The Myth of Subtle Notifications

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UbiComp'14 Adjunct, September 13-17, 2014, Seattle, WA, USA
ACM 978-1-4503-3047-3/14/09…$15.00.
http://dx.doi.org/10.1145/2638728.2638759

Abstract
Push notifications keep user informed and engaged with the events around the mobile applications. However not all the notifications are of the same importance level to the user. We explore how mobile notifications are regarded as increasing number of applications are adopting notification services. We logged notification management traces from 10 individuals for 15 days to understand how they perceived mobile notifications and their importance, accompanying our results with semi-structured interviews.

Author Keywords
Notification Management; Mobile Devices; User Study.

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Introduction
Notifications have become a major feature of many smart phone applications, enabling the application to interact with the user when it is not running in the foreground. These notifications are primarily designed to make users aware of what is happening in the application space, and to inform them about events such as a new email or simply to provoke users to launch the application. Although this degree of awareness is useful, it can also be disruptive. All notifications are not equally important to the users and

different users perceive notifications differently depending on their current engagement and situation.

There exists a vast body of literature that has studied the trade off between disruption and awareness caused by notifications [4,3,1,2]. However these works primarily focused on workplace environments where the user is engaged with some computational task at hand and notifications are delivered to the desktop computer. There has been little attention given to pervasive scenarios where the notifications are delivered to the mobile devices at anytime and any location. Shirazi et al [6] took the first step in understanding users' subjective perception of notifications by studying mobile notifications.

This paper aims to understand how the mobile notifications are perceived *on the device*. To do so, we investigate whether device features (such as modality of the notification delivery and activity engagement) as well as contextual characteristics of the user (such as time of day) have an impact on the users attending the notifications. Our findings suggest that users would like to have more fine-grained control over mobile notification management. Many of our participants stated that they would prefer different modalities for different notifications with varying priority, as well as more subtle and persistent notification modalities such as multi-colour ambient lights

Study Methodology

We recruited 10 participants (9 male, 1 female) aged between 27 - 49 years. All the participants are working professionals with technology background, and owned a smartphone for minimum of 2 years. Moreover they all had an Android smartphone as their primary device.

Our study consisted of collecting data about users' interactions with notifications through an Android application for 15 days, followed by in-depth interviews for further insights. We developed an Android application using *NotificationListenerService* provided with API 18, which logs three types of data: a) all notifications received on the device, b) name and activation time of foreground applications and c) timestamps corresponding to screen status. We logged the timestamp when a notification was received cleared, allowing us to measure the users *attendance time* for each notification (the delta time from arrival to removal of the notification). We additionally recorded the modality of the notification that is whether it had a sound, vibration or LED light associated with it. The collected dataset comprises a total number of 43958 notifications coming from 89 applications. Due to the non-normalised distribution of notifications across users, with some users receiving many notifications and some only a few. We have thus normalised the attendance time by transforming it through logarithmic function. At the end of the data collection phase, we conducted an hour long semi structured interviews with all participants, the subjective feedback was later coded manually into thematic matrices for pattern analysis. In conducting interviews we first gathered demographic information, followed by questions on their notification attendance behaviour such as their preferred modality, and their experience with notification management techniques.

Study Results

Active Engagement. We begin our analysis by studying whether active engagement with the mobile device has an impact on how the notifications are regarded. By *engagement* we mean whether the phone

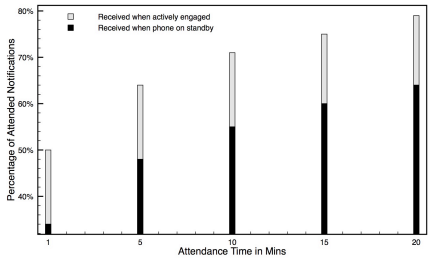

Figure 1: the percentage of the notifications attended when actively engaged with the device versus standby mode, presented as stacked bar.

was unlocked and an application was running on the foreground (we do not account for user typing or interacting with the display). We are then interested to see whether being engaged with the device had an impact on the notification being attended immediately (less than one minute). A Pearson χ^2 (7)=140.81 ($p < 0.01$) indicated that there exists a correlation between engagement with the device and immediate attendance to the notifications. Our result, depicted in Figure 1, shows that on average 49% of the notifications were attended immediately in the case of active engagement, in comparison to 34% of the notifications when the phone was on standby mode. To further investigate this feature, we built a linear regression model where the dependent variable was the normalised attendance time. The model showed a correlation (Adjusted R^2=0.18, $p < 0.001$) between the attendance time and active engagement.

This is an interesting finding as it shows that even though the users may not *immediately* attend to a notification, receiving of it (while engaged with the device) registers as a visual cue enabling them to go back to it in nearer future. This is confirmed by our qualitative study, where participants mentioned that the visual cue helps them to react to the notification at a later time.

Modality. We then considered the impact of delivery modality on the notification attendance by looking at different types and combinations of modalities - sound, light and vibration. We first compared amongst all users, the ratio of notifications that were immediately attended to (within one minute of receiving) that had *any* kind of modality associated with them over those that had none. Our data shows that on average a notification was 12 times more likely to be attended immediately if it had any modality accompanied with it. This observation corresponds to those reported in [5].

We then looked into which type of modality has the least attendance time. A two-way contingency table analysis across modalities and attendance time did not yield into any significant result. That is we cannot tell which modality had the highest impact amongst all the users. To confirm this result, we asked each participant to rank their preferred choice of modality and conducted a Borda Count analysis to find the most preferred modality across all participants. The results showed no clear preference towards one modality. While we could not find a solution to fit all, we uncovered interesting insights into users' preferences, e.g., users like to associate vibration and sound to important notifications. Users also mentioned that their social context plays a role in their choice of modality

More interestingly, we found that *light* is typically preferred for low priority notifications and also in social contexts where the user does not want to disturb others (e.g., meetings). The persistent nature of light as a modality was also found useful. One of the participants mentioned – "*the LED light stays on always, until I have read the notification. This is very useful ...sound and vibration have a temporal nature. If you miss them, you miss the notification."* Light is also used to quickly distinguish amongst different notifications. For example one participant mentioned *"My Facebook notifications have a blue light with them, so when I see blue light I know it can wait".*

Time of the Day. We studied the effect of the time of the day on how users regarded the notifications. We

split the course of the day into *three* hours time periods. We measured the ratio of notifications that were attended in each time bucket over all those that were received in that bucket. We observed that 7-10 am (72%), 13-16 pm (76%) and 16-19 pm (67%) period had the highest number of attended notifications. When we interviewed our participants, our findings were confirmed that users are generally more attentive to their notifications during the morning and evening time when they are at home. Thus the notifications that are pushed towards early part or end of the day have a higher impression rate. A number of users (n=9) mentioned that they would like to receive non-urgent notifications in the evening: "You can delay the low priority notifications and send them to me in the evening, when I am at home watching TV''. Another interesting insight from our interviews was that the participants called for more control power over their notifications, that is they desired to define what content should be sent to them at what time of the day.

We then built a linear regression model with independent variable being time period of the day and the dependent variable the attendance time. Our model suggested that time on its own is not a good predictor for notification attendance time. That is while we can argue that the notifications that have arrived in certain times of day are more likely to be attended by user, we cannot predict *how long* it will take him to do so by looking only at the time.

Design Implication

Our study revealed that the visual cue has a high impact on the user remembering to return to their unread notifications; also to deduce the source and importance at a glance. That is the notifications that are accompanied by sound or vibration are more likely to be forgotten if not answered immediately. Some participants suggested the need for a subtle persistent modality that will stay on, as well as desiring a multi-colour light that can be used not only to differentiate applications but also the *priority* of the content. Another important implication that this study revealed is that users desire to have more fine-grained control over the notification management allowing them to specify what is important to them. Our results resonated with findings in [6] that participants desired to control the notifications priority depending to the content and the people behind it. Such control setting should also be on the device instead of the application website, allowing ease of access and modification. Finally, our interviews revealed the desire for scheduling low priority notifications to be delivered as a group at a specific time of day set by the users.

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