What Do Smartphone Users Do when They Sense Phone Notifications?

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Abstract
Smartphone users receive a variety of notifications on their phone every day. To understand how smartphone users deal with notifications, recent mobile receptivity research has started studying notification management and attendance behavior. However, what do smartphone users do when they sense a notification, such as hearing the sound or feeling the vibration before they spot it? We present a study investigating smartphone users' behavior starting from the moment when they sense a notification, including speculating the source and deciding whether and when to look at it, until they attend to it. We explore how users' behaviors vary according to the situation, what factors affect the behaviors, and in what situations users need particular help from a notification system to be better aware of and to accurately judge the source of a notification. We expect the findings will provide useful implications for the design of future notification alert system.

Author Keywords
Notifications; Interruptibility; Mobile Receptivity.

ACM Classification Keywords
H.1.2. Models and Principles: User/Machine Systems; H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces.

Introduction

While user's attention is not always on the phone, the alert system is commonly used to signal users of phone notifications. An alert commonly comes in a form of audio or haptic to appeal to users' attention about incoming messages, emails, or other information worthwhile a look. The effectiveness of alert, however, is harmed by notification overload. As smartphone users install more and more apps on their phone, they also receive more and more notifications. Smartphone users have different strategies to deal with the increasing number of notifications: whereas some users keep their phone making alerts, other users prefer to make their "silent", such as the phone only delivering haptic alert (namely, the vibrate mode) or no alert at all [1,2] . However, making the phone silent may not be the best way to get notified. For example, Chang and Tang found that users are more likely to miss notifications when their phone does not deliver any alert [1]. This may let them miss urgent notifications they need to address immediately. Nevertheless, keeping the alert always open does not necessarily guarantee effective attendance to notifications. Users are likely to attend to unimportant notification because of the indistinguishable alerts between important and unimportant notifications. Ideally, if users can tell important and urgent notifications from otherwise based on the characteristics of the alert, their attendance to notifications may be more effective. However, a number of understandings need to be developed to design a useful phone alert system.

First, it is important to know whether smartphone users would speculate the source of a notification when they get notified by an alert. The alert system would not be helpful if users rarely speculate. Second, if users do speculate the source of a notification, when (in what situations) do they do it and how would they do it (e.g. based upon what information)? Third, after users speculate, regardless of their confidence in the speculation, what factors would affect their decision of reacting to the notifications? Fourth, when (in what situations) would users feel especially frustrated with ineffective attendance to notifications, and with missing notifications. Answers to these questions inform us of when an intelligent alert system should particularly assist users.

Unfortunately, currently in the literature we find little empirical evidence and findings for developing these understandings. Most notification and interruptibility research, where a notification questionnaire was used, asked users' preference of, attitudes toward, and actions on phone notifications *after* seeing the notification content [3,4,5,6,7,8,9]. However, to develop the understandings, it is important to ask their experience and decision making *prior to* reacting to the notifications, i.e. sensing the notifications. We assume that before looking at and acting on the notifications users may have already judged the source of the notifications and thereby decide whether and/or how to act on them. This paper aims to understand this unexplored area. In this paper, we present an ongoing study with an aim to develop these understandings. Our research questions are:

- *[RQ1-1]: When do smartphone users speculate the source of a notification and based on what information do they make the speculation?*
- *[RQ1-2]: What information do smartphone users consider more and less helpful to speculate in different situations?*

Group	Feature
notification	sender application, arrival time, tag, ticker text, sound mode, vibrate mode, category, title, text, subtext, priority, visibility, action, audio mode, clearable, ongoing of a notification
context	latest used application and time, ringer mode, audio mode, volume, network and wifi status, location, physical activity, acceleration, rotation, gravity, orientation, proximity, ambient light level, battery level, charging state
accessibility	triggered time, event type, event text, screen status

Table1: Description of features from the Mobile Receptivity dataset.

- *[RQ2]: For notifications of which smartphone users have and haven't speculated the source, what makes users decide to and decide not to attend to the notifications, respectively?*
- *[RQ3]: When are smartphone users more likely to sense/miss and not sense/miss notifications?*

The expected contribution of the paper would be as follows:

1. Identifying situations where users more likely to need the system to help enhance their awareness of certain notifications.
2. Identifying ways to help users more accurately tell the source of notifications in different situations.

Data Collection

We used mixed methods to collect our data, including ESM, phone logging, and post-study interviews. We used phone logging to capture context, notifications, and user's actions on the phone. Logging these allow us to understand the relationship between the phone context and users' notification attendance behavior. We logged users' action using Android's Accessibility Service[1]. This allowed us to capture when users interacted with the phone and use this information to infer users' attendance to notifications. More details about the logged data are in Table 1. We are aware that some notifications cannot be dismissed by the user and always stay in the notification drawer. These are labeled "ongoing notifications" by the system. We logged all notifications but our analysis will focus on non-ongoing notifications.

[1] Android's Accessibility Service: https://developer.android.com/reference/android/accessibilityservice/AccessibilityService.html

ESM Questionnaire

We used ESM to capture users' experience and behaviors concerning specific notifications. An ESM questionnaire is triggered when participants were detected to have started using their phone for 10 seconds. Every two ESM questionnaires had a minimum of 90-minute interval in between. And ESM questionnaires were not sent between 2 AM and 8 AM. We selected not to use random sampling because it might influence participants' overall awareness of notifications, thus contaminating the data.

Each ESM questionnaire consisted of 1-3 *notification questionnaire*—questionnaire asking the response to one specific notification received within 30 minutes from the trigger time. Notifications received 30 minutes before the questionnaire were not included because users might not reliably recall their experience with them. A questionnaire comprises sixteen multiple-choice questions and one free-response question asking their activity when receiving the notification.

Study Procedure

Participants were instructed to complete the entire study by running our Android logging app on their phone for 14 days. They were provided with NTD 1200 cash gratuity. The app logged contextual data, notifications, and user actions on the phone and prompted participants with ESM questionnaires every day. During the 14-day collection period, participants would generally receive 6 to 10 ESM questionnaires per day, depending on their usage of the phone. Participants were instructed to connect to a Wifi network every day to upload logged data.

After they completed the ESM study, we invited them to an optional post-study interview, with additional NTD 300 gratuity. To obtain more detailed and reliable context information from participants, in the invitation email we provided participants with their statistics of notifications as well as notification data classified into

Self-claimed number of receiving notification/day		Student	Non-Student
Male	10-30	3	2
	30-50	2	1
	50 up	1	1
Female	10-30	2	0
	30-50	3	1
	50 up	3	2

Table2: Participants Self-claimed number of receiving notification per day range.

speculated, non-speculated, and missed. We told them to review the notifications and try to recall the details to help the interview. In the interview, we used the cued retrospective technique (showing them the details of and their responses to the notifications) to ask them to recall the context and how and why they speculated and deal with the notifications. We tried to ask about latest instances to get more accurate self-report.

Recruitment

We recruited Android users living in Taipei and Hsinchu. We posted recruiting messages on a subject pool Facebook Group created in our university, bulletin boards intended for recruiting research participants on the largest BBS (Bulletin Board System) in Taiwan called PTT, and the research team members' personal social media pages. We screened respondents and notified who qualified. All qualified participants needed to use more than one communication app with different notification alert patterns (Facebook Messenger, LINE, WhatsApp, WeChat, etc.). We only selected respondents who reported that their phone was in the Silent mode less than 8 hours a day. In addition, we selected participants who used an Android phone with version 5.0 or above (but below 7.0). Within these participants, we intended to get diversity in their occupation and received number of notifications.

Participants

We started the data collection on March 17th. Until May 31st we have invited 31 participants to participate in the study, and 21 participants have successfully completed the study until the end of May. (9 males, 12 females). We will report the preliminary results of these 21 participants. The composition of the 21 participants were 6 male students, 8 female students, 3 male non-students (having a full-time/part-time job), and 4 female non-students (having a full-time/part-time job). None of them were acquainted with our research team members. Some participants dropped out of the study. One dropped out because something happened to her phone, and three dropped out because the logging app did not function on their phones. All the 21 participants who completed the study were in the 20-33 age range.

Dataset

From the 21 participants, we collected 101,835 non-ongoing notifications during the period. The top category is messenger (53.78%, 54769), followed by utility (17.8%, 18094), system (15.8%, 16058), mail (3.26%, 3324), social (2.9%, 2978), and reader/news (1.26%, 1280). A large number of notifications from messenger app was partial because some participants were in a number of group chats. 62.3% of the notifications were received in the Vibrate ringer mode; 34% were received in the Normal ringer mode (with both ringtone and vibration). For these 21 participants, 2308 questionnaire prompt were generated and 1788 were responded to, with a response rate 77.5%. Note that in each questionnaire we asked participants to report their experience and decision regarding 1-3 notifications. The 1788 responses contained responses to 2775 notifications (i.e. 1.55 notifications per questionnaire).

Preliminary Results

Here we present preliminary results of the ESM study from the 21 participants. Among the 2775 ESM responses, 92.5% were valid responses that said whether participants had seen the notification being asked in the questionnaire. 62% notifications had been seen (1594) before participants saw the questionnaire. As to notifications which participants reported they had sensed or not at the moment, 56% (641) were reported as sensed, and 42% (481) were reported as not sensed. By "sense" we mean that participants had *not* looked at the notification but had heard the sound and/or felt the vibration.

Did Users Speculate Notification Source?
Among the sensed notifications, interestingly, there were up to 63% (392) notifications of which participants reported that they speculated the source. 32% (195) of these notifications were speculated both about the app and the person who sent it (i.e. that the notifications were sent by a specific person via a specific app). And 27% (167) of the notifications were speculated solely about the app. Surprisingly, merely 2% (14) of the notifications were speculated solely about the person. For 3% (16) of the notifications, participants reported that they were not able to tell the source. To summarize, the results suggest that participants indeed speculated notification source. More often they speculated about the app than the person. Participants rarely speculated solely about the person alone. When they speculated about the person, they mostly also speculated about the app.

Regarding how participants speculated about the app, we let participants choose all information that applied to their speculation at the moment. Vibration Pattern was chosen as the top information (49%) their speculation was based on. Another top information was *recently used app* (43%). Interestingly, Sound Pattern was only chosen in 20% of the responses. We think this might be because our participants mostly put their phone in a vibrate mode. When speculating about the person, *recently interacting with whom* was the top information the speculation was based on (77%). The second top was a communication norm between the participant and the person (e.g. the person typically sends the participant a message at that time). But this option was only chosen in 12% of the responses. Note that this ESM question was single-choice. Our impression in the interview pointed out that the aforementioned two reasons were also mainly why participants speculated about a particular person. We realized that we should have made this question multi-choice after we learned this from the interview. Fortunately, the results still seemed to be able to highlight these two main reasons.

Was Users' Speculation about the Source Accurate?
Out of the 392 speculation instances, 96% were that participants reported whether their speculation on each notification was correct. 54% (202) were speculating both about the app and the person, and the rest were speculating about either the app or the person (mostly app). For the former, 85% of the speculation (171 out of 202) were correct about both, suggesting a high accuracy of participants' speculation. Most of the incorrect speculations were right about the app but wrong about the person. Participants were rarely wrong about both (1%). In responses where participants speculated about either one, they were accurate about the app (accuracy = 88%). To summarize, participants were accurate in judging sources of notifications, especially about the app. But they were less accurate about the person who sent the notifications.

What Did Users Do after They Speculated?
Regarding whether participants attended to the notification after they sensed it, 68% of the time participants attended to it right away; 26% of the time they did not attend to it; the rest (6%) was that participants already were using the phone at the time. Finally, when being asked whether their decision at the time (i.e. attending or ignoring) was helpful, 77% thought their speculation helped them make a decision. However, still 10% chose *"No. I did not need to look at this notification at the time, but I looked at it."* This

10% indicate when a notification system can assist users in deciding whether to attend more effectively.

Next Step

Since the study is still ongoing, we will not draw any conclusion. However, the preliminary results seem to suggest some interesting patterns. We hope to see more emerging patterns after we collect more data and conduct a formal analysis. We plan to analyze the correlation between participants' ESM responses with logged context and actual notification attendance behavior. We'll also put a great focus on qualitative data because the cued-retrospective self-report helped us obtain quite interesting insights into what they did between they sensed and attended to the notifications.

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