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Int. J. Human-Computer Studies 58 (2003) 509–514
International Journal of Human-Computer Studies
www.elsevier.com/locate/ijhcs

Introduction: design and evaluation of notification user interfaces

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Received 1 May 2002; accepted 1 November 2002

Abstract

Notification systems attempt to deliver current, important information to the computer screen in an efficient and effective manner. All notification systems require that the user attends to them to at least some degree if they are to succeed. Examples of notification systems include instant messaging systems, system and user status updates, email alerts and news and stock tickers. The benefits of notification systems are numerous, including rapid availability of important information, access to nearly instantaneous communication and heightened awareness of the availability of personal contacts. While the popularity of these systems has skyrocketed in recent years, the effects of incoming notifications on ongoing computing tasks have been relatively unexplored. The investigation of the costs, benefits and the optimal display of instant messages and all notifications in the context of desktop or mobile computing tasks falls in the general arena of psychological research on alerting and disruptions, but also requires research contributions from design, computer science and information visualization. To date, much of the psychological research on interruption leverages theoretical task constructions. In this special issue, we focus on the nature of interruptions such as messaging while computing and how to optimize the user experience.
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Keywords: Notification systems; Empirical studies; Awareness

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doi:10.1016/S1071-5819(03)00025-9

1. Introduction

People need information. This may be regarded as one of the few timeless, transcultural constants in our world, creating enormous research potential for understanding how to communicate constantly changing information to interested persons at the ideal time. This problem is compounded when information is intended for a user occupied with other tasks, since the human-attention system becomes a critical factor. Traditional HCI research provides theories and guidelines for information and interface design, but falls short on many levels when applied to these particular problems. Although basic psychological research on attention and task switching has been carried out since the late 1800s (Bryan and Harter, 1899), the tasks and theories from that literature are often too simple or low level to apply to a normal computer user's multitasking environment.

This special issue attempts to contribute to the field by compiling research focused on the design and evaluation of notification user interfaces. Notification systems—and research associated with these systems—attempt to deliver current, important information to users in an efficient and effective manner without causing unwanted distraction to ongoing tasks. Commonly known notification systems include stock tickers, instant messaging tools, system load monitors or alerts and the like. These types of displays share the common design goal of providing the user with access to additional information without requiring excessive levels or prolonged periods of attention. Achieving these goals may require special consideration of screen space, information encoding and other interface design choices. The benefits of notification systems are numerous, including rapid availability of important information, access to nearly instantaneous communication and heightened awareness of the availability of personal contacts. While the popularity of these systems has experienced large increases in recent years, the effects of incoming notifications on ongoing computing tasks have been relatively unexplored. This research is rooted in the general arena of psychological research on alerting and disruption, but also requires research contributions from design, computer science, information visualization and human factors.

The idea for this special issue of the International Journal of Human–Computer Studies was borne from the realization that many researchers were investigating problems related to notification design and modeling effects of interruption of tasks from an HCI perspective, but had no common forum in which to exchange ideas. Awareness of complementary efforts that promote research cohesion and growth were inhibited by lack of common terminology and problem conceptualizations. Diverse methods and approaches are being used to address a wide variety of questions related to notification user interfaces. At the same time, new technologies enable ever-more pervasive notification and multitasking usage scenarios, suggesting fertile ground for a broad research movement. Our hope is that this issue will extend the community of notification system researchers and practitioners that work toward a common agenda.

2. Perspective

Although the general study of supporting multiple activities with interface design is not a new area of concern within HCI, it has not been an area of intense and cohesive focus. Years ago, Allen Cypher presented usability considerations for programs that facilitate multiple activities (oftentimes by providing notification) (Cypher, 1986). This discussion included an overview of techniques (e.g., charting the flow of activities to prevent context clashes, providing reminders and activity management) that a designer could use to help a user linearize goals related to parallel activities. Likewise, Yoshiro Miyata and Don Norman provided an overview of three major psychology research areas that could be applied for system support of multiple activities: studies of memory and organization of knowledge, simultaneous and selective attention and task accomplishment action (Miyata and Norman, 1986). Their discussion extends Cypher's consideration to also focus on transition between activities and execution of simultaneous activities.

Significant work has been done in related fields to address similar issues (see Wickens and Hollands (2000) for an overview), notably in the domains of complex systems and alarm management (Bryan and Harter, 1899; Sarter and Woods, 1995; Woods, 1995). However, a body of work on these topics has not been developed, contextualized, or updated within HCI. Certainly, this is not to say that HCI researchers have not been producing important research for notification design. For example, we have learned much about the effects of instant messaging on ongoing tasks (Cutrell et al., 2001) and the role that probabilistic reliability plays in sustaining use of intelligent messaging systems (Tiernan et al., 2001). We assert that designers and evaluators—and ultimately users—of notification systems need greater and faster progress in understanding how to deliver efficient and effective notifications without causing unwanted distraction for other activities.

3. Contributions in this issue

The four papers presented in this special issue represent several motivating factors within the research area. First, there is a need for basic research that provides empirically determined design guidelines for interfaces that are used in divided attention situations. Second, new theories are needed to understand important aspects of a notification user's perception and interaction. Third, we must find focus that readily extends relevant basic research results and applies theoretical implications to our research problems. Finally, we must find ways to leverage research efforts in complementary fields to achieve broader solution strategies.

Bartram, Ware and Calvert (this issue) address the need for empirical results that suggest how to design notification displays that are mentally economical. Determining encoding strategies that allow rapid and efficient processing with the preattentive visual system is thought to decrease the impact of a notification on other tasks. The authors specifically probe the perceptual properties of motion in an information-dense display with three experiments. The first two experiments

compare cue detection effects resulting from the different encoding techniques in large screen interface design and the third experiment captures distraction effects observed during a variety of tasks. They find that icons with simple motions can be more effective coding techniques than color and shape for notifications that must be delivered with low interruption. Based on these studies, several specific advantages and limitations of motion-based icons are described. In addition, the authors vary the field of view affected during their detection tasks, making their guidelines and recommendations generalizable to larger display surfaces than a typical 17″ or 21″ monitor.

McCrickard, Catrambone, Chewar and Stasko (this issue) investigate information design options suitable for three often-conflicting design objectives of notification systems—interruption to primary tasks, reaction to specific notifications and comprehension of information over time. To improve our understanding of these competing user goals, the authors empirically probe the effects of text-based animation options on an ongoing browsing task. Scrolling and in-place animations are compared in the first experiment, and variations in size and speed are examined in the second experiment. Both studies present design options for notifications that can facilitate quick and accurate reaction, long-term comprehension and prevent interruption of a primary task. The approach employed by McCrickard et al. for these studies provides an impetus for adopting critical parameters within this emerging research community. They argue that focusing research and user studies within this field on critical parameters such as interruption, reaction and comprehension will increase cohesion among design and evaluation efforts for notification systems. Certainly, we need to be able to define success and measure progress in notification systems design according to commonly accepted metrics, and this article presents initial ideas in this regard.

Trafton, Altmann, Brock and Mintz (this issue) examine people's strategic cognitive responses to being interrupted while performing a task. They propose a simple but general task analysis of interruptions and resumption along with several measures (resumption lag and disruption score) that characterize the disruptive effects of interruption. Part of their theoretical framework for memory for goals is validated with an experiment in which participants in the experimental condition experienced notifications with an interruption lag (time difference between receiving an alert, e.g. a phone ring, and attending to the notification, e.g. a phone conversation), while participants in the control experienced no lag. Their results suggest several important considerations to notification design: people do in fact engage in preparatory cognitive activity during an interruption lag, this preparation allows quicker resumption of a primary task, and people that experience disruptive notifications introduced without a lag adapt to them with practice. Furthermore, they suggest additional research that will be valuable for achieving a theoretical basis for task interruption and resumption, including the investigation of the role played by environmental cues and the nature of the information considered important in preparing to resume the interrupted task.

Carroll, Neale, Isenhour, Rosson and McCrickard (this issue) describe their efforts in enhancing task-oriented collaborative activity with notifications and the

need to recognize various types of awareness. They describe the design effort of their Virtual School system, which includes notification systems that provide common ground essential for collaborative work. As part of its iterative refinement, they analysed breakdowns in support of awareness about presence, tasks and actions of collaborators, finding that support must also be provided for awareness of persistent and complex activities. They argue that the concept of activity awareness is essential for notification design when supporting complex and extended collaborations, such as by providing context factors for activity planning and coordination. Design strategies for notification systems that better support collaborative activity are provided. Based on their experience, the authors suggest that the relationship between awareness research and notification design is a mutually beneficial meeting ground for interests in both user interface design and computer-supported cooperative work.

4. The road ahead

Notification system research has the potential to become one of the farthest reaching areas of HCI, in terms of impact on and contribution to people's daily lives. Consideration of notification systems could be constrained to desktop interface elements; however, people's notification needs extend far beyond the computer desktop, and so should our interest in properly addressing these needs. Mobile and ubiquitous devices that are marketed to fill such requirements, especially those that include a display element, often conform to the same design goals as desktop notification systems and may be designed and evaluated with similar methods. A definition of notification systems research breadth must encapsulate as much of the human information awareness need domain as possible, and transcend the desktop.

As we define the research area, it would be beneficial to settle on a conceptualization of common problems (unique from other HCI fields) and an agenda for addressing them. We suspect that challenges in notification user interface design are fundamental consequences of limitations in the human-attention system, and solution imperatives are motivated by the cost of error within a given system of use. However, it will require consideration of a broad range of symptoms to achieve consensus. To grow as a community and achieve focus on critical research questions, we look for a reference task agenda (Whittaker et al., 2000) that we are developing in an ongoing series of workshops. We seek additional fora for the continued exchange of ideas and development of a cohesive community.

Acknowledgements

The papers included in this special issue were found to be the highest archival quality of several other submissions. We especially thank the members of the reviewing panel for their expertise in shaping this issue: Bradley Rhodes, Roel Vertegaal, Daniel McFarlane, Kristyn Greenwood, Jerry Francke, Susan Harkness

Regli, Colin Ware, Brian Fisher, Sheryl Miller, Aude Dufresne, Kori Inkpen, David Darvill, Edward Cutrell, Eric Horvitz, Erik Altmann, Greg Trafton, John Carroll, and Chris North.

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