Notifications and Awareness:
A Field Study of Alert Usage and Preferences

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ABSTRACT
Desktop notifications are designed to provide awareness of information while a user is attending to a primary task. Unfortunately the awareness can come with the price of disruption to the focal task. We review results of a field study on the use and perceived value of email notifications in the workplace. We recorded users' interactions with software applications for two weeks and studied how notifications or their forced absence influenced users' quest for awareness of new email arrival, as well as the impact of notifications on their overall task focus. Results showed that users view notifications as a mechanism to provide passive awareness rather than a trigger to switch tasks. Turing off notifications cause some users to self interrupt more to explicitly monitor email arrival, while others appear to be able to better focus on their tasks. Users acknowledge notifications as disruptive, yet opt for them because of their perceived value in providing awareness.

Author Keywords
Task Switching, Notifications, Workplace, Interruption.

ACM Classification Keywords
H5.2. [Information interfaces and presentation]: User Interfaces.

INTRODUCTION
To many, fast-paced multitasking defines the dominant activity pattern of information workers [9, 10]. As communication with collaborators continues to be an integral part of today's information workers' tasks, switching among productivity and communication applications remains a common practice. Such switches are often driven by the user's own need to forage information as per demands from the ongoing task, or after being proactively alerted about arrival of new information.

Notifications, in the form of visual pop-ups or auditory cues have been long viewed as an effective way of proactively helping users maintain information awareness. While such notifications hold great benefit in saving users the effort of

seeking information themselves, they unfortunately have also been considered to be a large source of disruption to ongoing tasks [2, 3, 7]. This assessment is due in part to the fact that notifications often occur at inopportune moments and lure users to process and respond to them [3, 7, 8]. Studies have shown that responding to notifications impedes the efficient resumption of interrupted tasks and negatively impacts task performance [1, 2]. A proposed solution is to relinquish notifications and allow users to seek for information at their own convenience. The argument is that users will chose to switch attention from ongoing tasks at moments that are more suitable for them, rather than allowing a notification to divert their attention unexpectedly during less opportune moments.

However, it is not clear how this shift in the balance towards reducing unexpected disruption and increasing effort in maintaining awareness may affect users and their tasks. We pursue an answer to these fundamental questions: How do notifications support users' need for information awareness? What effect does this need have on their focus on tasks that are interrupted by arrival of notifications? This work provides the initial steps in answering these questions.

Our goal is to understand how interruptions caused by notifications influence users' focus on ongoing tasks and to contrast this with task focus if notifications are turned off. We focus on notifications for email communications. We conducted a field study with 20 users where we recorded desktop interactions for two weeks, with the intervention of disabling notifications during the second week. Results showed that email notifications are primarily used as an awareness mechanism, rather than a trigger to switch to check email or perform other activities on the email client. Approximately a quarter of the notifications users receive result in an instant switch to the email client that had initiated the notification and these accesses are typically short in duration. We saw two behaviors, depending on the user, after users followed a request to turn off notifications: rates of accessing the email client went up for some users and were reduced in others. Post-study surveys revealed that while users are aware of the distractions that notifications can cause, they highly value the awareness of information provided. These results further highlight the importance of balancing cost and benefits in delivering notifications. We discuss design implications and directions for future research.

STUDY

Our focus in this study was on the impact on ongoing tasks and satisfaction of users' information needs resulting from notifications announcing arrival of new email. Notifications appear regardless of user state, task switches are generally not planned for, and as a result, require unexpected suspension of the ongoing task and occasionally, switch of work context. Specifically, we sought answers to the following questions:

1. How disruptive are email notifications in their role of providing information awareness to users? Does this disruption reduce with notifications turned off?

2. Following a period of time with notifications turned off, will users perceive the benefits of minimizing the potential disruption they cause and leave them off?

Methodology

We conducted a two-week in situ field study collecting desktop interaction data from computer users to answer these questions. Microsoft Outlook was used as the email client, a widely used application within our organization. Outlook is used for a variety of tasks beyond email management (*e.g.,* calendaring activities and maintaining to-do lists and contacts). Our interest was in the user's decision to switch to Outlook when they would receive an email notification, but once they switched we did not distinguish among the usage of Outlook. Outlook notifications appear as a small modal window in the lower right corner of the screen and persist for about 7 seconds before fading away. Notifications are enabled by default, but users can disable them if so desired. We only recruited users who had Outlook notifications enabled.

Users were recruited through a random selection process applied on the entire employee pool of our organization. 42 people signed up and eventually 20 users completed all stages of the study (Managers=12, Developers=8). Users were compensated with lunch coupons on completion. The study also administered a pre- and post-survey to collect self-reports on users' Outlook usage behavior, preferences and perceptions on notification usage.

Data Collection

Data was collected using a monitoring tool running as a background process in users' primary work machines. The tool logged time-stamped names of applications in focus and arrival of notifications. Logged data files were periodically flushed to a central server and later processed to be stored in an SQL database for future analysis.

For the first week, baseline data was collected without any intervention. For the second week, users were instructed to disable all notifications within Outlook. We collected data in the no-notification condition for a week which allowed users to settle into the new configuration. We assume that the information needs of users in week 1 and week 2 of the study were relatively stable. We have no reason to believe that they changed, but there is opportunity to explicitly control for such potential instability in future research.

RESULTS

Over 1682 hours of data was collected from the 20 users. In the pre-survey, users were asked to provide a list of applications that they used extensively as part of their primary job description. These *primary applications* were studied in the logs to evaluate task focus. For the purpose of comparison, we examine time spent on Outlook and primary applications, and reaction to notifications across the two weeks.

Time spent on email and primary applications

In the baseline condition of notifications turned on, users spent on average 30.5% (S.D. 12.1) of their active computing time in Outlook, and 33.2% (S.D 18.0) of their time interacting with other primary applications every session. We define a session to be delimited by either the logging on and off or by the unlocking and locking of a machine. Turning off notifications did not yield significant changes in these percentages; 31.7% (S.D. 13.7) of user time was spent on Outlook, and 34.8% (S.D. 16.4) was spent on other primary applications. This indicates that Outlook occupies a significant percentage of users' time, and notifications do not appear to affect this percentage.

Reactions to Notifications

Users received on average 3 (S.D. 2.12) email notifications from Outlook per hour, consistent with findings in [7, 8]. 4 users demonstrated no immediate responses (within less than a minute) to notifications. The remaining 16 users switched to Outlook solely as a result of a notification for 26.2% (S.D. 30.3) of the notifications. This shows that majority of notifications do not cause users to immediately suspend their ongoing task and switch to the source. Post study surveys suggested that the information nuggets (e.g. sender, subject) provided in the notification are sufficient for users to garner the important parts of the message and decide whether it merits immediate attention. As one user stated : "I'm usually able to tell whether they're worth viewing right away from the title." Users widely acknowledged the passive awareness and ability to ignore messages or defer responses as a valuable service of notifications – aptly summarized by one user : "It's just nice to know when new mail has arrived – even if I don't check outlook at that moment."

Time spent on Outlook

When users switched to Outlook solely as a result of seeing the notification, they spent on average 74.9s (S.D. 34.6) in Outlook. This is significantly lower ($F(1,15)=5.502$, $p<0.04$) than average time spent on Outlook (M=133.9s, S.D. 106.1) when accessed without being prompted by a notification. This suggests that Outlook switches triggered by notifications are more opportunistic and users wish to quickly return to their suspended tasks.

In the *no-notifications* condition users spent 149.9s (S.D. 123.4) on Outlook on every access. This was significantly higher ($F(1,15)=6.256$, $p<0.024$) than with accesses triggered by notifications, but not different than accesses without notifications triggers in the baseline condition. It appears that despite not having the awareness of new
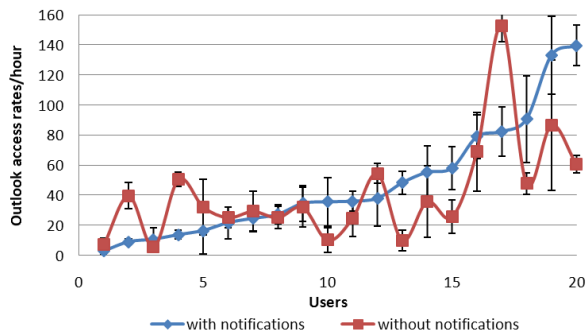
Figure 1: Illustration of how Outlook access rates change with notifications disabled for all users, normalized to an hour. The large number of Outlook accesses represent users whose job roles require them to be responsive to email.

information that notifications provide, users can still fulfill their information needs without significant increases in the time spent in Outlook when accessed independently.

Outlook Access Rates
In the no-notifications condition, users accessed Outlook at a rate of 19.3 times/hour (S.D. 12.9), not significantly different than the Outlook access rate with notifications enabled (M=21.9, S.D. 17.8). However, the post study survey showed that 13/18 respondents felt that with notifications turned off their Outlook access rates had changed. 7 users reported to have voluntarily switched to Outlook more under the no-notifications condition and 6 users reported to have switched less. This prompted us to explore whether the collected data also showed this dichotomy in Outlook access rates across the experimental conditions. Indeed, quantitatively one group (N=12) demonstrated a decrease in their Outlook access rates (M=40.7%, $F_{(1,11)}$=15.73, p<0.002) while the other group (N=8) showed an increase (M=130.6%, $F_{(1,7)}$=8.04, p<0.025). Figure 1 shows how Outlook access rates changed for all 20 users from week 1 to week 2. It appears that while some users were perhaps compensating for the lack of awareness by accessing Outlook on their own at an increased rate, for others absence of notifications allowed them to be more focused on their ongoing tasks.

The ability to focus more by sacrificing automatic awareness was not necessarily lauded by users. About notification usage one user commented: "I will continue to use them. I know I am more productive when I don't but I like keeping abreast of my new email." Another user stated: " I found with my notifications removed, that I would get more work done on whatever particular task I was doing… unfortunately, because I had no instant notifications, a lot of time would go by before I'd remember to check my Outlook—then I would have a ton of email to catch up on…"

It appears that the lightweight and passive delivery mechanism of notifications works well with users' needs for awareness, and the value of information provided often compensates for the disruption to ongoing tasks.

Outlook Access Patterns
We determined two patterns in Outlook accesses: rapid, almost cursory (duration <10s), and longer, spanning

multiple minutes. We hypothesized that the first type indicates accesses in pursuit of awareness, where the user would want to check email arrival status (or calendar information) and then quickly return to their primary tasks, while the other type of access represents more in depth interaction, *e.g.*, either planned or opportunistic reading and replying to emails. There were no differences overall in rapid and longer access across the experimental conditions.

However, for users whose Outlook accesses increased with notifications disabled, their longer Outlook access rates increased significantly (M=146.2%, $F_{(1,7)}$=14.1, p<0.007). Their rapid Outlook accesses did not increase. As one user stated in the post survey, this could be because this group of users now spent more time catching up with new information in Outlook, as they no longer could be passively aware of it via notifications.

For users whose Outlook accesses decreased, there was both a significant decrease in longer Outlook accesses (M=35.3%, $F_{(1,11)}$=6.844, p<0.024) , and in rapid Outlook accesses (M=43.3%, $F_{(1,11)}$=11.9, p<0.005). For this class of users, the absence of notifications appears to reduce the footprint of Outlook in the space of their focal applications, which, as users later stated, negatively impacts awareness.

Task Execution Behavior
For the first week with notifications enabled, users accessed on average 15.3 (S.D. 10.4) applications, had 1.05 application switches/min (S.D. 0.55) and spent 416.5s (S.D. 399.7) on each application per switch. With no notifications, users accessed 19.4 applications (S.D. 16.4), switched applications 0.97 times/min (S.D. 0.5) and spent 250.2s (S.D. 311.7) on each application, none of which were significantly different than in the baseline condition. This suggests that user focus on ongoing tasks is not significantly impacted with notifications turned off, primarily because users reportedly are using notifications to increase awareness and not as a trigger to switch. There was no effect of job role in any of the dependent measures.

User Perception about Notifications
A basic goal of this study was to understand how users perceived the use of notifications in their day-to-day activities. Our post study surveys showed that users do indeed acknowledge notifications to be often disruptive: " […] is very tempting to go and see the email when you receive a notification", but at the same time the lack of awareness could often be costly: "There were too many times when I had realized I hadn't read mail in several hours and was way behind in responding to international teams. Using the notifications I could often gauge if something was important or not."

When asked whether they would want to revert back to using notifications, 17/18 respondents responded in the affirmative. Users provided valuable feedback about how notification delivery should consider a user's current state and perhaps render notifications only for important emails. For example, one user stated:

"Yes. It can be distracting, but I also like the ability to work in another program and monitor my inbox for important events.

I'd prefer if I could filter and determine which emails I wanted to be notified of. This should be by person/group, but i also think it'd be fantastic to set a "watch" on an email thread and be notified whenever a new email in that thread appears."

Such comments highlight users' valuing awareness provided by notifications. Perhaps a combination of how notifications are currently being delivered and users' natural propensity to multitask is more responsible for the distraction that they admittedly cause.

DISCUSSION
Our findings provide evidence of the non-invasive role that notifications play on pursuit of awareness and task execution behavior. That users continue to work on their primary applications for three quarters of email notifications indicates that users can effectively choose which notifications to respond to. Users appear to find the awareness aspect of notifications valuable and to maintain that awareness, are willing to accept the potential disruption. Even when users admitted to getting more work done with notifications disabled, they also found it to be counterproductive, *e.g.,* having "a ton of email to catch up with and sift through." This finding indicates that by reducing one type of disruption, we may be introducing another. The results suggest that design efforts should be focused on balancing disruption and awareness.

Our results allude to a possible categorization of users, or to users within different work contexts, by their pattern of attention and disruption, based on their multitasking behavior. Turning off notifications appears to have affected users in different ways; some exhibited a greater need to interrupt themselves to monitor information arrival while others could remain more focused on their primary tasks. This presents opportunities for investigating notification design customized to different user types and their needs. As one user mentioned: "It's about discipline in using technology." Indeed, various levels of such discipline were observed in the task execution behavior of the users.

Although we focused on how user behavior was changed by the removal of notifications, we did not explore why this change may have occurred. Feedback from users suggested that consequences of missing urgent information, context of user tasks and users simply not getting totally used to not having notifications to remind them of new information could be some of the reasons. Additional research is required to explore these issues in more depth.

We believe that there is an opportunity to enhance the controls on notification presentation to better serve users' desire to stay aware. This study provides support to the potential value of a trusted system that can reliably identify subsets of incoming messages that a user would most like to be aware of. Promising methods include the use of machine learning to classify the urgency of messages, smarter scheduling of presentation [4, 6], and rule-based control of notifications in [5]. Users could specify thresholds on urgency for notifications and provide maximum bounds for deferral if they are currently focused

on a task [5]. Such methods could reduce distraction while maintaining awareness of key developments. Future designs of notifications could take topics and context (*e.g.,* messages from people in meetings that will occur soon) into consideration, providing even more insightful controls of notifications.

CONCLUSION AND FUTURE WORK
We investigated the effects of email notifications and their imposed absence on users' task-execution patterns. Results showed that users react to only about a quarter of all notifications, and that user focus on primary tasks is largely unaffected if notifications are disabled. Moreover, users value the awareness provided by notifications and are willing to incur some disruption to maintain that awareness. Future work includes field studies of the use of notification algorithms that take into account the timing and urgency of information conveyed [4] and studying the influences of such notifications on user focus of attention.

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