Interruptive notifications in support of task management☆,☆☆

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ABSTRACT

Our research explores how interruptive notifications support task management in a desktop environment. We conducted two user studies with a community of open source software users and developers to explore their experience with interruptive notifications. We found that certain kinds of notifications support multitasking, task prioritization, task management, as well as influence task disruption management. We discuss how these behaviors affect the notification-task management user experience and offer design guidelines derived from these results to inform better design of systems that interrupt through notification.

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1. Introduction

We live in an increasingly active information environment. As this becomes livelier and richer, the demands on our limited attention also increase. Continually checking for new information manually is tedious and time consuming. We require improved technology services that help us maintain awareness of updated information while mitigating the negative impact that interruptions can have by diverting our increasingly fractured attention. Interruptive notifications, such as alerts for the arrival of a new email, the completion of a remote backup, or a rapidly discharging laptop battery, are examples of notification services that help us maintain awareness of changing system state while allowing us to focus our attention on the other tasks at hand as they do not demand context switching, but rather communicate on the periphery. This research explores the complex environment that notifications exist in, and aims to characterize in more detail new and known factors that affect the interruptive notification user experience.

In our work, we define an *interruption* as the method of forcefully switching attention from one piece of information to another. *Notifications* are a type of information alert that informs the user of a system event or update. *Interruptive notifications* are notifications that intend to draw the user's attention in order to

inform the user of a new event or information, such as a new chat message from a friend.

Notification displays are inherently interruptive because the system must divert the user's attention in order to deliver the information. These notifications usually appear in a small popup window in the middle or at the periphery of the screen. This type of notification is different from passive notifications that do not interrupt users in order to inform them, such as an email about a new comment on your blog waiting for you in the Inbox. Many application event managers and remote information services rely on interruptive notifications to deliver information updates to users in a timely manner.

Interruptions are a classic Human Computer Interaction (HCI) topic and there is continuing interest in understanding interruptions in multitasking environments in the HCI community (Gould et al., 2012). Although interruptive notifications can degrade user attention by presenting competing focal points, this does not always have a negative effect. More importantly, when done well, notifications can also support task management and decrease user anxiety about the system's current state. Notifications provide an important service that helps users manage tasks and changes in their information (Iqbal and Horvitz, 2010). The design of interruptive notifications presents a challenge because these services must deliver information to the user while balancing the costs of interrupting the user with the benefits of information awareness.

The goal of our research is to study how interruptive notifications support multitasking for a common class of users, *knowledge workers*, using their common work platform, a networked desktop computer. We chose to focus on knowledge workers specifically because their daily tasks are information rich and they routinely

multi-task between very different kinds of work behavior, from more solitary critical thinking to highly communicative collaboration with others. Knowledge workers are known to be particularly sensitive to increases of information and interruptions in their environment (González and Mark, 2004; Mark et al., 2005). Most work with integrated, general-purpose computing devices versus the task-specific tools used in other more production-oriented work domains. This allows us to study a host of interruptive notifications within the shared context of one operating system on one machine per user.

A key contribution of this paper is to offer a qualitative methodology to study the user's own notification environment. We present results from User Experience Reports (UXR) adapted to study interruptive notifications in a desktop environment. The UXR allows us to move out of the laboratory environment into the real world of a user's work while maintaining detail about an experience that is sometimes lost in more general field research methods. We conducted two field studies of open source software users and developers using the UXR. This research both validates and extends prior laboratory- and field-based findings about interruptive notifications, including the fact that task management is one of the most important uses of interruptive notifications in desktop-based knowledge work. The results describe the different ways users utilize interruptive notifications to support task management. Building on our understanding of this behavior, we then propose design guidelines to inform the design of more effective interruptive notification systems.

2. Related work

Interruption and notification is a wide research area that has been investigated in the domains of psychology, computer science, and interaction design. We summarize related work in these areas to provide background in what has been done to date and to frame the motivation for our own research. Specifically, we review work in multitasking and interruptions, the design of interruptive notification systems, and field-based methodologies used to study interruptions.

2.1. Multitasking and interruptions

There is a large body of HCI research focused on understanding the effects of interruptions and notifications on users' work processes. The focus of our research is on the role of interruptive notifications in task management, thus we review relevant notification and task management research.

2.1.1. Multitasking and interruptions
The presence of notifications implies that multiple tasks exist in the user's environment. The task a user is working on at the time of a notification is referred to as the *main task*, while the task initiated by the notification is the *interruption* task. A series of experiments by Gillie and Broadbent (1989) are foundational to our modern understanding of the effect of interruption on a task. Although their studies had conflicting results, they provide evidence that similarity and complexity of the interruption did have an effect on the main task.

Mark et al.'s (2005, 2008) work described similar conflicting results. In their earlier study (2005), the researchers examined the nature of fragmented work. They found that interruptions outside the user's work sphere, a collection of tasks related to a goal, were more disruptive than interruptions that were related to the work sphere. However, in the later study, Mark et al. (2008) directly compared the differences in interruptions related and not related to the user's work sphere and found no effects. Although, a related study by Ardissono et al. (2009) then found that interruptions related to the user's current work sphere *were* less disruptive than interruptions not related to the user's current work sphere. In our research we aimed to identify similar types of relationships that exist between the main and interruption tasks and to describe the impact of these relationships on user behavior.

2.1.2. Task prioritization
After receiving a notification, the user has to decide when and how to react to the notification. Work by Iqbal and Bailey (2008) found that users responded more quickly to interruption tasks if the interruption was scheduled as a breakpoint between main task chunks. This confirms previous work by Cutrell et al. (2001) that found users interrupted earlier in a task were more likely to request a reminder after being interrupted, as well as confirms work by Cades et al. (2007) regarding task complexity. Cades et al. found that the longer users work on a main task, the less recovery time is necessary when returning to the main task after attending to an interruption.

Content and saliency of the notification also have an effect on the user. Avrahami et al. (2008) found a number of factors that affected the amount of time it took for users to respond to an interruption, such as salience of the interruptive window and content of the interruption message. Users responded faster to interruptions that had more prominent interruption windows and longer interruption messages. This indicates that content of the interruption may have an effect on the disruption and perceived value of an interruption.

The value of an interruptive notification and the users' decision to when and how to respond to it was often determined by the context surrounding the notification event. In a field study that measured the effects of interruptions during various tasks, Vastenburg et al. (2008) found that interruptions with higher urgency were considered to be the most valuable type of interruption experienced by users. Their results identified urgency as the "primary indicator" for interruption acceptability. Context was the defining factor for determining interruption urgency, which translated into overall interruption value.

Another example of value and context is in a study by Paul et al. (2011a). This study found that participants reported a more positive user experience for interruptive notifications that provided information about social services than non-social services. Additionally, participants in this study seemed to value interruptive notifications more from certain social contacts over lesser important contacts. In our research we further examine the role of various notification characteristics and how they affect users' task prioritization.

2.1.3. Managing task disruptions
Notifications alert users of new tasks they may want to switch to and help them prioritize and structure their workflow. Sanders and Baron (1975) found that anticipation of an interruption may make users work harder to compensate for the cost of distraction the interruption creates. Giveska and Sibert (2004) replicated Sanders and Baron's results and described this phenomenon through the concept of compensation for interruption during a main task. Users who experienced more frequent interruptions adjusted their workflows by decreasing the amount of time away from the main task and by resuming the main task faster after interruption.

Iqbal and Horvitz (2007) provided additional insight as to why interruption compensation may occur. They found that users completed certain task interactions, such as paragraph completion while writing a document, more quickly immediately following an interruption than when performed with no interruption. They described this behavior as *task stabilization*, completing a task