Towards Ambient Notifications

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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.

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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 call or a message.

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.

These studies reveal the importance of considering other forms of notification able to convey information with minimum distraction, potentially by exploring the periphery of the users' attention.

2 Ambient Notifications

Though Fogarty et al. investigated the prediction of human interruptibility with simple sensors back in 2005 [4], there are still no systems in sight that would make use of such information.

With ambient displays, the interrupting effect of a notication might be mitigated. They display notifications in the periphery of the user's attention. While the user can stay focused on the primary task, she can still perceive notifications thus reducing the anxiety of missing an important bit of information. Matthews et al. [8] suggested a set of notification levels for ambient displays and the corresponding attentional levels.

We report on two studies investigating the use of an ambient light display and how vibro-tactile patterns might become peripheral.

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).

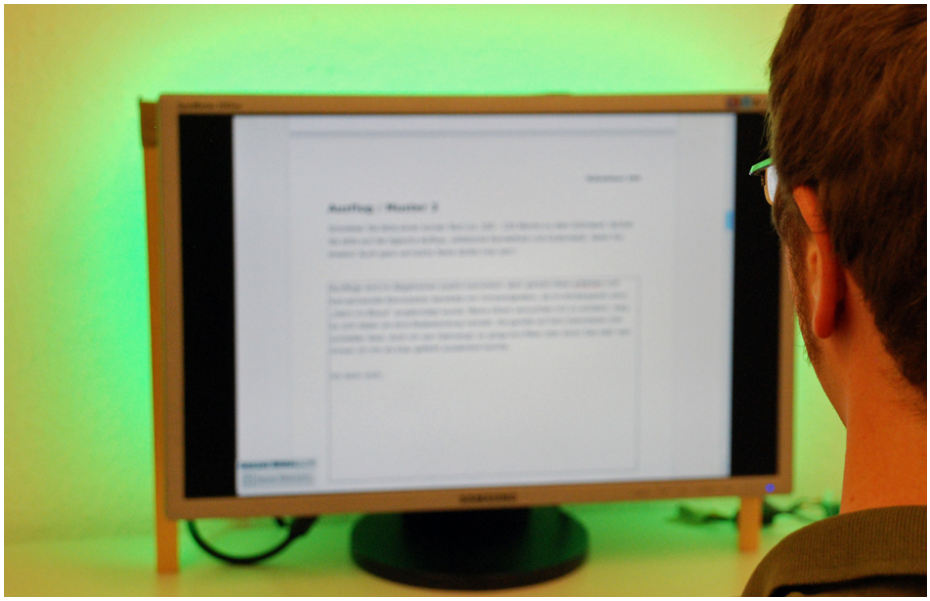

Fig. 1. Ambient Timer illuminating the surroundings of the monitor

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 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 the future, we want to investigate how ambient notifications can be further embedded into daily applications. Much work is e.g. needed to better understand for which type of information and in which situations ambient light may serve as an added modality for conveying information. While we have achieved promising results for the continuous display of temporal information, we are also interested in conveying spatial information in an ambient manner.

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