Towards Ambient Notifications

Heiko Müller, Martin Pielot, Rodrigo de Oliveira

OFFIS and Telefonica Research

Abstract. In this paper we report on two studies for displaying information in the periphery of the user's attention. One experiment explores the use of ambient light to inform users of upcoming tasks in an office scenario, while the other investigates whether vibro-tactile displays can become peripheral. We show that both modalities have potential for conveying information outside a user's focussed attention.

Key words: Ambient light display, reminder, interruptions, user studies.

Peripheral Interaction: Embedding HCI in Everyday Life http://www.peripheralinteraction.com/participation.html

1 Background and Motivation

Everyday life is filled with information competing for our attention. While at work, we receive notifications on incoming mail and reminders for the next meeting on top of phone calls and colleagues interrupting. Additionally there may be many more information sources trying to get our attention. Smartphones deliver push notifications whenever a contact writes a message in a chat, the Facebook timeline gets updated, or a tweet is retweeted, to name a few.

Iqbal and Bailey [5] define *notification* as a visual cue, auditory signal, or haptic alert generated by an application or service that relays information to a user outside her current focus of attention. On smartphones, notifications are typically delivered instantly, *e.g.,* when the user receives a message or when a meeting is about to begin.

Instant delivery of notifications has been extensively studied in the context of information workers. One particular challenge is that instantly delivered notifications may interrupt the receiver during other tasks. Czerwinski *et al.* [3] highlight that people find it difficult to return to disrupted tasks after being interrupted by *e.g.,* instant messages, calls, or an engagement with a colleague. They conducted a diary study, with 11 office workers and found that interrupted tasks were not resumed immediately after 40% of the interruptions. As a solution, they suggested to help interrupted users to return to the interrupted task by grouping applications and folders by task.

Cutrell et al. [2] conducted a study in which 16 participants performed a task of searching books in a list organized either by title or topic. They compared performance between search type (concrete title versus abstract topic), notification, and marker. Their results show that notifications make tasks much slower,

and their effect is more salient when the user is in the middle of a cognitively demanding task.

Iqbal *et al.* [6] studied the effect of email notification on the desktop computers of office workers. For two weeks, they monitored the application usage of 20 Microsoft employees. They found that the study participants spent roughly one third of their working time in Outlook and one third working in their primary applications. Turning off notifications had no significant effect on this distribution. In average, participants received 3 email notifications per hour, and 25% of notifications led users to immediately switch to email client. When checking Outlook right after receiving a notification, participants switched back twice as fast, thus indicating that Outlook notifications were triggering more opportunistic changes between applications. Outlook is accessed $19 - 22$ times per hour, or roughly every three minutes. In the second week of the study, participants were asked to turn off email notifications. While 8 participants checked emails more frequently, 12 participants checked them less often, which indicates that notifications can influence people in at least two ways: either by creating the urge to respond immediately or by serving as a form of awareness.

Mark et al. [7] studied the negative effects of interruptions by email through a radical approach. For 5 work days, they completely cut off 13 information workers from email usage. Their findings reveal that, without email, the workers multitasked less, spent more consecutive time on tasks, and had a decreased stress level.

Adamczyk *et al.* [1] studied the difference between delivering interruptions during and after completing a task. 16 graduate students had to fulfill different tasks (correct text, write text, web search) on a PC. From time to time, they were interrupted by a full-screen pop-up showing news. The results show that people felt higher workload, measured by the Nasa-Task Load Index, when the interruptions were delivered during the tasks. Fogarty et al. [4] showed that it is possible to predict of human interruptibility with simple sensors .

However, while delivering an email notification can be deferred until the user has completed a task, other notifications, such as calendar entry reminders, have to be delivered on time.

2 Ambient Notifications

With the concept of Ambient Notifications, we pursue the idea of slowly and gently catching a person's attention towards an upcoming notification over time. While the users can stay focused on the primary task, they will slowly be made aware of the upcoming event. According to Matthews et al. [8], (peripheral) displays can target different attentional levels, ranging from pre-attention to focussed attention. The typical notification alarm jumps from absence of directly to full attention. With Ambient Notifications, we aim at moving continuously from pre-attention to focussed attention by slowly increasing the saliency of the displayed cues. This allows users to be aware of the upcoming notification before it is actually due. We assume that this can reduce anxiety and allow workers to

finish tasks in time, opposed to leaving them unfinished when e.g. a meeting is beginning.

The challenge to solve is how to convey information in parallel to a work task, in particular how to continuously increase the peripheral display's saliency, so that it slowly becomes more and more present in the mind of the worker. We report on two studies investigating the use of ambient light and vibro-tactile patterns. For ambient light, we provide evidence that by continuously changing the color of an illuminated office wall behind the monitor, we can keep users aware of an approaching appointment. For vibro-tactile patters, we provide first evidence that continually repeated vibration patterns can be consumed in the periphery of attention at all.

2.1 Ambient Timer

With Ambient Timer [9], we created a system to unobtrusively and continuously remind users of upcoming events in an office scenario. Ambient Timer exploits the user's peripheral vision for conveying information on an upcoming task around a computer monitor in a way that the user can still focus on the primary task she is executing on the screen (see Figure 1).

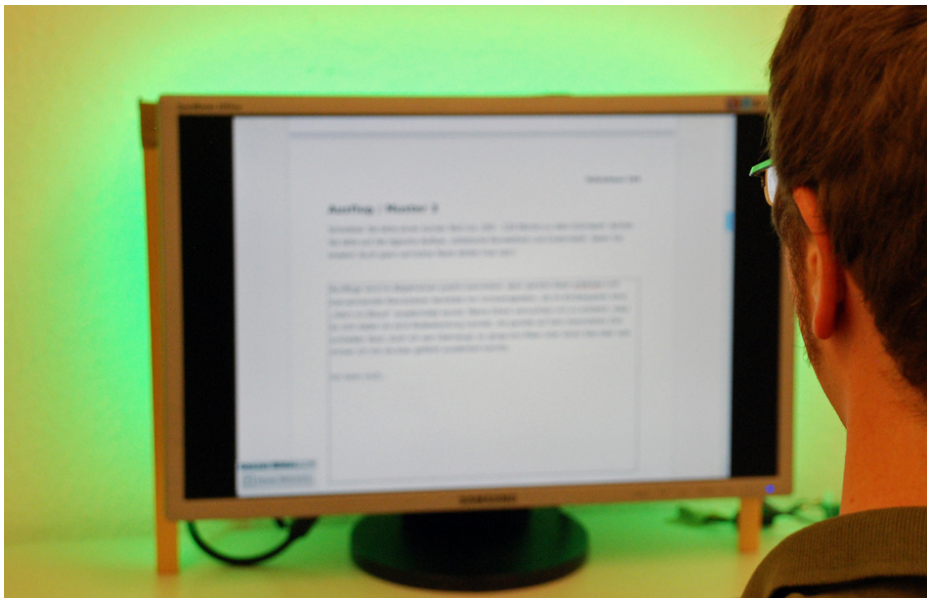

Fig. 1. Ambient Timer illuminating the surroundings of the monitor

We built an RGB-LED frame which we mounted to the back of a monitor. The light emitted by the LEDs was then reflected from the wall the monitor was

placed against. Exploring the design space we created continuous light patterns designed to increase obtrusiveness over time (in terms of Matthews' classification we continually increase obtrusiveness to slowly shift from pre-attention to devided attention) in order to slowly make users aware of upcoming tasks while still giving them the chance to wrap up their primary task in a sensible way. We then conducted a lab experiment with controlled light conditions to test our system against traditional reminding techniques. 12 Participants were asked to conduct writing tasks while keeping track of when to finish in time. We found out that our system is at least competitive with traditional reminding techniques such as notification popups or users checking the clock.

2.2 Peripheral Perception of Vibration Patterns

While light has shown to be a powerful modality to design ambient displays, it may have disadvantages if the goal is to keep the interaction private or to avoid polluting the information with more information. The sense of touch, in contrast, offers strong potentials for personal, private information presentation. For example, Tam *et al.* [11] recently presented a timing tool for oral presentations that sends different signals to presenters indicating that 3, 1, or 0 minutes are left before finishing the talk. At each of the intervals, a wristband would start generating different vibration cues, which would "*terminate after an interval, but allowed the speaker to stop them earlier by pressing the wristband*" [11].

As such, these vibration cues can still be seen as interruptions, which attracts attention at three points in time, rather than continuously grabbing attention, as the Ambient Timer.

Hence, we recently explored the question whether continuous vibro-tactile pattern can, at all, become peripheral [10]. For three days, we exposed 15 subjects to a continual vibration pattern, emitted by a mobile devices which was carried in the trouser pocket. The subjects set the vibration to an intensity, where they could barely perceive it. At random intervals, the vibration stopped. In this case, the subject had to take the phone out of the pocket and acknowledge this event by pressing a button. When doing so, they were presented with a short questionnaire to gather subjective feedback. In average, subjects did not acknowledge these events immediately – as if vibration was on their focussed attention –, but rather in 15.2 minutes in average ($\tilde{x} = 8.3$ min, $s = 19.6$) At the same time, they reported not to be annoyed by the signal in 94.4% of the events. These results indicate that the stimuli were perceived in the periphery of attention, i.e. outside of focussed attention, while remained aware of it.

While we have yet to investigate how well people perceive subtle, continuous changes in the vibration pattern, this shows that there is an opportunity to use peripheral vibro-tactile displays to deliver ambient notifications.

3 Future Work

In future work, we need to deepen our understanding on how to manipulate perceived saliency of a peripheral display. For vibro-tactile patterns, we just have

shown that conveying information in the periphery of attention is possible. What is missing is a way to continuously increase saliency over time. For the Ambient Reminder, we have shown how to increase saliency in a lab study. However, first, informal tests have shown, that in an actual work context other factors appear to be present which influence the perceived salience. Future work hence needs to test these displays in-situ in order to identify these factors, and provide us with an understanding on how to control for them. Taking things a step further future work has to focus on how users will not only perceive information in the periphery of their attention but also control the information device in a way that does not require their focussed attention.

References

1. P. D. Adamczyk and B. P. Bailey. If not now, when?: the effects of interruption at different moments within task execution. In *Proc. CHI '04*, pages 271–278, New York, NY, USA, 2004. ACM.
2. E. Cutrell, M. Czerwinski, and E. Horvitz. Notification, disruption, and memory: Effects of messaging interruptions on memory and performance. In *Proc. INTERACT '11*, 2001.
3. M. Czerwinski, E. Horvitz, and S. Wilhite. A diary study of task switching and interruptions. In *Proc. CHI '04*, pages 175–182, New York, NY, USA, 2004. ACM.
4. J. Fogarty, S. E. Hudson, C. G. Atkeson, D. Avrahami, J. Forlizzi, S. Kiesler, J. C. Lee, and J. Yang. Predicting human interruptibility with sensors. *ACM Trans. Comput.-Hum. Interact.*, 12(1):119–146, mar 2005.
5. S. T. Iqbal and B. P. Bailey. Oasis: A framework for linking notification delivery to the perceptual structure of goal-directed tasks. *ACM Trans. Comput.-Hum. Interact.*, 17(4):15:1–15:28, Dec. 2010.
6. S. T. Iqbal and E. Horvitz. Notifications and awareness: a field study of alert usage and preferences. In *Proc. CSCW '10*. ACM, 2010.
7. G. Mark, S. Voida, and A. Cardello. "a pace not dictated by electrons": an empirical study of work without email. In *Proc. CHI '12*, pages 555–564, New York, NY, USA, 2012. ACM.
8. T. Matthews, A. K. Dey, J. Mankoff, S. Carter, and T. Rattenbury. A toolkit for managing user attention in peripheral displays. In *Proc. UIST*, 2004.
9. H. Mueller, A. Kazakova, M. Pielot, W. Heuten, and S. Boll. Ambient timer - unobtrusively reminding users of upcoming tasks with ambient light. In *Proc. INTERACT '13*, 2013.
10. M. Pielot and R. de Oliveira. Peripheral vibro-tactile displays. In *Proc. MobileHCI '13*, 2013.
11. D. Tam, K. MacLean, J. McGrenere, and K. J. Kuchenbecker. The design and field observation of a haptic notification system for timing awareness during oral presentations. In *Proc. CHI '13*. ACM, 2013.