A Preliminary Study of an Intelligent System Facilitating Selective Notification Attendance on Smartphones via Alert Assistance

Yi-Hao Shih
National Chiao Tung University
Hsinchu, Taiwan
sam1424061933155.cs05@g2.nctu.edu.tw

Tang-Jie Chang
National Chiao Tung University
Hsinchu, Taiwan
tjchang.cs08g@nctu.edu.tw

Jian-Hua Jiang Chen
National Chiao Tung University
Hsinchu, Taiwan
novel860329.cs08g@nctu.edu.tw

Hao-Ping Lee
National Chiao Tung University
Hsinchu, Taiwan
dimension4.cs03@nctu.edu.tw

Yung-Ju Chang
National Chiao Tung University
Hsinchu, Taiwan
armuro@nctu.edu.tw

ABSTRACT

A large body of interruptibility research has attempted to minimize disruptions caused by smartphone notifications. Yet, little research has explored ways to enable users to selectively attend to notifications, which can occur as early as users first notice the notification alert and start to speculate about its source. Nevertheless, users' speculation may not be always accurate. We took the first step in helping users make speculations about notifications to facilitate selective attendance. We developed *Notiware*, an Android app that helps users speculate about notifications by generating alert assistance when it detects that an arriving notification cannot be correctly speculated. An ESM study with 30 users who used Notiware for 4 weeks shows that, overall, Notiware increased the accuracy of participants' speculation of notification source by 28%. Moreover, Notiware helped the participants skipped irrelevant notifications 1.21 times more often than without the assistance.

KEYWORDS

Notification source; receptivity; intelligent system

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1 INTRODUCTION

Mobile phones are an essential element of our daily lives and are used for sending and receiving a wide variety of information. The number of notifications that users have to deal with daily has increased dramatically, leading to notification overloads [15]. Researchers have speculated on whether disabling notifications could help users avoid interruptions, but found that this instead made participants feel stressed and maintain their frequency in checking their phones [11, 12]. Likewise, Chang and Tang [4] reported that users' overall number of phone-attending actions were similar across silent and non-silent conditions because users tend to spontaneously check their phones when the phone is in silent mode. This "more-than-enough" notification- reading can be ascribed to users' tendency to check their phones frequently [5, 6], but it may also be driven by their lack of awareness of what triggers the notification, which piques their curiosity. Research has shown that users have a preference toward reading notifications of certain kinds [13] or from certain sources [8]. Prior research also showed that users speculate the notification source upon the arrival of notifications and affect their decision on attendance [3]. However, users' speculation may not be always accurate, because of lacking sufficient information to speculate, or the alert was not clear enough [3]. To help users speculate notifications to facilitate selective notification attendance, we took the first step by developing an intelligent Android application called Notiware. Notiware helps users speculate about notifications by generating an additional alert when it detects that an arriving notification would not be correctly speculated. The detection was based on a machine learning model that was trained using the dataset obtained in [3], which contained 34 smartphone users' speculation instances on their smartphone notifications. Each speculation instance was associated with phone sensor information and a label indicating the correctness of the speculation. We deployed Notiware with 30 smartphone users to assess how effectively it improved these users' notification speculation and notification attendance. The preliminary results show that Notiware increased the accuracy of study participants identifying the sources of notifications by 28%. Notiware also helped the participants skipped irrelevant notifications 1.21 times more often than without the assistance. Below we provide more details regarding Notiware and the user study.

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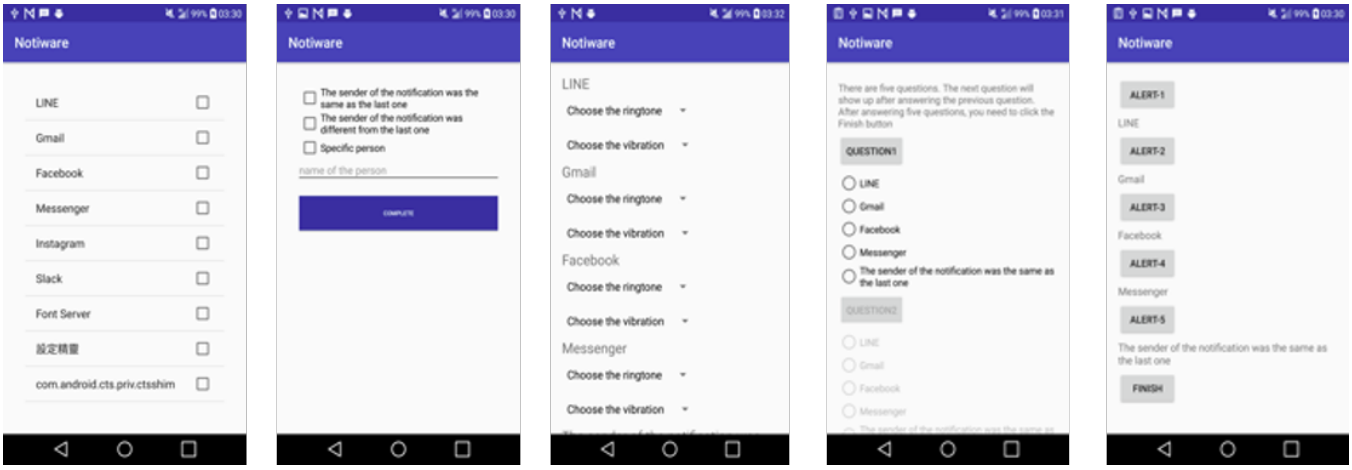

Figure 1: The Notiware interface allows its users to customize five ringtones and vibrations for any app as well as for special events they need help with (columns 1 through 3). To help users become familiar with customized alerts, the system also provides an Exercise Mode (column 4) and a Test Mode (column 5).

2 NOTIWARE

2.1 Training Data Collection

The training dataset was from the ESM study described in [3]. To briefly describe the dataset. In the ESM study, 34 smartphone users reported whether they sensed a specific notification had come (sampled by the ESM research mobile app) and whether they correctly speculated about where it was from for over two weeks. The research app also logged the users' phones' sensor data. The final training dataset contained a total of 1,869 notification responses from 33 users, in which the users reported that they noticed 52.4% of the notifications, and had speculated about the notification sources 71.6% of the time, with an overall accuracy of 89.5%.

2.2 Types of Alert Assistance Provided

Notiware that we developed provided three kinds of assistance: speculating assistance (PA), sensing assistance (SA), and special-event assistance (EA). When Notiware predicted that the user would not correctly tell the source of the notification, it provided PA–playing a customized alert 10 seconds after the original notification alert generated by the app. The sensing assistance, i.e. SA, was an additional alert assistance we designed to help users be aware of the arrival of a notification when Notiware detected that users were even not able to be aware of its arrival. Notiware provided SA, which played a customized alert twice. Although the Notiware provided such prediction and assistance, in this paper we only focused on whether PA improved users' speculation. Finally, EA was another additional alert assistance for users to be aware of "special events": 1) when the notification sender was the same as the sender of the last notification, 2) when the sender was different from the sender of the last notification, and 3) when the sender was someone specified in advance by the user. These events were inspired by [3] that users can easily associate incoming notification with the people they recently interacted with. Our study participants could freely attach a customized alert to any of these special events if they wanted to. Note that EA is independent of model prediction because if a user decides to set an alert for any of these three types of events, alert assistance is desired.

2.3 Alert Customization

Users can assign any of Notiware's five built-in ringtones and vibration patterns to any apps they need help with when alert assistance was to be delivered to help them. To help users quickly familiarize themselves with the available and user-selected alerts, Notiware has an Exercise Mode for practice and a Test Mode to check users' learning progress. The interface for customization and the two modes are shown in Figure 1.

For vibration alerts, Notiware uses combinations of short (200 ms) and long signals (600 ms), as recommended by Schulze *et al.* [14], to form five readily distinguishable vibration patterns. These are 1) long, long, and long, 2) short, short, and short, 3) long, short, and long, 4) short, long, and short, and 5) short, long, and long. The interval between each of the three signals within each alert is 200 ms. Finally, the five ringtones were designed by a digital musician according to published guidelines for earcons [2] and alarms [7].

3 PRELIMINARY STUDY OF NOTIWARE

To assess the effectiveness of alert assistance, we deployed Notiware to assess participants' speculations with and without the assistance of the system. Again, while Notiware also provided alert for helping notification sensing, in this paper, we focused on PA that was aimed to help speculation.

3.1 Study Procedure

The field study was conducted in four phases: training, examination, ESM, and interviews. Participants were required to complete the first two of these stages before starting the ESM study to ensure that they were able to recognize the alerts they had customized. This was to reduce the possibility that they could not tell notifications' sources simply because of their unfamiliarity with the alerts. After

participants passed the examination stage, we helped them install the version of Notiware that would send them ESM questionnaires for the study. Finally, participants were invited to a post-study interview where we gained deeper insight into users' experiences with Notiware.

3.2 ESM Study

We used an ESM study to shed light on the users' experience with Notiware. Two kinds of ESM questionnaires were delivered, depending on whether alert assistance had been given. When such assistance was absent, the ESM questionnaire contained a basic set of 10 multiple-choice questions asking about the user's experience with the notification. On the other hand, when assistance was present, the participants answered the same basic set of questions, along with seven additional questions concerning the reasons for their speculating, their perceptions of the helpfulness of the assistance, and their reasons for such perceptions. Notiware sent out ESM questionnaire prompts between 6 and 10 times per day. Each questionnaire would expire if the user did not respond to it within 30 minutes. A minimum of 60 minutes elapsed between the delivery of any two ESM questionnaires to avoid overwhelming our participants.

We sought to balance the number of occasions in which assistance was provided with the number of occasions they were not provided at predicted moments. We balanced them by providing assistance at predicted moments randomly with a 50% chance.

3.3 Participants

We recruited 30 participants (15 males; 15 females) that 1) used at least two apps with different notification alerts, 2) set their phones to silent mode (disable both the sound and vibration) for less than 8 hours per day, and 3) frequently used at least three different apps. All participants completed the first three phases of the study, and all but four participated in a post-study interview.

4 PRELIMINARY RESULTS

Over the four weeks of the field study, we analyzed a total of 316,684 notifications that were not always staying in the drawer. The top five apps by type, in terms of the numbers of notifications issued, were messaging (63.2%), system (15%), utility (9%), mail (7.6%), and social (3.3%). The proportions of the 316,684 non-dormant notifications that were collected in normal mode, vibrate mode, and silent mode were 28.7%, 64.1%, and 7.2%, respectively. Regarding the 4,604 notifications covered by ESM, participants yielded a response rate of 88.2%. We focused our analysis on the 2,825 of the notifications that participants reported having read after they had attended to the phone, as opposed to having seen directly when they were already using the phone.

In this paper, we examined whether Notiware helped the participants correctly speculate their sources by classifying received responses into four conditions: *i.e.*, 1) noticed: the participant noticed alert assistance; 2) not noticed: the participant did not notice alert assistance; 3) without assistance: no assistance was provided when Notiware predicted it was needed; and 4) no assistance needed: Notiware predicted that the participant would both sense and correctly speculate the notification, and thus did not provide any assistance.

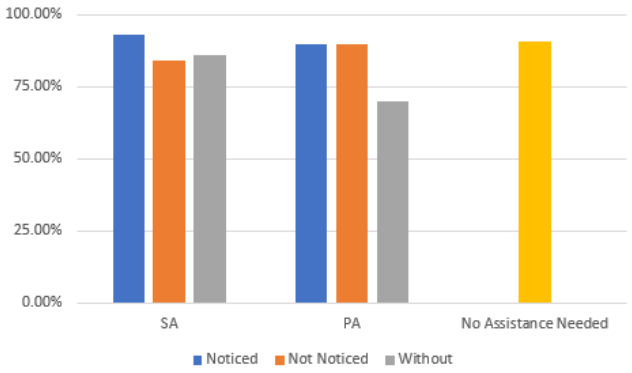

Figure 2: The accuracy of participants speculate notifications' sources at specific situation.

4.1 Notiware Improved Speculation about Apps

Our results indicate that Notiware succeeded in helping participants determine notification sources about which apps they had come from. As shown in Figure 2, when participants needed assistance, they identified the app associated with a notification more often when they noticed a PA (89.8%) than when no PA was provided (69.8%, p=.003). In other words, the addition of PA made the accuracy of speculation 1.28 times as much as without providing the PA. On the other hand, when Notiware deemed a PA unnecessary, the participants achieved an accuracy of 90.6%. This indeed indicated a high awareness of notifications' sources when Notiware assumed that participants were able to tell the notification source on their own. Out of curiosity, we also evaluated whether SA helped with speculation of notifications' sources, but found no statistically significant difference between noticing SA (92.9%), not noticing it (84.2%, p=.28), and not receiving it at all (85.7%, p=.29). This result was not surprising, as SA was supposed to help sensing but not speculation. It was likely that at these moments when SA was delivered, participants indeed did not need assistance for making a speculation.

While participants also had high speculation accuracy regardless of the presence of Notiware's assistance, they consistently gave positive feedback on how such assistance helped their speculation about notification sources. When assistance was provided, participants reported that 59.8% of the time they could identify the source based on the PA, and 39.2% based on the original alert. When the participants identified the source via PA, they rated PA as helpful 96.6% of the time. Some participants mentioned that the assistance was unique enough to help them distinguish the alert whenever it was heard. Others said that the original alerts were too similar to one another; thus, even though they had heard the original alert, they could not tell which app a notification had come from. For example, P6 said, *"Before I used your app, I would be confused about whether alerts were coming from Instagram, Gmail, or Facebook. It was just a little vibration. After I used your app, I just needed to notice the vibration pattern I set for Instagram, which was 'long-short-long'. If there were other patterns I heard, I knew it wasn't from Instagram, but from other apps."*

Some participants mentioned that, although they speculated source apps based on their original alerts, PA allowed them to confirm these speculations. As P14 explained, *"I had already felt the notification, based on the original alert. But your app's alert helped me be more sure about which app had created it."* Interestingly, the participants' sense that a Notiware alert was helpful increased when there were multiple phones nearby, as it provided them with greater certainty about which phone had issued the notification. As P31 said, *"It's easy to tell if a message is from Line. But when you are with other people, you don't know who got the Line message."*

4.2 Notiware Did Not Improve Speculations about Senders

However, we found that PA did not improve the accuracy of the participants' speculations about the senders of the notifications. Instead, the participants seemed to have better speculation of senders without PA than when they noticed PA (PA noticed: 67.2%, PA not noticed: 65.8%, p=.59; without PA: 76.7%, PA: p=.11), though there was no statistical significance. Nevertheless, the participants rated Notiware's assistance as helpful if they noticed PA, and rated PA as helpful 97.8% of the time (somewhat helpful: 38.6%, very helpful: 61.4%). In 85.4% of cases where participants reported noticing EA, they speculated the notification's sender correctly, as compared to 72% of the time when EA was not noticed. However, this difference was not statistically significant (p=.31), presumably due to the study's small sample size. This result shows that while the current model could help users better tell which app generated the notification, it was insufficient to help users tell who (sender) sent the notification.

4.3 Notiware and Notification Non-attendance

Finally, we explored whether raising participants' awareness of notifications led them to read fewer or more beneficial and non-beneficial notifications. For the purposes of this evaluation, we did not distinguish between noticed and not noticed, but only between the with-assistance (i.e., SA+PA) and without-assistance conditions. The reason for this was that, regardless of which type of assistance the participant noticed that made him or her attend to a notification, as long as Notiware generated an alert, the participant should not have been driven to read a greater number of unnecessary notifications due to higher awareness. We did not consider EA in this analysis as there was no *without…* condition for it. The results show that, despite a difference of 7.7%, there was no statistically significant difference in benefit perceptions of the attended-to notification across the with- and without-assistance conditions (with assistance (SA+PA), 78.8%; without assistance, 86.5%, p=.62). This result implies that PA did not prompt the participants to attend to a higher proportion of beneficial notifications. We suspect that this was because content mattered the most in participants' evaluations of the benefit of a notification. That is, although Notiware's alerts helped participants to speculate notifications' sources more accurately, the notification often turned out to be not as important as they had expected. Participants' feedback confirmed that many found notifications unimportant even when they correctly speculate their sources. As P30 commented, *"I was working on PowerPoint at that time but I noticed this notification. I read the notification and found it was just a notification for joining a group, which was useless."*

Within the category of notifications the participants decided not to read, those deemed unnecessary were 1.21 times more likely to go unread when assistance was given than when it was not (see Figure 3). With assistance, 86% of the notifications not attended to were deemed not worth reading and successfully skipped, but only 71% of such notifications were skipped when Notiware did not deliver assistance. This difference was statistically significant (p=.009). However, when assistance was being delivered, the participants skipped only half as many notifications that they subsequently deemed beneficial to read as they skipped when no assistance was given (14% vs. 29%)

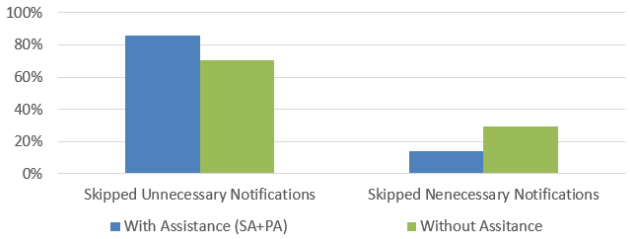

Figure 3: Percentages of unnecessary and necessary notifications that were skipped when Notiware provided assistance and did not provide it.

4.4 Situations in Which Notiware Was Not Helpful

While the participants reported that Notiware did help them identify notification sources, they also mentioned a few situations in which, rather than helping, the alerts provided by our app led to annoyance and disruptions, such as when they were taking breaks or concentrating on work, study, or game-play. As P7 explained, *"I was discussing assignments and the phone was on the table. [...] The app assistance came several times in a row and interrupted the discussion."* Similarly, P6 said, *"I was playing a video game with my friends. [...] I felt the original alert. Then, the longer vibration from the system came. My friend and I were interrupted and we stopped the game."* Sometimes, participants disliked Notiware's alerts when they disturbed others nearby, causing embarrassment. For example, P11 said, *"most of the time I stayed in a public place like the lab. [...] When it vibrated, it also vibrated other people's tables."* A few participants also mentioned that Notiware's alerts were not harmonious: with P30 commenting, *"If my phone was in normal mode, I felt embarrassed when others were around because [Notiware's alerts] did not sound good."* A few expressed desires for ringtones and vibrations of their own. Finally, a few participants felt that the strengthened alerts altered their behavior in ways that were not always welcome. Regarding one specific instance, P34 said, *"If the alert vibrated one time, I could hold on and decide not to look at it. Then your assistance came, which vibrated twice, and I felt it was pushing me to look at it."*

5 DISCUSSION AND FUTURE WORK

To conclude, we evaluated how Notiware's alert assistance helped participants speculate about notifications and attend to notifications. The results indicated that participants were more likely to speculate notifications' sources with the app's assistance than without it. Moreover, Notiware helped the participants skipped irrelevant notifications 1.21 times more often than without the assistance. However, it did not make them attend to a higher proportion of beneficial notifications. To inform future designs, we turn to questions of how Notiware supported the participants' notification attendance and how it could be further improved.

5.1 Notiware and Users' Awareness

Participants told us about the app's special and longer sounds that helped them easier to notice notifications and also distinguish among notifications. We then wondered whether this was due to the uniqueness of the sound or the correctness of its timing. Our data suggest that the answer is both: more distinguishable sounds can undeniably help people sense notifications more easily, but Notiware was also able to detect moments when the participants were less likely to correctly speculate their sources. For example, while a PA could help participants speculate notifications' sources more accurately than they did when no PA was provided, SAs did not improve their speculation to the same extent. This suggests a difference between the moments in which users need assistance for sensing and the moments in which users need assistance on speculation. We found that the model could, at a quantitatively significant proportion, successfully distinguish between these two types of moments.

We learned from the qualitative findings that the key to helping users identify the notification source lays in the ability to distinguish between similar alerts and those that arrive in rapid succession, rather than in the creation of a special sound for each app. This is because, as the number of unique Notiware alerts rises alongside the number of apps in a given user's phone, it becomes progressively more challenging for that user to remember which alert is which. These findings also suggest a promising avenue for future research efforts in raising notification awareness. Such research could identify situations when it is difficult to distinguish among different apps' notifications, and how to better represent the meanings of notifications at low-awareness moments, taking into account human knowledge regarding embarrassment provoked by alerts.

5.2 Next: Considering Opportune Moments and Content

Unfortunately, because our ESM questionnaires were focused on evaluating the effectiveness of its assistance, we did not obtain any quantitative data about disruption. However, from the qualitative data, we did learn that Notiware occasionally disturbed our participants with its special sounds and/or by failing to consider whether the user was suitable to be interrupted (*e.g.,* interruptibility). [1, 6, 9, 10]. We also learned that increased awareness enhanced the effectiveness of attendance only partially. That is, although it helped the participants decide to skip a higher proportion of the notifications they deemed unimportant and preferred not to read (*e.g.*, ads, or messages from a certain person), it did not lead them to attend to a higher proportion of the notifications they deemed beneficial and wanted to hear from (*e.g.*, instant messages). We attribute this to their lack of awareness about the notifications' senders and content. Thus, meaningful evaluation of the helpfulness of attendance, sender, and content information should be rated more highly than app information.

While building technology that rigorously focuses on enhancing awareness of notifications, it is also important to consider both opportune moments and notification content. In several instances, our participants were busy, yet appreciated the assistance provided by Notiware because a notification was urgent in their prevailing context. Thus, we argue that the concept of opportune moments should not be limited to interruptibility, but also include the relation between content and context.

5.3 Content Study Limitations

The current study is subject to a number of limitations and biases. First, its results were derived from a small sample of people in Taiwan, and while we recruited participants with diverse backgrounds, they cannot have been representative of mobile users as a whole. Second, we recruited participants whose phones were in silent mode for less than 8 hours per day. As a group, such users may have behaviors and concerns that differ in various ways from those of the general run of smartphone owners, raising questions about our models' wider applicability.

Future work will need to investigate whether Notiware helped the participants identify the sender of the notification and helped them more effectively attend to the notifications. Furthermore, we recognize that there is considerable scope for making Notiware less disruptive and more helpful. Important steps in that direction will be to analyze notification content as part of predicting moments in which it will be beneficial for users to receive and deal with them.

6 CONCLUSION

Our four-week field study with 30 smartphone users demonstrated that Notiware allowed participants to more correctly speculate their sources, and to ignore notifications that they subsequently deemed irrelevant. Our qualitative findings, meanwhile, revealed the moments in which Notiware helped and did not help users attend to notifications. Despite Notiware's key purpose being to help users selective attendance, it did not allow users to attend to a higher number or proportion of irrelevant and low-priority notifications. Nevertheless, we recognize that there is considerable scope for making Notiware less disruptive and more helpful. Important steps in that direction will be to take greater account of interruptibility and to analyze notification content in order to predict moments in which it will be beneficial for users to receive and deal with them.

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