (Rheingold 1994b, Hillis 1999). Against the seemingly boundless freedom promised by proponents of virtual reality, Ubicomp did not seek to transcend the flesh and privilege the technological. Instead, ubiquitous computing was meant to go beyond the machine – render *it* invisible – and privilege the social and material worlds. In this sense, ubiquitous computing was positioned to bring computers to 'our world' (domesticating *them*), rather than us having to adapt to the 'computer world' (domesticating *us*). As Norman (1998, p. 261) later wrote 'today, it is the individual who must conform to the needs of technology. It is time to make technology conform to the needs of people'.

Ubiquitous computing as calm technology

By 1996, Weiser and Seely Brown were predicting the 'coming age of calm technology'. Despite the rather mundane contexts projected for ubiquitous computing – computers in everyday objects and places – it was also presented as exceptional technology:

> The most potentially interesting, challenging, and profound change implied by the ubiquitous computing era is a focus on *calm*. If computers are everywhere they better stay out of the way, and that means designing them so that the people being shared by the computers remain serene and in control . . . [W]hen computers are all around, so that we want to compute while doing something else and have more time to be more fully human, we must radically rethink the goals, context and technology of the computer and all the other technology crowding into our lives. Calmness is a fundamental challenge for all technological design of the next fifty years.
>
> (Weiser & Seely Brown 1996, p. 3)

But what exactly did they mean by 'calm technology?' They described technology that moves between the *periphery* and *centre* of our attention, outside of conscious awareness (but not completely absent) until we actively focus on it. In this way, they argued, the 'result of calm technology is to put us at home, in a familiar place' (Weiser & Seely Brown 1996, pp. 4–5). Put otherwise, calm technology could be distinguished as technology that would be so embedded, so pervasive, that it could be *taken for granted*. It would be informative without being overwhelming or distracting. They suggested that ubiquitous computing would become 'so commonplace, so unremarkable' that we would forget its enormous impact, just as we have with writing and electricity, two other ubiquitous technologies (Weiser & Seely Brown 1996, p. 2).

Weiser believed that the design of ubiquitous computing would greatly benefit from research in the humanities and social sciences. Social and cultural studies of everyday life are uniquely suited to question the implications of 'invisible' and context-aware technologies, and we may begin to ask how critiques of everyday life can contribute to the design of ubiquitous computing. To continue this larger project, the second part of this essay looks at current Ubicomp, context-aware technologies, and particular projects that bring the space and time of social interaction to the foreground.

Current ubiquitous computing

In its broadest sense, ubiquitous computing is currently seen to comprise any number of mobile, wearable, distributed and context-aware computing applications. In this way, Ubicomp may consist of research into 'how information technology can be diffused into everyday objects and settings, and to see how this can lead to new ways of supporting and enhancing people's lives', as examined by *The Disappearing Computer* Initiative (http://www.disappearing-computer.net), as well as the 'integration of physical and digital interaction', explored by the *EQUATOR Interdisciplinary Research Collaboration* (http://www.equator.ac.uk). A wide variety of scientific research labs around the world are currently studying the many types of hardware and software components necessary for ubiquitous computing. In addition to research in engineering, computer and hard sciences, continuing investigations in human-computer interaction and computer supported cooperative work draw on psychology, anthropology and sociology (see for example Nardi and O'Day 1999, Dourish 2001, Brown *et al*. 2002).

Context-aware computing

Central to ubiquitous or pervasive technologies is the ability of computers to be perceptive, interpretive and reactive. In other words, information

infrastructures must be able to shift from periphery to centre, and to recognize and respond to actual contexts of use. Context-aware computing therefore relies primarily on two types of information: physical location and user identity, both requiring extensive data acquisition, storage and delivery mechanisms.

The global positioning system (GPS) is a now familiar location-awareness technology. An increasingly common technology enabling broader context-awareness is radio frequency identification (RFID) tags. Put simply, individually programmed RFID tags, or transponders, use radio signals to capture and share data between mobile and fixed computing devices, allowing automatic data capture and object identification. For example, since the 1980s, very small RFID tags have been inserted under the skin to track livestock, and built into new automobiles to allow for automated vehicle identification (AVI). They may be invisibly embedded into virtually any object, and global industry and business are currently working towards implementing RFID tags throughout the entire supply chain (http://www.aimglobal.org/technologies/rfid/).

Of concern here are the implications of context-aware computing for privacy in everyday life. Such comprehensive monitoring or surveillance is not contained by either space or time, as these technologies may cross both physical and social boundaries (Langheinrich 2002). For example, consumer profiles could expand to include not only what people have purchased, but where, when and by whom these items are used. Not only might consumers automatically receive individualized information, but they might also be denied access to information not deemed part of their data profile. In addition, ephemeral or transitory activities may be captured, stored and redistributed in perpetuity. The questions of where data will be stored, and who owns or has access to these data, become paramount issues in the development of ubiquitous computing that respects social and democratic expectations around everyday privacy (Lederer *et al*. 2002). The question of 'invisibility' also raises concerns over privacy, as it may be impossible for people to recognize, let alone control, their interaction with ubiquitous computing applications (Nguyen & Mynatt 2002). Partly in response to such concerns, and despite the current focus on 'seamless' applications, Ubicomp researchers are now suggesting more 'visibility' and recalling Weiser's notion of 'seamful' interaction, with 'beautiful seams' (see for example MacColl *et al*. 2002).

Hybrid worlds: between physical and virtual spaces

The types of ubiquitous computing of interest here are those that most openly seek to create unique forms of inhabitable space and means of habitation, and therefore raise issues not only of spatialization, but also of temporalization and embodiment. So-called mixed reality technologies are explicitly concerned with questions that have long been in the arena of social and cultural discussions of everyday life.

Mixed reality environments refer to spaces that combine elements of the physical and virtual worlds. According to Milgram *et al*. (1994, p. 1), 'rather than regarding the two concepts simply as antitheses, however, it is more convenient to view them as lying at opposite ends of a *continuum*, which we refer to as the *Reality-Virtuality (RV) continuum*'. At one end of the continuum are seen to be 'real' objects that can be observed directly or 'sampled and then resynthesized via some display device', while at the other end are 'virtual' objects that are 'simulated' through 'some sort of a description, or *model*, of the object' (Milgram and Kishino 1994, p. 1). Similarly, a '*real image* [is] any image which has some luminosity at the location at which it appears to be located . . . [whereas] a virtual image of an object [is] one which appears *transparent*, that is, which does not occlude other objects located behind it' (Milgram & Kishino 1994, p. 2). Put otherwise, the 'real' is defined as material fixed in place, whereas the 'virtual' is defined as immaterial, outside of time, both distant and close.

Mixed-reality comprises anything between the two extremes of the spectrum, and combines aspects of both to create a *hybrid* environment. The two most common types of mixed reality technologies are 'augmented reality' and 'augmented virtuality'. Augmented reality seeks to enhance physical spaces and objects with virtual reality; augmented virtuality seeks to enhance virtual reality with real-world data and objects. Of interest here is augmented reality, which attempts to overlay physical objects with virtual objects in real-time and allows people to experience the virtual as if it were real (Azuma 1997). In some ways, augmented reality has the same ultimate goal as virtual reality: to create new interactive spaces through computation. Where they differ is in how they see this best accomplished, which, in part, involves their assumptions about space, time and the body.

While augmented reality is much closer to Weiser's vision for Ubicomp than is augmented virtuality, Falk *et al*. (1999, p. 3) refine the concept by introducing the term 'amplified reality'.

> While augmented reality is about enhancing our impressions of everyday objects in our surrounding, *amplified reality* is about enhancing the *expressions* of objects and people in the world . . .
>
> An amplified object is self-contained in regards to its properties. In practice, this means that that the properties are *embedded* parts of the object. In contrast, augmented reality superimposes virtual properties on an object, which in effect does not change the actual object, but rather how we perceive or experience it. Augmented properties are not persistent outside the augmented reality. The important difference between these two approaches lies in the proprietary rights to the information. An amplified object controls the flow of information, while in an augmented reality system the perceiver is in control of the information . . . In other words, an

> augmented reality systems alters the impressions of its user, without there being any corresponding properties in the *expression* of the object she is perceiving. This is quite different from ordinary life.

Most notable in this description is the introduction of computation as a *material* for designing not only the digital realm but also the physical world (see also Orth 2001, Redström 2001), and a shift from concerns with the functional *use* of computers to the *presence*, expressions and aesthetics of computational artefacts in everyday life (Hallnäs & Redström 2001). I think Weiser would have been interested in this more existential design approach to embedded computing, and cultural studies of everyday life offer further critical insights into discussions of 'reality' and 'virtuality' (see for example Massumi 2002; Shields 2003).

To continue my exploration of the connections between ubiquitous computing and theories of everyday life, I would like to introduce several projects that focus on augmenting and amplifying physical spaces and experiences through a variety of mobile and context-aware technologies. The projects, presented in alphabetical order, are in various stages of development, prototyping or testing. All information has been culled from whatever online project descriptions and research progress reports were available at the time of writing.

Amplified and annotated city spaces

All of the following projects use wireless and ubiquitous technologies to explore our everyday experience of the city. Their shared interests in moving through the city as integral to its experience bring to mind Lefebvre's (1991) production of space and de Certeau's (1984) spatial practices. Theorists of everyday life will also recognize Benjamin's (1969, 1999) *flâneur* and the ability of technology to make the invisible visible, as well as Situationist *derivé* and *detournément*. Their visions also conjure Lynch's (1960) city as our experiences with districts, edges, paths, nodes and landmarks, and their relational properties (Lynch 1984). All of these projects raise issues of spatialization, temporalization and the social; issues which allow us the opportunity to reexamine our assumptions about the city and everyday life (cf. Borden *et al*. 2001). If virtual reality technologies may be understood as visual, and spatial, technologies (Hillis 1999), these wireless and ubiquitous technologies firmly add the dimensions of sound, and time, to our everyday experiences.

Amble Time

A project by Media Lab Europe's Everyday Learning research group, *Amble Time* overlays a digital map of the city with context-aware spatial and temporal information:

> A shortcoming of standard maps is their inability to convey a sense of temporal scale. Can I stroll to the park for lunch, or would it take me all day? *Amble Time* adds an element of time to a PDA-based tourist map. By using a GPS system and your average walking speed, it creates a bubble that indicates everywhere you could walk in an hour. Alternatively, given a final destination, it can show where you could roam along the way and still arrive on time. In the second situation, as your position changes and time ticks by, the bubble slowly shrinks and morphs until eventually it highlights the shortest path to your destination.
>
> (http://www.medialabeurope.org/el/Projects/Amble_Time.htm)

In an interview with the BBC (2003), lead researcher Brendan Donovan explains further:

> Say that you have to be at the train station at 3 o'clock. The software draws a bubble around you showing everywhere that you could walk to and still get to your destination on time . . . You could click on various locations on the map and see what times the trains were running or see information about restaurants etc.

Amble Time provides a means to augment physical spaces by providing context-specific information to mobile users walking through the city. The city emerges as a spatial, temporal and embodied experience, as the traditional map is visually overlaid with information on particular places physically accessible within particular frames of time. *Amble Time* also associates everyday life in the city with consumerism, where ubiquitous computing may bring mobile users closer to sites of consumption. If projects like *Amble Time* were to be commercialized, what might be the impact on practices of consumption and everyday life? If we recall the metaphor of domestication used above, could we claim that Ubicomp may still be used to indirectly domesticate consumers by leading them to commodified experiences?

Sonic City

Sonic City is a joint project between the Play Research Studio of the Interactive Institute and the Future Applications Lab of the Viktoria Institute, Sweden, in which the city is seen to act as a musical instrument.

> In the project *Sonic City*, we are developing an application that enables people to create music by walking through a city. From wearable and context-aware computing, perception of place, time, situation, and activity is applied to real-time, personal audio creation. We are exploring and prototyping new experiences and interactions with audio content, considering mobile

> behaviors and urban conditions as parameters in music composition . . . Implementation involves a portable laptop, biometric and environmental sensors. Sensor data is processed, transmitted as MIDI signals and mapped to musical parameters in a program created in the interactive environment PD. Ultimately, we intend the program to run on a PDA or as a wearable device.
>
> (http://www.playresearch.com/projects/soniccity/)

Essentially, *Sonic City* conjures city spaces in terms of sound and music, that is, as the ability to create sound and experience musical compositions. Since sound and music necessarily comprise the passage of time, space is also defined in terms of time. Furthermore, music is expressive and 'where it presents a world, a world one could be in, there only a person can go' (Evens 2002, p. 173). Again, the city is explored in terms of spatialization, temporalization and embodiment. Perhaps more importantly, we may ask what role sound plays in these processes. How do sound and music affect the performance and experience of space and time? What are the expressive qualities at play here? How does sound interpolate bodies in motion?

Sonic City expands the reach of technology by making it mobile, while simultaneously limiting its reach by playing the music to individually carried devices. The project raises interesting connections as music is performed not only through movement in space and time, creating mobile musical 'soundscapes' (Westerkamp 1999), but is also connected to the body through wearable computers which may be seen to create musical human-machine hybrids, or embodied music (see, for example, Hayles 1999, Grenville 2002).

> For illustration, consider the following scenario: a person is taking a walk through the busy streets of her town without any particular destination in mind. She puts on a pair of headphones and switches on her music creation device. Progressively, she begins to hear an evolving musical rhythm of concrete urban sounds, a tempo which follows her steps. The tempo keeps an acceptable pulse even when she stops for a red light, and catches up when she starts walking again. The structure of the music composition is non-linear, such that it changes each time her path does: switching to a bridge as she turns left after the bookshop on the corner, and back to the motif as she crosses the street. She decides to walk through a park: the music adapts to this different, quieter environment, shifting to a more basic rhythm pattern consisting of a few ground sounds. A more complex pattern emerges when she leaves the park and heads for a busy street. At some point, she cannot help but to try a little dance step: this disturbs the system that was expecting roughly binary steps. After brief structural chaos, the device stabilizes to a newly syncopated rhythm pattern as she walks on.
>
> (Gaye *et al*. 2003, p. 2)

Sonic City also conjures Situationist *derivé*, or playful 'nomadic' wanderings through the city, as it creates mobile musical ambiences and 'rewrites' the urban experiences of the user. Here we may also ask what roles sound and mobility play in our experiences of the city. Do notions of embodiment better capture a sense of mobility than do notions of the body? How may the body be understood as a wearable device, or perform as a musical instrument? How can Ubicomp be used to resist, or 'write against', totalizing concepts of the city?

Tejp

Also a joint project between the Play Research Studio and the Future Applications Lab, *Tejp* (Swedish for 'tape') consists of sound-based prototypes inspired by 'situationism, graffiti and other forms of street art'.

> This project explores various possibilities for overlaying personal traces and information on public spaces through different mediums and behavior patterns. It is our hope that *Tejp* will transform spectators into players and encourage playful ways to personalize territory in the public realm. We also hope to connect local communities by providing a space and sounding board for existing social relationships.
>
> (http://civ.idc.cs.chalmers.se/projects/pps/tejp/)

The first of two prototypes consists of audio tags, 'left at hidden places in public spaces [where] personal messages that have been previously recorded are whispered to by-passers as they lean towards [the tag]':

> Someone who wants to share personal messages anonymously (or not) records it into the small box by talking, singing, playing music etc. to it while holding a button. He/she sticks [the audio tag] on a wall somewhere . . . Passers-by notice/recognize the sticker because of its particular yet discrete design, leans/reaches towards it and hears the content of the tag. Others happen to pass by the device without seeing it, and hear its content by accident.
>
> (http://civ.idc.cs.chalmers.se/projects/pps/tejp/prototype1.html)

The audio tags create a means for people to interact with their physical and social surroundings in novel ways, annotating spaces and creating particular places, again performing the city through practices of spatialization, temporalization and embodiment.

The second prototype is called *Glitch*:

> An array of speakers are [*sic*] hidden in public places. The speakers loudly broadcasts interference glitches caused when passersby receive incoming

> messages and phone calls. The prototype draws attention to the amount of personal communication taking place in a given space and will be used to analyze behaviors in response to its presence in the public realm . . .
>
> The nature and origin of the noises are familiar and easily identifiable but the speakers are hidden. Because of the linear disposition of the speaker array along a usual pedestrian path, the glitches stalk the person during the whole phase of mobile communication initiation.
>
> (http://civ.idc.cs.chalmers.se/projects/pps/tejp/prototype2.html)

While *Tejp* draws on *derivé*, *Glitch* appears to be inspired more by Situationist tactics of *détournement*. As a disruptive, or interruptive, technology *Glitch* makes tangible what may otherwise be intangible: the volume of mobile phone communication in a given space. *Glitch* also has the ability to render strange that which has become common-place, and create the technology anew. Transforming familiar meanings around mobile technologies draws attention to the place of these technologies in our everyday lives. How might other wireless technologies be used to defamiliarize particular technological practices and offer critiques of everyday life? How might ubiquitous technologies offer people a means to resist totalizing concepts of the city or of technology in general? Relatedly, how might wireless and ubiquitous technologies be used to limit social agency? What are the privacy implications of such technologies?

Texting glances: ambient interludes from the Dublin cityscape

Texting Glances is a joint project of the Story Networks Group at Media Lab Europe and the Networks and Telecommunications Research Group (NTRG), University of Dublin, Trinity College. Instead of using audio annotation and mobility, it focuses on waiting-place annotation through text and image:

> The system proposes to introduce a personal yet sociable and visual activity into urban 'waiting' spaces. Personal, because the input device is a cell phone; sociable and visual, because people can work together to co-construct a visual narrative. As people wait, they text to the system; the system responds to their texting by providing an image; as more people text the sequence of visuals plus text forms a multi-authored narrative. *Texting glances* is an ambient 'waiting' game in which transient audience participants use SMS texting to evolve a visual story on a large display which is installed in a public space such as a bus or train station.
>
> We imagine *Texting Glances* has a network of sites in the City. The moving audience interacts with the sites as they go about their daily lives. Audience can become author by adding to the image content of the system. Images 'live' in the system and are triggered into making an appearance, at any time and at any place by other users. An image can go undiscovered for months

> unless exposed by the audience. Audience can also become collector and download passing images. The city becomes a hiding place for images to be uncovered and collected. *Texting Glances* could affect changes in behavior as people move to different city spaces to find new images and stories.
>
> (Vaucelle *et al*. 2003, pp. 1–2)

In addition to raising issues of collective memory, *Texting Glances* conjures cultural studies of *in-between* spaces. For example, Clifford (1997) examines the hotel lobby as a metaphor for being away from home, in movement, in ambiguity. Morris (1988, p. 3) explains that motels 'memorialize only movement, speed and perpetual circulation;' the motel then represents 'neither arrival not departure, but the "pause"'. Braidotti (1994, pp. 18–19) also focuses on the 'places of transit that go with travelling: stations and airport lounges, trams, shuttle buses and check-in areas. In between zones where all ties are suspended and time stretched to a sort of continuous present'. What might ubiquitous technologies add to these discussions of non-space or in-between spaces? What might constitute the temporality of waiting? What sorts of rituals occur in these liminal spaces?

Urban tapestries

Sonic Geographies is a set of technological experiments being developed by Proboscis' Social Matrices research programme, which:

> takes sound as the entry point for excavating and mapping urban experience and invisible infrastructures of the city. A series of experiments and scenarios are being developed that operate as maps and journeys but also as highly personal renderings of sonic experience – sounds of the personal world in conversation with sounds of the city . . .
>
> The excavation is designed to open up a new space of enquiry into the experience of the city, and how sound functions as a kind of infrastructure for understandings of place and geography particular to contemporary conditions in the city.
>
> (Proboscis 2003, p. 2)

Of particular note is the *Urban Tapestries* project:

> *Urban Tapestries* allows users to annotate their own virtual city, enabling a community's collective memory to grow organically, allowing ordinary citizens to embed social knowledge in the new wireless landscape of the city. Users will be able to add new locations, location content and the 'threads' which link individual locations to local contexts, which are accessed via handheld user devices such as PDAs and mobile phones.
>
> (http://www.proboscis.org.uk/urbantapestries/index.html)

> Users of *Urban Tapestries* will be able to select threads to follow (such as historical or social threads linking individual places), or drift across all the threads. Having selected a thread, the user will receive a map of the locations in the area associated with it. They can either follow it as a trail, or set the system to give a proximity alert when they pass a location.
>
> (http://www.proboscis.org.uk/urbantapestries/scenarios_2.html)

The *Urban Tapestries* project, and *Sonic Geographies* in general, raise issues of the lived city, 'invisibility', storytelling and the performance of collective memory (see, for example, Calvino 2002, Boyer 2003). How are space and time in the city negotiated by wireless technologies? What might constitute a sense of 'place' in such scenarios? How might ubiquitous technologies map mobile experiences of everyday life? How might such technologies rearticulate what it means to 'write' the city? How are individual and collective memory reconfigured by these and similar Ubicomp applications?

All of the above ubiquitous computing projects can be seen to problematize our understandings of spatialization, temporalization and, to varying extents, embodiment. The final part of this paper will more closely examine these categories of everyday life, and their connections to ubiquitous technologies.

Beyond structure: spatialization, temporalization and everyday life

Cultural studies may be seen to privilege ethnography and historiography in its accounts of everyday life, while it also remains indebted to a variety of philosophical approaches within phenomenology and existentialism to explain our being-in-the-world (Highmore 2001). As such, critiques of everyday life have offered unique perspectives to help social and cultural theorists manoeuvre the space between purely objectivist and subjectivist accounts (Gardiner 2000). In many ways, theories of everyday life are exactly what Weiser referred to when he wrote that the humanities and social sciences are good at making visible what is invisible, and exposing the taken-for-granted aspects of lived experience that form our common ground. However, we risk falling back into interior/exterior dichotomies if we use theories of everyday life to account for what is *really* going on under the surface of things. As van Loon (2002, p. 94) reminds us, 'We will not understand anything about everyday life as long as we seek to reduce it to epiphenomena of hidden and secret "structures"'.

Post-structural thought in the humanities and social sciences, and especially that of Deleuze and Guattari, shifted the ground of study from interior/exterior dichotomies toward what might be called the 'relational' and notions of decentred subjectivity. This move focuses attention on the space *in-between* subjects and therefore not on any particular subject; in other words, the space of subjectless

subjectivities where 'the product is the process' (Bains 2002, p. 112) and full accounting, or representation, becomes impossible.

This shifts analysis away from totalizing explanations or representations and towards decentralized performativity, which 'forces one to consider the space that would otherwise simply be glossed over as void. Suddenly, what happens between matters most' (van Loon 2002, p. 90). However, the 'void' of relational space is not empty at all; it is where everyday life happens. Theorists such as Bakhtin, Debord, Vaneigem, Lefebvre and de Certeau explored these relational spaces in terms of dialogic and material practices of everyday life. And rather than desiring and searching for the 'unification between representation and authenticity', we may instead look to performances of spatialization and temporalization in *shadows* and *resonances*:

> The shadows, however, no longer represent 'objects' but have become flows; they entail variations and differentiations only in intensity, not essence. Without having to resort to any other authentic being than the shadow flow itself, we do not have to make up stories about origins of being. Instead, the matter at hand is pure performativity . . .
>
> What the shadow does to vision and spatiality, resonance does to hearing and temporality. The resonance is sound that comes after; it is a trace that marks the vanishing event, the presence that never sustains . . .
>
> [W]hereas the relationship between the object and its shadow is relatively immediate and mimetic, the relationship between a sound and its resonance is always necessarily delayed. We need both figures if we are to make sense out of spatialization in cultural analyses and do justice to its im/materiality.
>
> (van Loon 2002, pp. 91–92)

In this way, the performativity of everyday life involves spatialization, temporalization, embodiment and identification at play – those processes that perform space, time, bodies and identities so essential to being-in-the-world. Rather than looking at shadows and resonances as *representing something else*, we may understand them as spatially and temporally variable flows and intensities of the same 'things'. We are after all, as Weiser tried to convince fellow engineers and computer scientists, *mobile* creatures.

Shadows and resonances allow us to engage relations and *in-betweeness*, and drawing on the notion of flow from the work of Deleuze and Irigaray, Shields (1997, p. 2) explains that fluid relations are spatial, temporal and also material:

> The significance of the material quality of flows is that they have content, beyond merely being processes . . . Flows signal pure movement, without suggesting a point of origin or a destination, only a certain character of

> movement, fluidity and direction . . . It is not that they are relational between objects or fixed points – which are taken as immutable mobiles – but they are the being of relation.

Flows may also be understood in terms of embodiment and becoming. As suggested above, the performative in the everyday has often been overlooked as studies tend to focus on structures, bodies and subjects. But as Harrison (2000, p. 497) claims, it is 'the performative, collective, and material nature of embodiment' that may lead us to conclude that 'everyday life should be understood in terms of enaction and immanence'.

So we may turn to the flows of everyday life and ask what spaces and times – what *places* – are being performed in ubiquitous computing, or more precisely, what are the spatializing and temporalizing roles of these sociotechnical assemblages? We may also begin to ask more questions about Ubicomp, materiality, embodiment and sociality.

Technology as everyday transductions and flows

Despite broader shifts from representation to performativity, theories of technological innovation, like theories of everyday life alluded to above, seem to maintain an almost contradictory sense of consistency and coherency. Part of this stems from the tendency to discuss new technologies as (representational) objects or artefacts, rather than as (performative) 'practices, arrangements and ensembles . . . which permit certain objects to materialize or solidify and not others' (Mackenzie 2003, p. 3).

Technical innovation as cultural practice has been explored within social studies of science and technology (see, for example, Latour 1999, Stengers 2000) but there remains the problem of applying relational ways of thinking to theories of technology and everyday life. As information technologies become more pervasive in everyday life, the analytical usefulness of such concepts becomes evident, and the concept of *transduction* provides a means to refocus our investigations towards non-representational understandings of technological practice:

> Transduction provides a way of thinking about technologies processually, that is, as events rather than objects, as contingent the whole way down, rather than covering over or reducing contingency . . . It proposes that both normalizing and generative capacities of technologies can be understood as a process of individuation, as an ontogenetic process which results in individuated things and which involves both ordinary and singular events. Much of what is represented as 'new' is in fact the capture and containment of the processual mode of existence in technology.
>
> (Mackenzie 2003, pp. 4–5)

Applied to Ubicomp, the concept of transduction allows us to shift our focus from ubiquitous computers as networked objects or artefacts, to ubiquitous computing as diverse procedures or performances in which socio-technical assemblages take shape. The primary benefit of this sort of approach is the ability to identify precise moments and locations in which we may possibly intervene and alter the course of events, thereby reasserting the role of social and cultural agency – and the potential for critiques of everyday life – in the development and use of ubiquitous computing.

Mackenzie (2002) also suggests that *technicity* is a transductive way of understanding technology in terms of flow and movements between abstraction and concreteness, or virtuality and actuality. These and other ontological categories – the virtual, concrete, abstract and probable – have also been explored in terms of intensities and flows by Shields (2003). The idea here is that by focussing our attention on these relations and flows, we may better understand the role of technologies in the spatialization, temporalization and embodiment of everyday life.

> Beyond technical objects, technicity inheres with the relationality of the ensembles or assemblages composed of bodies, institutions, conventions, representations, methods and practices. Read transductively, technical objects evolve over time by articulating diverse realities with each other. Technicity is a transcontextual linkage which can be objectified in context-limited ways, but also exceeds its objectification, stabilization or immutabilization.
>
> (Mackenzie 2003, p. 18)

Put differently, any given ubiquitous technology may be understood to comprise its contexts of research, development, manufacture, sale, implementation, use and eventual disposal. Shifting socio-technical arrangements are negotiated in particular space-times, and it becomes impossible to reduce Ubicomp to discrete (stable) objects of computation. And so, in order to begin to understand ubiquitous technologies transductively, we must seek out their intimations – their shadows and resonances – and begin to ask about their flows.

Ubiquitous computing, power and everyday life

Research into human-computer interaction and ubiquitous technologies has begun in earnest to examine the value of embodiment and presence from a broadly phenomenological perspective (see, for example, Dourish 2001, Hallnäs & Redström 2002, MacColl *et al*. 2002), but has largely taken for granted related matters of spatialization and temporalization. The very desire of Ubicomp to become embedded or pervasive technology serves to render space and time invisible; it quite simply seeks to go anywhere and be everywhere. One of the

consequences of this approach is that relations of power and control are rendered similarly invisible.

Deleuze (1997) makes the case that although there remain disciplinary social institutions, we have moved away from a disciplinary society (following Foucault) and towards a more pervasive and intrusive society of control. This control manifests itself in multitudes of interconnected networks, where people, objects, activities and ideas are deeply intertwined, and dichotomies between public and private, or global and local, become untenable. If the disciplinary society may be understood to *mould* individual and collective behaviour through categorical segregation and fixing, societies of control instead *modulate* interactions by integrating and organizing difference. Control societies comprise hybrid and mobile forms of interaction, rather than structures that follow predictable rules. At issue here are not objects or subjects, but relations between bodies, and processes of embodiment; performed in these processes are relations of power and control in everyday life.

Easily envisioned as part of Latour's (1999) 'proliferation of hybrids', ubiquitous computing is the archetypal hybrid and mobile technology at work within a society of control. Latour (1999, p. 214) claims that we live and act as a 'collective of humans and non-humans' in which

> an increasingly large number of humans are mixed with an increasingly large number of nonhumans, to the point that, today, the whole planet is engaged in the making of politics, law, and soon, I suspect, morality . . . The nasty problem we now have to deal with is that, unfortunately, we do *not* have a definition of politics that can answer the specifications of this nonmodern history.

The techno-political implications of Ubicomp have a broad reach largely beyond the scope of this paper, but it is important to articulate a few basic questions and concerns around pervasive computing, power and control in everyday life.

If we indeed live and act as a collective of humans and non-humans, as I believe we do, then our connections and relations to our technologies need to be evaluated by means which recognize this multiplicity. Despite the appearance of novelty, ubiquitous computing draws on a long and complex history of relations between materials and ideas, industry and business, government and law, individuals and groups, to name but a few. All of these processes have been mobilized – and will continue to be mobilized - to shape Ubicomp as we know it. To separate ubiquitous computing from these contexts is to deny that it is always already embedded in practices of everyday life. It is precisely this blurring of boundaries, this hybridization, that challenges traditional practices of autonomy and social control, and makes responsibility and accountability increasingly difficult to locate. Just as context shapes Ubicomp, so too ubiquitous computing shapes contexts of interaction. Recalling Latour, I believe we are not

politically ready to engage Ubicomp as long as we continue to assume that ubiquitous computing merely comprises new tools, neutral in and of themselves, and independent of broader networks of relation.

To begin, we need to be clear on, and be able to justify, what it is about the mundane nature of everyday life that can be 'improved' through augmentation, amplification or attempts to merge the physical and the virtual – especially if the technologies themselves are expected to become ordinary and pervasive aspects of everyday life. We need to become more careful about contrasting interaction as it occurs in everyday life with the types of interaction that are possible because of this 'novel' medium we call computation, and recognize the ways in which the virtual is not separate from the real. The 'mixed-reality' enabled by ubiquitous computing may be better understood as shifting intensities or flows of the virtual and the actual, rather than as points on a continuum between the virtual and the real. Through technicity and transduction, Ubicomp may be seen as assemblages and procedures that actualize virtualities in particular ways, and enact particular spaces, times, bodies and relations of power. Without necessarily advocating a Marxist approach, it is still important to ask how ubiquitous technologies may bring together and organize unequal local and global populations.

For example, the technology that allows someone on the street to record their thoughts at a particular location and share it with others – as in the *Urban Tapestries* or *Texting Glances* projects discussed above – also mobilizes local and global procedures and policies surrounding the use of city architecture and public space, the manufacture, implementation and ownership of computer hardware, and socio-technical assemblages for the acquisition and administration of data. If similar types of ubiquitous computing processes are embedded in our everyday urban environments, we need to understand which relations may be privileged and which may be prohibited, again, both locally and globally. What sorts of politics and ethics will we need to ensure accountability in these global ensembles in which we are embroiled? At which points in our processes and procedures may we successfully intervene and affect change, and at which points are particular changes especially difficult or not even possible?

The matter of surveillance in context-aware computing has already emerged as the single greatest social concern surrounding Ubicomp. Public awareness and protest of now familiar video surveillance and data tracking technologies is expanding to address the types of public and private monitoring, as well as citizen interventions, enabled by hundreds of thousands of invisible, mobile computers, including RFID tags (see, for example, Rheingold 2002). Engineer Steve Mann suggests that a possible response to surveillance technologies is to turn them back on the powers-that-be through what he refers to as *sousveillance* (Mann & Niedzviecki 2002). Aware of the potential privacy violations made possible by mobile, context-aware computing, Mann argues that citizens may resist institutional control by using the same technology to gather data on the institutions

themselves. For example, by attempting to digitally mediate and record our interactions in 'public' spaces like shopping malls or airports, we may find ourselves stopped by security guards and forbidden to proceed. In these procedures, we are made aware of the private control of these locations; through the customs of protecting property or national security, regulation of these spaces allows only one-way monitoring. Presumably, this awareness allows for a more informed citizenship, while also calling for greater institutional transparency. However, in a society of control it remains unclear how the perpetuation of surveillance, even if bottom-up rather than top-down, may be a successful act of resistance and actually affect change.

We also need to ask how ubiquitous technologies like those used in the *Amble Time* project may be commercialized and not only track the movements of people and objects, but also lead people directly to places of consumption. In the design of these types of technology, maps of the city need to be programmed and, presumably, businesses will be able to pay to have themselves included as points on the map. As such, the maps include and exclude particular aspects of the city, and just as new empowering relations may be enabled, so too may certain unequal power relations be perpetuated and new limitations or restrictions emerge. Without accounting for these possibilities, the design of ubiquitous technologies may set us on paths for which we are not socially and culturally prepared, and at the same time limit chances for creativity, serendipity and innovation. We need to continually ask about the risks and stakes involved in ubiquitous applications, as our everyday lives will be increasingly intertwined with 'invisible' technologies.

Moving through the city, and through public spaces, has always been a performative practice where the citizen is relatively able to use the material world for her own purposes and enjoyment, and engage in critiques of everyday life (see, for example, de Certeau 1984, Lefebvre 1991, Borden *et al*. 2001). Where ubiquitous technologies might fail is if they prevent or inhibit the ability of a person to experience the city on his own terms; if they start from a premise of what the city *is* rather than allowing it to emerge through the movements of its people. The ability for users to comment on a map, to delete meaningless places, add meaningful places, and to share those comments and places with others, may provide means of putting practices of spatialization and temporalization in the hands of users – allowing them to manipulate, or shape, their city – instead of limiting the potential of everyday life and controlling the flow through abstracted technological objects and models of information. Individuals and collectives need to feel safe and secure in the midst of all these computers, and we need to devise ways of balancing those possibly conflicting needs and desires.

By recalling *Sonic City* and *Tejp*, we may ask how ubiquitous technologies may act as critiques of everyday life. These types of critiques may guide decision-making at local and global scales, and we need to better understand how

Ubicomp may be used to resist and sustain networks of control, and how people may be able to engage with pervasive computing on their own terms (see, for example, Rheingold 2002). With the variable sounds and rhythms of *Sonic City*, the city is spatialized and temporalized through embodied movement and material practices. The shifts and delays in real-time sound and musical composition as the walker passes through particular environments draw our attention to *resonances* of everyday life, as sound implicates the spaces in-between (Evens 2002). Perhaps most importantly, technology demonstrably slows down in these moments, allowing not only space and time for reflection, but creating space and time for becoming and tracing our being-in-the-world. We need to understand exactly what happens during delays and 'crashes', instead of hiding, ignoring or naturalizing them.

A similar critique of everyday life is taken in the *Tejp* sound prototypes. The audio tags created by random passersby and 'whispered' at other passersby immediately conjure *resonances* of everyday life as physical and social boundaries are breached. The potential for both individual and collective action and experience is limited only by the location and governance of tags, and users are offered glimpses of different experiences in the process of making their own expanding the sense of inter-connection. The *Glitch* prototype more obviously disrupts our understandings and expectations of mobile technologies in public spaces by rendering audible what is usually inaudible, and making publicly visible our reactions to these technologies. In these ways, particular 'invisible' ubiquitous technologies may be used to render other material and social processes 'visible', and we may ask how certain relations are enacted in certain contexts, and how those relations create and flow into new contexts. This may enable us to articulate exact processes and events that mobilize specific relations between people, objects and ideas, which, in turn, offer us means to support or resist.

The relations between Ubicomp, power and everyday life are complex and in flux, and yet we need to ensure the responsible development, implementation and use of ubiquitous technologies. Without an understanding of the local and global stakes at hand, we risk the control of people in everyday life and decreased quality of life for everyone.

Conclusions

Visions for ubiquitous computing originated with the social and cultural, and have the ultimate goal of embedding computational devices in everyday objects and places. However, the contribution of social and cultural studies to Ubicomp has been mostly restricted to ethnographic evaluations of technologies and human-computer interaction. This essay, as part of a larger project, points to another place of possible articulation: theories and practices of everyday life.

When everyday life is understood in terms of spatialization, temporalization

and embodiment, ubiquitous computing offers a unique opportunity to evaluate the 'relational' as flows, intensities and transductions that mobilize sociotechnical assemblages. In this way, neither technologies nor familiar categories of everyday life are allowed to slip back into oppositional relationships of interiority and exteriority, and theories of everyday are also better able to account for the increasing pervasiveness of communications technologies in everyday life.

Weiser wanted ubiquitous computing to become *invisible,* but he also called on the humanities and social sciences to make visible to engineers and computer scientists what is often invisible so that they could better design for context-awareness. Theories of everyday life are dedicated to that very task, and provide a means by which to explore augmented and amplified reality applications, and understand the ways in which they spatialize, temporalize and embody everyday life. Conversely, ubiquitous technologies will become more active in the performance of everyday life, and social and cultural studies will benefit from an awareness of their design principles and particular applications. It is my hope that social and cultural theorists, as well as designers of ubiquitous computing, will find new ways of looking at the roles of technology in everyday life. This essay is an attempt to move us in that direction by asking questions and suggesting possibilities, and it will be left to researchers in both fields to take up the challenge of future collaboration.

References

Azuma, R. (1997) 'A survey of augmented reality', *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, pp. 355–385.

Baines, P. (2002) 'Subjectless subjectivities', in *Shock to Thought: Expression after Deluze and Guattari*, ed. B. Massumi, Routledge, London, pp. 101–116.

Bakhtin, M. (1981) *The Dialogical Imagination: Four Essays by M.M. Bakhtin*, ed. M. Holquist, University of Texas Press, Austin, TX.

BBC (2003) 'Digital maps tell the time', 9 May 2003, [online] Available at http://news.bbc.co.uk/1/hi/technology/2986655.stm

Benjamin, W. (1969) *Illuminations*, Schocken, New York.

Benjamin, W. (1999) *The Arcades Project*, Harvard University Press, Cambridge, MA.

Borden, I., Kerr, J., Rendell, J. & Pivaro, A. (eds) (2001) *The Unknown City: Contesting Architecture and Social Space*, MIT Press, Cambridge, MA.

Boyer, C. (2003) *City of Collective Memory: Its Historical Imagery and Architectural Entertainments*, MIT Press, Cambridge, MA.

Braidotti, R. (1994) *Nomadic Subjects*, Columbia University Press, New York.

Brown, B., Green, N. & Harper, R. (eds) (2002) *Wireless World: Social and Interactional Aspects of the Mobile Age*, Springer, London.

Calvino, I. (2002) *Invisible Cities*, Vintage, New York.

Clifford, J. (1997) *Routes*, Harvard University Press, Cambridge, MA.

de Certeau, M. (1984) *The Practice of Everyday Life*, University of California Press, Berkeley, CA.

Debord, G. (2003) *The Society of the Spectacle*, Zone Books, New York.

Deleuze, G. (1997) *Negotiations: 1972–1990*, Columbia University Press, New York.

Department of Electrical Engineering and Computer Sciences, University of California, Berkeley (1999) 'Mark Weiser dies at 46', [online] Available at http://www.cs.berkeley.edu/Weiser/bio.shtml

Dourish, P. (2001) *Where the Action Is: The Foundations of Embodied Interaction*, MIT Press, Cambridge, MA.

Evens, A. (2002) 'Sound ideas', in *Shock to Thought: Expression after Deleuze and Guattari*, ed. B. Massumi, Routledge, London, pp. 171–187.

Falk, J., Redström, J. & Björk, S. (1999) 'Amplifying reality', *Proceedings of the First International Symposium on Handheld and Ubiquitous Computing (HUC) '99*, Springer Verlag, London, [online] Available at http://civ.idc.cs.chalmers.se/publications/1999/AmpReality.pdf

Gardiner, M. (2000) *Critiques of Everyday Life*, Routledge, London and New York.

Gaye, L., Holmquist, L. E. & Mazé, R. (2003) 'Sonic city: the urban environment as a musical interface', *Proceedings of NIME '03*, [online] Available at http://www.viktoria.se/fal/projects/soniccity/pdf/soniccity.pdf

Grenville, B. (2002) *The Uncanny: Experiments in Cyborg Culture*, Vancouver Art Gallery, Vancouver.

Hallnäs, L. & Redström, J. (2002) 'From use to presence: on the expressions and aesthetics of everyday computational things', submitted for publication, [online] Available at http://www.math.chalmers.se/~redstrom/thesis/hi/use2presence.pdf

Harrison, P. (2000) 'Making sense: embodiment and the sensibilities of the everyday', *Environment and Planning D: Society and Space*, vol. 18, no. 4, pp. 497–517.

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

Highmore, B. (2002) *Everyday Life and Cultural Theory: An Introduction*, Routledge, London.

Hillis, K. (1999) *Digital Sensations: Space, Identity and Embodiment in Virtual Reality*, University of Minnesota Press, Minneapolis.

Langheinrich, M. (2002) 'Privacy invasions in ubiquitous computing', paper presented at Ubicomp 2002 Privacy Workshop, Göteborg, Sweden, [online] Available at http://guir.berkeley.edu/pubs/ubicomp2002/privacyworkshop/papers/uc2002-pws.pdf

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science Studies*, Harvard University Press, Cambridge, MA.

Lederer, S., Dey, A. K. & Mankoff, J. (2002) 'Everyday privacy in ubiquitous computing environments', paper presented at Ubicomp 2002 Privacy Workshop, Gothenburg, Sweden, [online] Available at http://guir.berkeley.edu/pubs/ubicomp2002/privacyworkshop/papers/lederer-ubicomp02-workshop. pdf

Lefebvre, H. (1991) *The Production of Space*, Blackwell, London.
Lynch, K. (1960) *The Image of the City*, MIT Press, Cambridge, MA.
Lynch, K. (1984) 'Reconsidering the image of the city', in *Cities of the Mind: Images and Themes of the City in the Social Sciences*, eds L. Rodwin & R. M. Hollister, Plenum Press, New York, pp. 151–161.
MacColl, I., Chalmers, M., Rogers, Y. & Smith, H. (2002) 'Seamful ubiquity: beyond seamless integration', Technical Report Equator-02-020, Equator, September 2002, [online] Available at http://www.dcs.gla.ac.uk/scripts/global/equator/moin.cgi/SeamfulUbiquity
Mackenzie, A. (2002) *Transductions: Bodies and Machines at Speed*, Continuum, London.
Mackenzie, A. (2003) 'Transduction: invention, innovation and collective life', draft, [online] Available at http://www.lancs.ac.uk/staff/mackenza/papers/transduction.pdf
Mann, S. & Niedzviecki, H. (2002) *Cyborg: Digital Destiny and Human Possibility in the Age of the Wearable Computer*, DoubleDay Canada, Toronto.
Massumi, B. (2002) *Parables for the Virtual: Movement, Affect, Sensation*, Duke University Press, Durham, NC.
Milgram, P. & Kishino, F. (1994) 'A taxonomy of mixed reality visual displays', IEICE (Institute of Electronics, Information and Communication Engineers) Transactions on Information and Systems, Special Issue on Networked Reality, E77D (12), pp. 1321–1329.
Milgram, P., Takemura, H., Utsumi, A. & Kishino, F. (1994) 'Augmented reality: a class of displays on the reality-virtuality continuum', *Proceedings of Telemanipulator and Telepresence Technologies*, SPIE vol. 2351, pp. 282–292.
Morris, M. (1988) 'At Henry Parkes Motel', *Cultural Studies*, vol. 2, pp. 1–47.
Nardi, B. & O'Day, V. (1999) *Information Ecologies: Using Technology with Heart*, MIT Press, Cambridge, MA.
Nguyen, D. H. & Mynatt, E. D. (2002) 'Privacy mirrors: understanding and shaping socio-technical ubiquitous computing systems', unpublished manuscript, [online] Available at http://quixotic.cc.gt.atl.ga.us/~dnguyen/writings/PrivacyMirrors.pdf
Norman, D. (1998) *The Invisible Computer*, MIT Press, Cambridge, MA.
Orth, M. (2001) 'Sculpted computational objects with smart and active computing materials', doctoral dissertation, Massachusetts Institute of Technology, Cambridge, MA, [online] Available at http://web.media.mit.edu/~morth/thesis/thesis.html
Proboscis (2003) Urban Tapestries Postcard, [online] Available at http://www.proboscis.org.uk/urbantapestries/UT_postcard_2003.pdf
Redström, J. (2001) 'Designing everyday computational things', PhD thesis, Dept of Informatics, Göteborg University, [online] Available at http://www.math.chalmers.se/~redstrom/thesis/
Rheingold, H. (1994a) 'PARC is back', *Wired 2.02*, [online] Available http://www.wired.com/wired/archive/2.02/parc.html

Rheingold, H. (1994b) *Virtual Reality*, Simon and Schuster, New York.
Rheingold, H. (2002) *Smart Mobs: The Next Social Revolution*, Perseus, Cambridge, MA.
Shields, R. (1997) 'Flow as a new paradigm', *Space and Culture*, vol. 1, pp. 1-8.
Shields, R. (2003) *The Virtual*, Routledge, London.
Stengers, I. (2000) *The Invention of Modern Science*, University of Minnesota Press, Minneapolis.
Van Loon, J. (2002) 'Social spatialization and everyday life', *Space and Culture*, vol. 5, no. 2, pp. 88–95.
Vaneigem, R. (2001) *The Revolution of Everyday Life*, AK Press, New York.
Weiser, M. (1991) 'The computer for the 21st century', *Scientific American*, vol. 265, no. 3, pp. 94–104, [online] Available at http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html
Weiser, M. (1993a) 'Some computer science issues in ubiquitous computing', *Communications of the ACM,* July 1993, [online] Available at http://www.ubiq.com/hypertext/weiser/UbiCACM.html
Weiser, M. (1993b) 'The world is not a desktop', *ACM Interactions*, January 1994, pp. 7–8, [online] Available at http://www.ubiq.com/hypertext/weiser/ACMInteractions2.html
Weiser, M. & Brown, J. S. (1996) 'The coming age of calm technology', [online] Available at http://www.ubiq.com/hypertext/weiser/acmfuture2endnote.htm
Westerkamp, H. (1999) 'Soundscape composition: linking inner and outer worlds', lecture held at Soundscape voor 2000, Amsterdam, Holland, 19–26 November 1999, [online] Available at http://www.sfu.ca/~westerka/writings/soundscapecomp.html