User Attention in Mobile Devices

Pekka Isomursu
School of Music, Dance and Media
Oulu University of Applied Sciences
Oulu, Finland
e-mail: pekka.isomursu@oamk.fi

Minna Isomursu and Mari Ervasti
Technical Research Centre of Finland
VTT
FIN-90571 Oulu, Finland
e-mail: minna.isomursu@vtt.fi
mari.ervasti@vtt.fi

***Abstract*— The multichannel information (over)flow emerging in modern mobile multimedia devices creates a situation where the user's attention is a valuable asset for which different channels have to compete. This paper explores issues that help in effective use and maintenance of the user's attention level in such environment. We demonstrate with examples how the user's attention level can maintain high at different stages of task switching and execution.**

Keywords-mobile Internet; attentive user interface; user interface; UI; ambient notification; human factors; design.

I. Introduction

Today's mobile communication has come a long way from simple voice calls. People are blending channels and media in a device-agnostic way, using mobiles not only for communication but also for being informed and entertained as well as for creating and maintaining their social networks. Web2.0 is turning mobile. Users' communication threads may include both synchronous and asynchronous communication that may not have clear temporal start and end points. The number of participants may vary during a single communication thread.

Digital interruptions and related disruptions have been extensively studied in the desktop world. In the desktop environment, the interruptions disrupt digital activities, as the user is working with PC and is rarely doing other activities. However, interruptions in mobile and ubiquitous environments interrupt us in our everyday tasks such as sleeping, working or enjoying the opera. Therefore, design of interruptions for mobile and ubiquitous communication technology requires special research and design attention.

On a related work from the desktop context, Jackson et al. [8] have studied the effect that the incoming flow of emails has in people's work efficiency. They found out that the way most users handle incoming email causes far more interruption than what is commonly assumed. The common reaction to the arrival of an email message is not to delay the response to a time that is more convenient to the user but to react within six seconds. The time it took to recover from email interrupts and return to the interrupted work task at the original work rate was on average 64 seconds.

All this multichannel information (over)flow creates a situation where the user's attention is a valuable asset for which different channels have to compete. Some see attention as new currency for business and individuals [3].

In our current research, we are looking at novel ways to minimize disruption in mobile devices. This paper explores issues that help in effective use and maintenance of the user's attention level in a mobile environment. We first briefly look at theoretical models of attention in Section II. Then, in Section III we discuss the principles of minimizing disruption and maximizing comprehension that help in the design of alerts and notifications, and the tools that we have identified to support those principles. In Section IV, we describe use scenarios that exploit the principles and tools described in Section III. Finally, we draw conclusions and discuss possible future work in Section V.

II. Theoretical Background

Attention is the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things. Human attention is very complicated both psychologically and physically. Current understanding of attention divides it into several phases and concurrent processes that co-operate in complicated ways. A clinical model by Sohlberg and Mateer [13] divides attention into five classes with growing difficulty of execution:

- ***Focused attention:*** responding discretely to specific visual, auditory or tactile stimuli.
- ***Sustained attention:*** maintaining a consistent behavioral response during continuous and repetitive activity.
- ***Selective attention***: maintaining a behavioral or cognitive set in the face of distracting or competing stimuli.
- ***Alternating attention:*** shifting the focus of attention and moving between tasks with different cognitive requirements.
- ***Divided attention***: responding simultaneously to multiple tasks or multiple task demands.

An investigative model by Posner and Fan [10] includes the following attentive networks that coexist in the human brain:

 ISBN: 978-1-61208-177-9

- ***Alerting network:*** perceiving an incoming stimulus, which leads to a state of raised alertness.
- ***Orienting network:*** selecting relevant information from the stream of incoming stimuli, i.e., focusing attention to the sensory events.
- ***Executive network:*** exercising voluntary control over thoughts, feelings and actions, in order to maintain behavioral goals, i.e., maintaining attention.

Posner and Fan's model corresponds to the typical steps taken when the user switches tasks in the mobile context: 1) the user is alerted to pay attention to an event, 2) she orients her attention towards understanding what it is about, and then 3) decides how to respond and discards or executes the related task. As a simple example, the user pays alert attention when she hears the beeping of the phone and flashing of an email icon on the device screen. At a suitable moment, she then orients her attention to check the information content of the alert, e.g., sender and the topic of the email. Executive attention comes to action when she starts reading and processing the content. Each of these three attentive networks has its own role in the attention process and they can act simultaneously.

III. MINIMIZING DISRUPTION, MAXIMIZING COMPREHENSION

Alert and notification design needs to balance between minimizing the caused disruption and at the same time, maximizing comprehension. A notification causes an interruption, which may cause disruption to whatever the user is doing. The level of disruption depends on several things, e.g., user context, how focused the user is on her current task, how strong the notification signal is, how similar the notification is to the current task, and what interaction modality (sound, visual, vibration, etc.) is used for the notification.

The user interface (UI) and the notification itself should support the user in responding to the notification in an appropriate manner. Response options should be clearly presented, and the desired action should be easy to perform. Similarly to alerts and notifications, also the execution of user responses can be designed to disrupt as little as possible, giving the user the possibility to continue with the primary task as smoothly as possible.

Alerts and notifications cause interruption (prompting transition and reallocation of attention focus) that can cause disruption. For the user, the disruption can mean the following:

- It draws the user's attention away from current activity.
- It requires cognitive processing and/or physical activity.
- It makes it difficult to return to the primary task.

Additionally, in mobile environments the mobile device can interrupt and disrupt not only the user of the device, but also other people that are physically or virtually nearby. This can create socially challenging (e.g., embarrassing) situations and tension.

Notification cues that take into account the needs of both the user as well as other people in the vicinity of the user are both subtle and public [5]. Successful subtle and public cues can help avoiding attention overload and misinterpretations in social context. Often they enable a combination of different kinds of notification cues, including new ways for devices to notify their users that also enable people to express themselves in various ways.

The following tools can be identified in minimizing disruption and maximizing comprehension of notifications and alerts:

- Filtering
- Choosing modality
- Interruptibility status of others
- Attentive UI, and
- Support for task switching.

In the following paragraphs, we will discuss these tools in detail.

Filtering can be done by setting priorities and rules on the handling of notifications. Simple examples are the rules to filter spam out of incoming emails and directing certain emails to different folders [11]. One might also control the rhythm of the information flow, e.g., by having clear intervals between non-urgent notifications so that the user is not disrupted continuously, and thus is able to concentrate on her primary task more efficiently. The eWatch system [12] is a wrist watch with vibration motor and sensors. This wearable device is aware of user activities and context. It combines an interruptibility measure, email priority level, and cybersensor data to decide how and when to notify the user.

Choosing modality of the notification cue according to a person's context or foreground task. The device could identify user's context, for example, according to measured ambient noise levels or usage level based on time since the user's last interaction with the device, and choose the most optimal modality to present notification cues. Also, research suggests that the notification creates most disruption if it is very similar to the modality of the foreground task [4], e.g., when the user is in the middle of the conversation, speech cues would be more disruptive than, for example, visual color coded cues.

Brown and Kaaresoja [2] have investigated vibrotactile messages that communicate multidimensional information in mobile phone alerts. They enable communication of more information through phone alerts, information to be communicated discretely without disturbing others, and alerting users in noisy environments.

Ambient soundscape by Jung and Schwartz [9] subtly notifies mobile users in a multi-user environment by offering an artificial sound environment and ambient notification service. For example, an incoming email is announced by enhancing background music with a personal non-speech audio cue (favorite notification instrument) that is played from the loudspeakers near the user's current position with increased volume. The service avoids distraction of other people, increases privacy and confidentiality, and prevents the audio cue to be identified as a notification cue by outsiders.

Interruptibility status of others. Users of mobile phones tend not to be aware of the status of interruptibility of the person they are trying to contact. There is also limited freedom in choosing alternative channels of interruption, and channels that do exist do not allow for any subtlety of expression. The system could set the appropriate notification level, e.g., message, vibration, private knock or public ring, of the user's cell phone and also show the user's level of haste [14]. This profile would then be available to the users' contact network, thus helping callers to choose an appropriate level of interruption.

Attentive UI. With Attentive UI, the device exploits the measurement of user's attention level and focus. It can, e.g., alert the user for a non-urgent notification only when it realizes the user is not concentrating on another task and after that show more information on the location where the user's attention is focused. The concept of attentive UI is utilized in AuraOrb [1]. It is an ambient notification display that uses social awareness cues, such as eye contact to detect user interest in an initially ambient light notification. Once detected, it displays a text message with a notification heading visible from any direction. Touching the orb causes the associated message to be displayed on the user's computer screen. When user interest is lost, AuraOrb automatically reverts back to its idle state.

Support for the switching between the old and the new task, i.e., for alternating attention. Recovery tools can help the user to re-focus attention easier and faster. These tools can include, for example, visual indicators of occluded application windows, saving and displaying task context at the time of disruption, and playback of actions [7].

We next describe use scenarios that exploit the principles and tools described above.

IV. Mobile Scenarios

The first scenario described below, "Gaining User Attention", supports subtle alerting. The second scenario, "Supporting task switching", helps the user orient on the new task and rapidly switch to the Execution Attention mode.

A. *Scenario: Gaining User Attention*

Angela is meeting her friends, with her monoblock phone in her pocket when a message arrives (Fig. 1). The phone recognizes that she has the phone in a tight pocket and thus vibrates gently, in a sequence that indicates it's a non-urgent message and not, e.g., a phone call. If she had baggy trousers the skin contact would be weaker and the vibration would be stronger.

At her convenience, Angela picks up the phone. The device recognizes that it is been held in hand, and checks if there is a face in the view of its camera, eyes facing the phone. If this is the case the device automatically displays the message details.

In a variation of this scenario, Peter is in a meeting, with his foldable phone opened up on the table. A message arrives. The phone beeps quietly and changes its screen color. Peter recognizes that a message arrived but is in the middle of a lively discussion. After a few minutes there is a suitable micro break and Peter looks at the phone. With its secondary camera facing Peter, the device recognizes the gaze and displays message details.

Additionally, if the device has enough processing power and good-enough camera to identify that the gazer is Peter, this would add security to the system as the message would not be shown to others that might glance at the device display.

B. *Supporting task switching*

Jill is in the middle of editing a Smiley image when her business acquaintance John calls. On display (Fig. 2), Jill sees pointers to John's business information, her correspondence with John as well as the document she wanted to discuss with her next time they speak. Just by glancing at all this, she gets better oriented back to her business with John. If she desires so, before answering she can also use a precious moment to open and check some related data. This can be done fast since everything is readily available behind the shown links.

After the call, Jill switches back to her image editing. But now she is disoriented as her mind still wanders on what she discussed with John. To help her orient back into her previous task the device shows on the screen an animation of the last edits she made (Fig. 3). Now her thoughts are back to her previous task

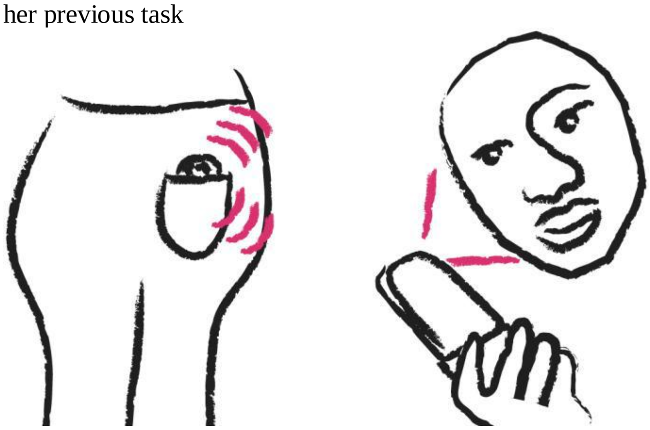

Figure 1. Gaining and recognizing user attention.

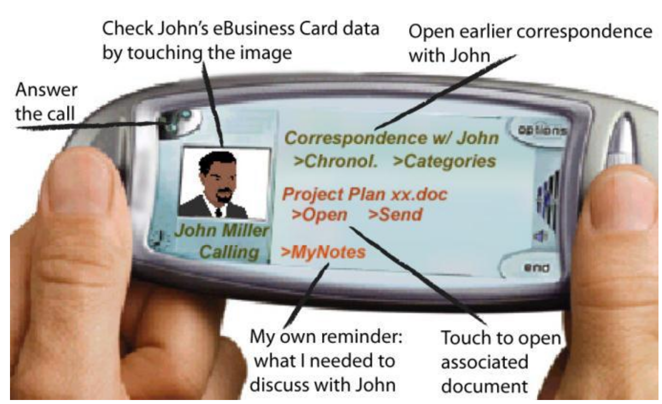

Figure 2. Associative UI.

Figure 3. Animating last edits of user's disrupted task.

V. CONCLUSION AND FUTURE WORK

To tackle the mobile multichannel information overflow, we have shown examples about how user attention can be supported at different stages of task switching and execution. In our future work we wish to extend the tools described in Section III and their usage in the mobile environment.

We would also like to better understand the pitfalls in the user experience of these technologies. For example, on one hand, due to its appeal to the basic instinct of survival humans have a natural inclination to seek for moving, bright, eye-catching, and rapid access to information even if it distracted them. Even when we know what is best for us we do not always act accordingly, as is demonstrated, e.g., by Jackson's observation [8] that most people let the constant flow of email distract their work, or by the common habits of smoking and unhealthy diet. On the other hand, being focused requires effort, willpower and practice, and we easily loose our attention to spontaneous thought. Designers of attentive UI's may face a problem of balancing between calm and attentive UI's that allow us to focus, and our natural inclination for craving constant stream of new, mobile and flashy interruptions that create the illusion of being connected and informed, but at the same time corrupt our possibilities to concentrate and focus.

In this paper, we have focused on switching from one task to another. In the future, we would also like to study divided attention, i.e., how to support situations where people wish to simultaneously execute multiple tasks.

ACKNOWLEDGMENT

We gratefully acknowledge the support to our work from the following sources: Nokia Corporation and, at Oulu University of Applied Sciences, both Focus Area of Internet and ICT (Mr. Kimmo Paajanen) and the InnoMajakka project (Ms Sanna Oja), funded by the European Social Fund of the European Union.

REFERENCES

[1] Altosaar, M., Vertegaal, R., Sohn, C., and Cheng, D. (2006) AuraOrb: Social Notification Appliance. Proc. ACM SIGCHI Conference on Human Factors in Computing Systems CHI 2006, April 22-27, Montréal, Québec, Canada, pp. 381-386.

[2] Brown, L.M. and Kaaresoja, T. (2006) Feel Who's Talking: Using Tactons for Mobile Phone Alerts. Proc. ACM SIGCHI Conference on Human Factors in Computing Systems CHI 2006, Montréal, Québec, Canada, pp. 604-609.

[3] Davenport, T. and Beck, J. (2001) The Attention Economy: Understanding the New Currency of Business, Harvard Business School Press.

[4] Gillie, T. and Broadbent, D. (1989). What makes interruptions disruptive? A study of length, similarity, and complexity. Psychological Research (50), pp. 243-250.

[5] Hansson, R. (2001) Subtle and Public Notification Cues for Mobile Devices. Proc. Ubiquitous Computing: International Conference, Ubicomp 2001, Atlanta, Ga, USA. Springer. Pp. 240–246.

[6] Hudson, S.E. and Smith, I. (1996) Electronic Mail Previews Using Non-Speech Audio. Proc. ACM SIGCHI Conference on Human Factors in Computing Systems CHI 1996, Vancouver, Canada., pp. 237–238.

[7] Iqbal, S. and Horvitz, E. (2007) Disruption and Recovery of Computing Tasks: Field Study, Analysis and Directions. Proc. ACM SIGCHI Conference on Human Factors in Computing Systems CHI 2007, San Jose, California, USA, pp. 677 – 686.

[8] Jackson, T. W., Dawson, R., and Wilson, D. Understanding email interaction increases organizational productivity. August 2003/Vol. 46, No. 8 Communications of the ACM. pp. 80-84

[9] Jung, R. and Schwartz, T. (2007) A Location-Adaptive Human-Centered Audio Email Notification Service for Multi-user Environments. Human-Computer Interaction, Part III, Proc. 12th International Conference on Human-Computer Interaction HCII 2007, Beijing, China, pp. 340-348.

[10] Posner, M. I. and Fan, J. (2001) Attention as organ system. J. Pomerantz (ed), Neurobiology of Perception and Communication: From Synapse to Society the IVth De Lange Conference. Cambridge, UK: Cambridge University Press.

[11] Röcker, C., Bayon, V., Memisoglu, M., and Streitz, N. (2005) Context-Dependent Email Notification Using Ambient Displays and Mobile Devices. Active Media Technology 2005 (AMT 2005), pp. 137-138.

[12] Smailagic, A., Sieworek, D., Maurer, U., Rowe, A., and Tang, K. (2005) eWatch: Context Sensitive System Design Case Study. Proc. IEEE Computer Society Annual Symposium on VLSI, ISVLSI 2005, pp. 98-103.

[13] Sohlberg, M. M. and Mateer, C. A. (2001) Cognitive Rehabilitation: An integrative neuropsychological approach. New York: Guilford Press.

[14] Vertegaal, R., Dickie, C., Sohn, C. and Flickner, M. (2002) Designing Attentive Cell Phones Using Wearable EyeContact Sensors. Proc. ACM SIGCHI Conference on Human Factors in Computing Systems CHI 2002, Minneapolis, Minnesota, USA, pp. 646-647.

 ISBN: 978-1-61208-177-9