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Interrupting the Here and Now: Implications and Opportunities

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Abstract

This paper presents our research approach of interruptions in mobile HCI inspired by a phenomenological view of context and mobility. On that basis, we outline a research framework and methodology to study the contextual factors at play during the interruption process. Building on that, we propose a design framework based on the discovery of *contextual opportunity* and delineate the design of a naturalistic study to test the veracity of our design rationale. Finally, we point towards future work to extend the design framework's empirical foundation and to apply the framework to create applications that enrich the user's current experience by sensing contextual opportunity.

1 Introduction

Recent advances in mobile information technology have made the promise of information *anywhere, anytime* a reality for many users. As people on the move engage with interactive, mobile experiences, social networks, real-time services, location-based services, and pervasive games, mobile Human-Computer Interaction (HCI) is increasingly becoming fragmented across media, time and space (Fischer & Benford 2009; Oulasvirta et al. 2005). It is especially information push technologies that effectively transform our mobile devices into communication hubs that obediently notify us of every incoming piece of information in addition to phone calls and SMS. Together with the *anywhere-anytime* paradigm, which makes the user's context more apt to change radically over time, the mobile device's disruptive potential is increased through the notification of incoming email, instant messages, or messages on real-time social network services. As applications increasingly accompany our mobility, so may unintended side effects such as 'information overload' and 'attention economy' (Hudson et al. 2002) whereby information competes for the scarce resource that is human attention. On the other hand, the progression of mobile platforms to include more and more sensors such as AGPS, accelerometer and compass as well as enabling the capturing of usage behaviour provides exciting opportunities to tackle a long-standing challenge in con-

text-aware computing: to make computing sensitive and responsive to its setting (Dourish 2004) in order to provide the user with the right thing at the right time (Ho & Intille 2005).

As HCI is fundamentally concerned with the *experience* of technology, it is not surprising that ideas of the philosophical tradition most intimately concerned with the *human experience* have gained currency and influenced widespread adoption of its terminology in HCI (e.g. *Embodied Interaction* (Dourish 2001)). Thus, we draw on foundations in phenomenological philosophy to develop our understanding of mobility and context. This should highlight some of the intricate problems that arise when trying to build context-aware systems and at the same time inform probable solutions. In this paper, we present applied research around interruptions and context-awareness that inform novel methods for information delivery, interruption management and proactive initiation of interaction. Rather than reporting on any one of the conducted studies in detail, we give an overview of the foundations, methodology and research approach thus far and point to more detailed accounts of the studies where appropriate.

2 Mobility and Context

Mobility and context are inextricably intertwined. Taking on a phenomenological perspective of context (Svanæs 2001) means to view being mobile as a form of being-in-the-world (Fallman 2003). Accordingly for mobile HCI, the focus is on the subjective experience whilst being mobile, which entails not only the interaction with the technology, but first and foremost the ongoing involvement with the world as negotiated and enacted in the moment (Dourish 2004). In this view, context becomes an *interactional* problem rather than a *representational* one; i.e. rather than being context *per se*, something may or may not become contextually relevant in the moment because it is individually perceived to be (ibid.).

Humans in face-to-face situations in the Here and Now achieve and maintain a mutual understanding of each other's context that helps an interrupter in determining a good moment for an interruption through the process of *intersubjectivity* (Schutz 1932 as cited by Dourish 2001) grounded in mutual perception. Consider people's skilfulness in interrupting ongoing conversations at cocktail parties in non-disruptive ways to initiate new conversations. In contrast to technology-mediated interruptions, people are usually capable at spotting and using an opportune moment to interrupt and engage with other people.

By exploring temporal, spatial and corporeal properties of mobility further in the following, we motivate both our conception of interruptions and our methodology and research approach, aiming towards the development of an empirically informed model of interruption management that responds to contextual intricacies of being-in-the-world.

2.1 Spatial and temporal properties

For the designer of mobile technology, it is difficult to cater for the scenarios it is used in, as its usage settings are inherently uncertain. We are all familiar with the consequences of con-

text-insensitive mobile phones, ringing, buzzing and beeping at the wrong time in the wrong place. Spatial properties may not just render the mobile device's "behaviour" inappropriate, they may also diminish its usability, or even make it dangerous; for instance think of reading or typing on your phone while driving or walking at the side of a road. The importance of location for context-aware mobile systems has been acknowledged in HCI research (e.g. Dix et al. 2000), but location alone does not make a device context-sensitive. Physical spaces become meaningful through the occasioning of space, through activities and social interactions that take place in them, transforming them into *places;* consider for example the difference between a "house" (space) and a "home" (place) (Harrison & Dourish 1996). Thus, the design of context-aware systems need not only be aware of location, e.g. GPS coordinates, but need to have a notion of the semantic meaning of that space.

Temporal properties of context raise another set of challenges for mobile HCI. Social norms of interruption are not only linked to spatial properties as outlined above, but also to temporal aspects. Consider the notion of "work time" and "private time". Whereas in the age before mobile communication one would simply not be available at work outside of "work time", mobile technology may cause disruption by channelling all communication to one device. Furthermore, as a consequence of mobility, interaction with mobile HCI is often limited to short episodes or *bursts* of interaction, as attention is a sparse resource when being mobile (Oulasvirta, 2005). This often leads to interaction being *fragmented* across time (Fischer & Benford 2009). Furthermore, technology-mediated interaction is often slow-paced and long-term (Dix et al. 1998), without clear beginnings and endings. For instance, consider a conversation via SMS that lasts for days or longer. Temporal patterns of interaction may also be related to the level of engagement with the application. We showed that the temporal properties *response time* (player's time to respond to a game message) and *elapsed time* (time between player messages) in the long-term, slow-paced, SMS-based game *Day of the Figurines* can be used to predict player engagement (Fischer & Benford 2009). The research had raised several temporal challenges of episodic engagement: Players reported that they often felt 'flooded' with messages when being disengaged and that outdated messages confused them into taking actions that were no longer relevant when re-engaging. The notion of a relationship between temporal properties of interaction and engagement anticipates the next section where we take a look at phenomenology's concept akin to engagement and key to our research: involvement.

2.2 Involvement

Heidegger has posited, "one must not understand a human being's existence (being-in-the-world) as simply a matter of spatial and temporal location with respect to other objects" (Fallmann 2003, 157). "Human mobility is a matter of shifting contexts; of changing involvements" (ibid.). Merleau-Ponty describes this involvement with the world as being directed by an embodied intentionality towards the world (Svanæs 2001). Our orientation towards the world changes according to the direction of our intentionality. This is often illustrated by the experience of tool use. Both Heidegger and Merleau-Ponty give compelling examples of how the experience of interacting with and *through* objects in the world changes by adapting and extending the bodily experience through external devices. It is arguably

these ideas that have made phenomenological thought popular in HCI. For example, Dourish (2001) applies Heidegger's notion of how the orientation towards things in the world may change from "ready-to-hand" (*zuhanden*) to "present-at-hand" (*vorhanden*) to the computer mouse. Dourish illustrates that as long as "I act through the mouse, the mouse is an extension of my hand […]." (ibid., 109), and is in Heidegger's terms ready-to-hand. Then, when the mouse cannot be moved further at the edge of the mousepad, the orientation towards the mouse changes. "I become conscious of the mouse mediating my action, precisely because of the fact that it had been interrupted. The mouse becomes the object of my attention as I pick it up and move it back to the center of the mousepad." (ibid.), and becomes in Heidegger's terms present-at-hand.

In the light of this notion of involvement in the world, technology-mediated interruptions have the potential to interfere with our orientation towards the world by directing and guiding our attention. In fact, Dourish used the same terminology of *interrupted* experience in the example above. In this broad view, interruptions become a mundane, yet essential constituent of human experience, initiating change in our orientation towards the world.

3 Studying receptivity to interruptions

Even though our focus is on technology-mediated interruptions, the previous section has suggested a broad view in which interruptions are ubiquitous and central to the human experience. An interruption has been defined as "any event or activity that demands attention to be redirected from the primary task toward an interruption task, forcing a task-switch" (Dabbish 2006). In this sense, the event that causes the consciousness toward the mouse to switch from ready-to-hand to present-at-hand in Dourish's example is an interruption just like more obvious examples, for instance a ringing phone or an incoming SMS.

3.1 Receptivity in context

As technological interventions have real consequences for their users we have to develop an understanding of what it is that the system aims to improve. The goal for the system is to minimize the negative impact of interruptions by maximizing the amount of interruptions delivered when the user is *receptive* to them. Receptivity has been used as a dependent measure in studies of interruptions (Ho & Intille, 2005), and has been described as one's "willingness to be interrupted" (Begole et al. 2004). We extend this notion by saying that receptivity places the receiver's actual experience of the interruption into the focus. Hence, it caters for a user-centred, subjective perspective onto the problem of interruption. Studying receptivity to interruptions then raises the following research question: What makes someone receptive to an interruption?

The volatile nature of contextual involvement in the world as stated above makes it difficult to study "context" in a systematic way. Nevertheless, the identification and study of contextual "factors" at play in the interruption process may raise our understanding sufficiently so as to inform potential systems design. In order to study receptivity in a systematic way, we

ask: what are the factors that influence a person's receptivity to an interruption? We have learned that context is not just found in the world, but created through involvement and that there are a whole host of environmental and psychological factors involved in this process. Here, we try to structure the factors by extending the distinction between *local* and *relational* contextual factors (Grandhi & Jones 2009).

3.1.1 Local contextual factors

Local contextual factors are those that are local to the recipient of an interruption, and include *environmental*, *social* and *embodied* factors.

Environmental factors include the appearance, affordances, configuration and appropriation of the space[26] surrounding the recipient. Studies that fall into this category have looked for example at the impact of office doors (open vs. closed) on interruptibility (Avrahmi et al. 2007), or how specific organizational or cultural norms influence interruption management (Hudson et al. 2002; Tolmie et al. 2008). *Social* factors include not just the presence of other people close to the recipient, but also their role and relationship to the recipient. For instance, related work has looked at the impact of the presence of others in the recipient's office and found a significant effect on self-reported interruptibility (Avrahmi et al. 2007). *Embodied* factors that have been studied are local to the recipient's body, and include cognitive and physical factors. For example, the recipient's current activity usually has both a cognitive and a physical component. Significant effects in the cognitive space have for instance been found for *mental workload* (Adamczyk & Bailey 2004), and *attentional focus* (Horvitz & Apacible 2003). On the physical side, significant effects were found for *transitions between physical activity* (Ho & Intille 2005), and *body position* (Avrahmi et al. 2007).

The embodied factors are key here as they account for the recipient's involvement in the world. For instance, the proximity of other people alone is not decisive; it is rather the moment-by-moment orientation towards them that matters.

To demonstrate how local factors could inform an interruption management system, consider the activity of driving a car. Driving requires that eyes be kept on the road and hands on the steering wheel. However, the environment (i.e. the car) affords all sorts of activity, including talking on the mobile phone. An implication for interruption management for this scenario would be that the requirement to keep eyes free and hands on the steering wheel is not violated. In practice this could mean that a text message would be read out by the system.

3.1.2 Relational contextual factors

The consideration of relational factors in studies of receptivity acknowledges that aspects of the interruption may influence receptivity in a way that is not accounted for by local contextual factors traditionally studied in interruption studies. For example, despite that my local context may suggest that I am not receptive, I may be receptive to a message if the *content* and the relationship to the *sender* justify the interruption; consider the message: "It's a girl!".

[26] The attentive reader will have noticed that this is equivalent with Harrison's and Dourish's notion of *place* (1996).

Studies showed that the recipient's relative status, affiliation, closeness and reciprocity to the sender influences their willingness to be interrupted (Dabbish 2006). A study found that the identity of the caller to be the main factor in call handling decisions (Grandhi & Jones 2009). The relevance of content to the interrupted task has been shown to have a significant effect on receptivity to the interruption (Czerwinski et al. 2000). We have found in an earlier study that perceived relevance, interest, entertainment and actionability (the likelihood of the content to motivate a future action) of the content all increase receptivity to the interruption significantly (Fischer et al. 2010).

Other relational factors include the *presentation* of the interruption. McFarlane (2002) introduces four methods of interruption in HCI of which two relate to the presentation: *immediate,* in which the interruption is delivered to the screen directly; and *negotiated,* in which the user is notified of the interruption and then switches to it explicitly to attend to it.
The *channel* of the interruption may also play a significant role, as it often determines how the interruption is presented and may constrain the possible ways of dealing with the interruption. A ringing phone, for example, is more immediate and may act as a summons (Schegloff 1968). A ringing phone is what McFarlane would call an immediate interruption. In contrast, channels such as email, instant messengers or SMS do not demand attention in such an immediate way. In McFarlane's topology they represent negotiated interruptions.
Lasswell's formula of communication lends itself well to summarise the local and contextual relational factors at play during the interruption process. To guide the design of studies of interruptions, I extend the question with *where, when,* and *how* (table 1).

Lasswell's original formula of communication					*Extension*		
Who	**says What**	**in which Channel**	**to Whom**	**with what Effect?**	**Where?**	**When?**	**How?**
Sender	*Content*	*Medium*	*Recipient (me)*	*Outcome*	*Environment*	*Timing*	*Presentation*
What is my relationship to the sender?	How do I relate to the content?	Character and affordances?	Embodied cognitive and physical state of self: Involvement	Do I accept/ defer communication?	Character of space/place Social: who else is here?	Is now a good moment to be interrupted?	How is the interruption presented?

Table 1: An adaptation of Lasswell's formula (1948) to guide studies of interruptions.

3.2 Methodology

In HCI, there is a disparity in the methods used to study the subjective experience and the settings they can be applied to. On the one hand, ethnographic procedures focus on the overt action; the covert inner experience remains opaque to purely observational techniques. Such idiographic approaches that focus on the individual level often remain qualitative and questionable in representativity and validity. On the other hand, we apply nomothetic quantitative techniques such as comparing different treatments to groups of people to derive rules that apply for populations. The settings of technology-in-use raise another set of challenges. A dynamically changing and unpredictable experience is created when participants are mobile

and locally dispersed. A laboratory approach where the participant's current involvement is controlled and the situation is closely monitored is not feasible for research in naturalistic settings, where the user experience is interwoven with the participant's everyday live (Benford & Giannachi 2008).

Methodologically, a promising compromise to study the subjective experience idiographically in naturalistic settings and still achieve representative and valid results may be the Experience-Sampling Method (ESM) (Csikszentmihalyi 1977). ESM is an *in situ* method to gauge the quality of experience by prompting participants to complete short questionnaires during their current experience over longer periods of time (ibid.). Their founders have described ESM as a "systematic phenomenology" as it makes idiographic data available for statistical reasoning (Hektner et al. 2007). Furthermore, by conducting an idiographic study with several participants, salient characteristics might emerge across the collection of participants. Thus, ESM is a method with which nomothetic insight can be achieved through a series of idiographic descriptions of subjective experiences (Hurlburt & Akhter 2006). Key to the research presented here is that in addition to self-reports about the experience, ESM is used to collect behavioural data, which is analysed to discover where information from the self-reports is represented in the behavioural logs describing system use. Thus, self-reports are a vehicle and technique to empirically test assumptions about behaviour. For example, we used it to verify that longer response times correlate with lower self-reported receptivity (Fischer & Benford 2009) or to test hypothesised good moments for interruptions. The ESM is invaluable in this work both for HCI-centred research questions around interruptions and for empirical testing of novel concepts of context-aware information delivery and proactive initiation of interaction.

4 Exploiting opportunity as a design framework

The research presented here on the one hand can be applied to the design of systems that manage interruptions from the recipient's existing social communication network where the sender may either be a person in some form of social relationship with the recipient or other information aggregators such as web services. On the other hand, it can be applied to systems that initiate interaction proactively to engage the recipient in an experience, where interruptions are prompts for action, such as game messages via SMS (Fischer & Benford 2009) or messages via a custom system that senses the user's current location (Rowland et al. 2009). In both cases we first have to ask which factors could sensibly be adapted through system intervention to increase receptivity to the interruptions. In the former case, we cannot sensibly let a system adapt the *who* (sender) or the *what* (content) of the interruption, whereas in the latter case we can also design the content of the interruption to become more relevant or interesting to the user's system-inferred current context. In any case, I argue that we can adapt the *when*[27], the *where,* and the *how* of the interruption delivery in order to increase receptivity to the interruption most effectively.

[27] Optimisation of *timing* may be the most common adaptation in related work (e.g. Horvitz & Apacible 2003)

The design framework relies on an opportunistic, pragmatic strategy for managing interruptions and initiating interaction. Whereas for the management of interruptions from the user's social network this approach is constrained to content that is less time critical for the user and may reasonably be held back until an opportune moment for delivery arises, systems that convey a dedicated user experience may be designed to initiate interaction on the basis of *contextual opportunity*. Opportune moments surface out of the user's current contextual involvement, which is sensed by the user's mobile device. The premises are:

- The already existing ubiquity of interruptions in the user's world present opportunities for our system to "piggyback" onto.
- People may be more apt to be receptive to interruptions when engaged in certain activities, which in turn may be likely to occur in certain locations.

We develop our concept of exploiting *contextual opportunities* in the following.

4.1 Opportune moments for interruptions

The quest for opportune moments to interrupt humans in HCI has mostly focussed on the controllable settings of offices. Laboratory studies in office settings have indicated that the disruptive impact on the primary task can be minimized by timing the interruption appropriately (Czerwinski et al. 2000; Adamczyk & Bailey 2004). Why the focus on *tasks*? Tasks engage the participants mind in a predictable way. To an extent, making participants engage with tasks controls their involvement in the world, and defines their experience of it. Prior work in cognitive psychology has found that tasks can be segmented, for instance into the phases of *planning, execution and evaluation* (Miyata & Norman 1986). Such knowledge about the nature of tasks enables empirical exploration of effects of the *timing* of interruptions during tasks in relation to the phases. Indeed, results promise that opportune moments for interruptions lay at breakpoints between different phases of tasks (Adamczyk & Bailey 2004). More fundamentally, recent research in neuropsychology has found that not only are the tasks humans engage in structured into phases, but the brain structures our *everyday experience* into temporally bounded episodes (Zacks et al. 2001). The episodic nature of our experience suggests that breakpoints between episodes must exist – transition phases in which attention shifts and which would lend themselves to provide opportune moments for interruption.

When we consider breakpoints between different phases of a *task* as opportune moments for an interruption (Adamzcyk & Bailey 2004), are their any analogous well-defined breakpoints in *everyday experience* that we can leverage in a mobile, naturalistic context? Ho & Intille (2005) have shown that the *transitions between physical activities* are indicative of such breakpoints in experience, as participants were more receptive to interruptions at these transitions. I claim that *episodes of mobile device use* are framed by breakpoints in experience as the attention shifts to the mobile interaction episode at the beginning and away from it at the end. This approach provides an alternative to the constraint of using bodily worn sensors in experimentation (Ho & Intille 2005), in that mobile phone technology is used to identify phone activity and thereby opportune moments for interruption.

If the transitions to and from episodes of mobile interaction represent breakpoints of the ongoing experience, the breakpoint that marks the end of the episode lends itself as an opportune moment for an interruption. The strategy is to piggyback onto other interruptions as they occur. In order to test this assumption, a naturalistic experiment was designed and conducted that interrupted people on their mobile phones for a period of two weeks at some of these hypothesised contextual opportune moments: right after they made a phone call and right after they had read an SMS. We cannot go into detail about the design and the findings of the study here due to lack of space, but early analysis of the data shows that people are significantly more responsive right after they have completed a mobile episode of interaction when compared to a baseline of random other times.

4.2 Future work: opportune places for interruptions

Even though it may be technically a difficult problem to infer receptivity from sensor readings in *all* places due to the situated appropriation and shifting orientation towards places, *some* places may give rise to involvements in which people are inherently more receptive to interruptions. Consider for example places where the activity is likely to be *waiting,* such as a bus stop or a train station. *Waiting* is an activity related to the activity that is being waited for. In a sense it is a *transitional* activity that takes place in the downtime between other activities and thus may constitute an opportune moment as outlined above.

In our next naturalistic study, we will investigate receptivity to interruptions in queuing areas in theme parks. The experience of a theme park is relatively constrained: activities such as queuing or being on a ride are likely to be predictable given the user's current location and an underlying semantic location model of the park. The aim is to exploit the sensing of opportune places (by example of queuing areas) to build an application that engages people while they queue for a ride to document their experience e.g. by taking photos, by commenting on and rating rides and other playful interaction that will be shared with their social network. The system will also deliver custom content and other users' generated content relevant to the users' current surrounding to make queuing more pleasurable.

Hence, we do not only study the potential of predicting receptivity according to hypothesised opportune places, but we leverage *contextual opportunity* as a design framework in order to enrich the user's current experience by initiating engagement at opportune moments and places and delivering situationally-relevant content.

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