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Acting by hand: Informing interaction design for the periphery of people's attention ☆

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ABSTRACT

Interactions in and with the physical world have enabled us to perform everyday activities in the periphery of our attention. Even though digital technologies are becoming increasingly present in the everyday environment, interaction with these technologies usually requires people's focused attention. In the realm of the vision of calm technology, we think that designing interactions with the digital world inspired by our peripheral interaction with the physical world, will enable digital technologies to better blend into our everyday lives. However, for such interaction design to be effective, a detailed understanding of the everyday periphery is required. In this paper, we therefore present a qualitative study on everyday activities that may take place in the periphery of the attention. We provide a broad range of examples of such everyday activities and cluster them to present the conditions under which they may be performed peripherally. Furthermore, we discuss how our findings may be relevant for the design of peripheral interactions with digital technologies, and present two conceptual designs that are based on our findings.

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1. Introduction

Today, we see that digital technologies are being integrated in everyday objects and environments. These developments have lead to wide discussions on how the computer of the future can fit into everyday life in the physical world. As a result, several areas of research aim at developing and evaluating interactions with digital technologies, which are inspired by interactions in the physical world. Embodied interaction (Dourish, 2001) as well as tangible user interfaces (Ullmer and Ishii, 2000) for example aim at leveraging motor abilities and cognitive mechanisms in interaction with technology, by using designated physical artifacts. Weiser (1991) discusses the computer fading into the background, not only by 'hiding' technology in artifacts or surroundings, but also by enabling users to perceive and interact with computers in the background, so that "we are freed to use them without thinking and so to focus beyond them on new goals" (Weiser, 1991, p. 3).

Weiser's vision seems highly interesting from a ubiquitous computing point of view. Traditionally, human computer interaction happens through screens, keyboards and mouses, interaction methods that usually require the user's focused attention. In the physical world however, many interactions take place without focused attention. Tying your shoelaces, switching the lights on, chewing your breakfast; such activities can easily be performed without direct attention. To fit computing technology in everyday life, traditional types of interfaces will thus not be effective. Weiser and Brown (1997) therefore envisioned *calm technology*; "technology that engages both the center and periphery of the attention and in fact moves back and forth between the two" (Weiser and Brown, 1997, p. 79). In other words, calm technology aims at leveraging human attention abilities, which enable us to perform certain activities without direct attention, in interaction with digital technologies. In the realm of this vision, several researchers have developed and evaluated systems that display information in the background or *periphery* of the attention (Mynatt et al., 1998; Eggen and van Mensvoort, 2009; Ishii et al., 1998; Matthews et al., 2004).

Apart from perceiving information in the periphery of the attention, we also see many everyday examples of physical *actions* that may take place in the periphery of the attention. If such actions in the physical world can be performed without direct attention, it could be interesting to investigate if we can similarly design peripheral interactions with the digital world. Since these examples mostly involve bodily actions, we think that tangible (Ullmer and Ishii, 2000; Hornecker and Buur, 2006; Mazalek and van den Hoven, 2009; Shear and Hornecker, 2010) or embodied interaction (Dourish, 2001) would be suitable interaction styles for such systems. Tangible interaction (Ullmer and Ishii, 2000; Hornecker

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and Buur, 2006; Mazalek and van den Hoven, 2009; Shear and Hornecker, 2010) combines the benefits of both physical and digital world through the use of physical artifacts to represent as well as control digital data. Embodied interaction, as envisioned by Dourish (2001), overlaps with tangible interaction as it also origins in the view that tangibility is a key factor in interaction with the physical world. Embodied interaction however takes a broader stance by envisioning meaningful interaction with technology inspired by not only physical but also social phenomena of everyday life (also see Shear and Hornecker, 2010 for differences and similarities between tangible and embodied interaction).

In order to design interactions inspired by human attention processes in the real world, it is required to have an understanding of how human attention abilities are used in everyday life. Therefore, in this paper we present an extensive qualitative study on peripheral actions in everyday situations, in order to inform the design of interactive systems that aim at leveraging these abilities. But first we will discuss attention theory as well as related research in the area of calm technology.

2. Attention theory

In the areas of psychology and neuroscience, several theories of the cognitive processes that underlie human attention have been developed. Based on these theories, we now present our current understanding of human attention abilities.

Literature distinguishes two main functions of attention, *selective attention* and *divided attention* (Sternberg, 1999; Wickens and McCarley, 2008). Selective attention theory describes attention by analogy with a mental filter, which enables selectively focusing the attention on one stimulus while intentionally ignoring others (Sternberg, 1999). As suggested by models of selective attention, this mental filter is not only influenced by choice, but also by *salience* (Pashler, 1998) as well as by a cognitive process called *priming* (Cherry, 1953; Treisman, 1964). A sudden movement for example has such salient physical properties that it immediately passes the filter and is thus attended to. Furthermore, certain highly relevant stimuli are more likely to pass the filter as a result of priming (Treisman, 1964). A common example of a primed stimulus is one's own name; when one's own name is mentioned in a distant conversation, this is likely to be noticed.

Divided attention theory finds its basis in the observation that we are, under certain circumstances, able to perform multiple tasks at once (Sternberg, 1999). Models of divided attention describe attention as a finite amount of mental resources that can be divided over different activities. The two functions of attention (selective and divided attention) are not mutually exclusive; both selectivity and resource allocation characterize the attention process (Pashler, 1998). Selectivity primarily plays a role when attention is devoted to sensorial stimuli, whereas resources can be allocated to physical activities, thought processes and sensorial activities. In other words, selective attention theory seems to overlap with divided attention theory in the sense that a selective filter may determine the availability of sensorial activities to which mental resources can be allocated. Since we are particularly interested in physical activities that take place in the periphery of the attention, the research presented in this paper is positioned in divided attention theory.

An influential model which describes attention as the allocation of mental resources is presented by Kahneman (1973). This divided attention model centers around a number of potential activities that one can perform as a result of (sensorial or intellectual) information input. These activities may be bodily activities (e.g. running), cognitive activities (e.g. thinking), sensorial activities (e.g. listening to music) or combinations of these types (e.g. having a conversation, which requires bodily, cognitive and sensorial activities). Kahneman (1973) speaks of *potential activities* since not all these activities will be performed at the moment: activities can only be performed when mental resources are allocated to them. As a limited amount of mental resources is available, not all potential activities can be performed at once. The amount of mental resources required for each activity depends on different aspects of the activity, namely *difficulty* of the task and *automaticity*. Automated processes (Wickens and McCarley, 2008) are those that one is very experienced in and therefore require only few mental resources. Driving a car is a common example of an automated process; once experienced in driving a car one can do all kinds of activities simultaneously, e.g. making a phone call, eating a sandwich or listening to music. Kahneman's model (Kahneman, 1973) assumes that a limited amount of mental resources is available to allocate to, and thus perform, potential activities. When such activities require few resources, multiple tasks can be performed at once.

Divided attention theory is frequently studied in experiments on multitasking (Wickens and McCarley, 2008; Wickens and Hollands, 2000; Gladstones et al., 1989). In such experiments, participants are usually asked to perform two high attentional tasks, e.g. dialing a phone number while driving (Wickens and McCarley, 2008). Contrary to such studies however, we are interested in low-attentional and most likely non-crucial activities that are performed simultaneous to everyday main activities. Although many multitasking studies do not show evidence for multitasking being more efficient compared to single task processing (Gladstones et al., 1989), we believe that leveraging the human ability to perform low-attentional tasks in the periphery of the attention may benefit users on a different level. We envision the added value of our approach not to be in the efficiency of performing tasks, but merely in the experience of not needing to focus attention on interactions with technology and therefore seamlessly fitting them in the user's everyday routine. This may enhance the experienced fluency with which this everyday routine can be carried out.

In Fig. 1, we present an illustrative overview of our current understanding of the human attention process which is largely based on Kahneman's model (Kahneman, 1973). This overview is primarily meant to structure our understanding of divided atten-

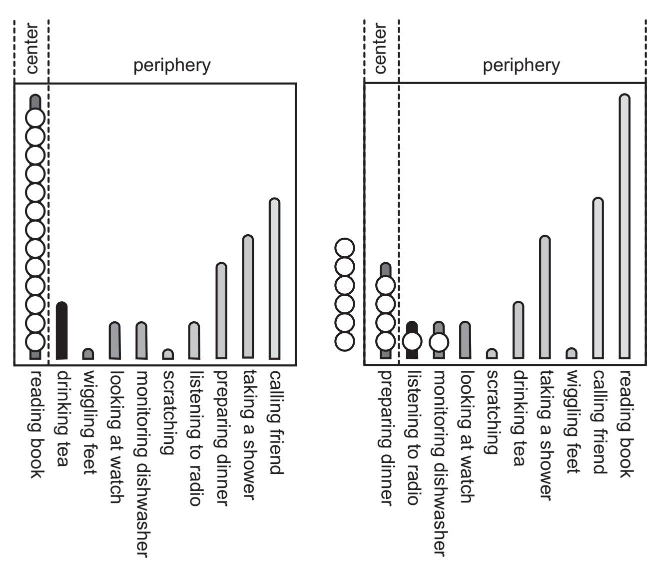

Fig. 1. Illustration of the center and periphery of the attention. The division of mental resources during a high attentional task (left) and during a combination of low attentional tasks (right). Vertical bars represent potential activities that are performed when mental resources (white circles) are allocated to them.

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