
Impact of Smartphone Notification Display Choice in a Typing Task

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Figure 1: Experiment Setup. A test participant is negotiating interruptions via the situated display.

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Abstract

External displays have the potential to make smartphone notifications less obtrusive when a user has committed their attention to a primary task. We compare six notification displays, and evaluate the impact that negotiating smartphone interruptions has on a typing task when the number of notifications to ignore and act on are equal. A lab experiment with 30 participants is conducted, and initial results show that desktop pop-ups are preferred significantly more, where they require the fewest actions to read. Managing notifications via the notification bar is least preferred, despite requiring fewer actions to respond. This work is a well-controlled pre-cursor to the application of notification displays in social scenarios. The results motivate the use of external displays to manage attention around smartphone interruptions.

Author Keywords

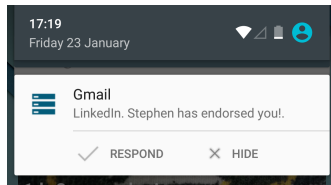
Smartphone, Desktop, Typing, Notifications.

ACM Classification Keywords

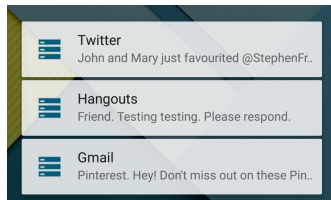
H.5.2 [Information interfaces and presentation]: UI

Introduction

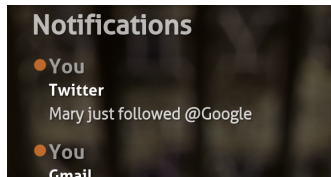
Smartphone notifications provide awareness of important emails and messages. However, without consideration of the user and their context, notifications can be distracting, and frequent interruptions can result in stress. Negotiated interruptions [3] let the user to decide the onset of an interruption, and is an approach to managing notifications that can improve concentration on a primary task.



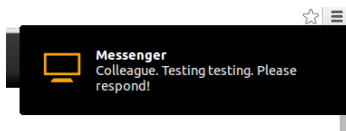
(a) NB (Android 5.0)



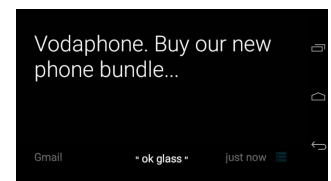
(b) LS (Android 5.0)



(c) SD (Cast Together)



(d) DP (Linconnect)



(e) SE (Google Glass)



Hangouts
Boss. Are you around
after the meeting?
Please respond!

(f) SW (Moto 360)

On an Android smartphone, users negotiate interruptions via the notification bar (*NB*). The NB displays a list of recent notifications in a pull-down menu, and is always one step away when the device is in use. However, when the smartphone is not in use, the NB can require many actions to read the notification. Displaying notifications on the lockscreen (*LS*) can reduce the cost of reading a notification when the device is in hand but not unlocked. Compared to the NB, the cost of responding to the notification from the LS is increased, as the device has still to be unlocked. However, by reading the notification at a glance, prolonged smartphone diversion could be less likely when attention is committed to a typing task, or a co-located social situation.

External displays create new opportunities to deliver notifications to the user. Smartwatches (*SW*) and smart eyewear (*SE*) allow users to read notifications when the device is not in hand, by looking towards the wrist or glancing upwards. Notifications can also be displayed on a monitor as desktop pop-ups (*DP*), or on a situated display in the user environment (*SD*). The choice of an external notification display has the potential to increase focus on a task by making it easier to read notifications, but more difficult to respond. As new ways of reading smartphone notifications become available, it is important to consider the impact that they will have on attention to everyday tasks.

This work contributes a study of six smartphone notification displays, shown in Figure 2, and their impact on attention to a typing task. Though many notifications do not require a response or can be ignored [5, 4], we select an equal number to be ignored and acted on to compare the relative importance of each notification type on subjective opinion.

User Experiment

30 participants took part in a 1.5 hour lab experiment, and were asked to manage notifications while performing six 10

minute typing tasks. A £10 reward was provided for participation. The experiment setup can be seen in Figure 1.

Participants

Participants were aged 18 - 35 (mean=25, st.dev.=5), 10 were female. 26/30 participants studied Computing Science and were recruited from an undergraduate mailing list.

A preliminary questionnaire was provided to understand any source of bias. On a 7-point Likert scale, all participants reported to type on a keyboard regularly (6.63 +/- 0.82), and were more likely to receive smartphone notifications (6.28 +/- 0.91) than to respond (5.25 +/- 1.30). Participants were most likely to position the smartphone beside them (left or right) while typing at a computer (27/30), which is in line with the design of the experiment. Allowing participants to choose the onset of an interruption fits with the design of negotiated interruptions: 16/30 participants would finish a task before checking notifications, and 12/30 participants would allow notifications to interrupt their task. Few participants would wait until a predefined time of day. Participants were asked which display they would choose to read smartphone notifications while typing at a desktop PC. 16/30 participants indicated that they would choose a smartphone display, and 9/30 chose a DP or SD, and only 4/30 chose a wearable.

Typing Task

A custom text editor was implemented as a web page to log key strokes as participants typed phrases during the typing task. Phrases were consistently displayed in a single line at the top of the page to minimise head movements during the typing task. The next phrase appeared when a newline was entered in the editor.

We merged two popular phrase sets for text entry [2, 6] to create a large collection of simple phrases. Phrases were localised for UK English and phrases with names and numbers were removed. The remaining phrases were randomised

Figure 2: Notification displays.

Participant Objective

You are an office worker who is tasked with typing as many phrases as possible before the end of the day. However, you are regularly interrupted by smartphone notifications, some of which are important and will require a timely response (less than 15 seconds).

You will use each of the six display methods and take notes to determine which will help you manage both tasks.

You can assume that a human editor will proof-read the phrases and will fix any small spelling mistakes for you.

and formed six groups of 80 phrases.

Notification Task

Smartphone notifications acted as distractions from the typing task. An app was developed to schedule notifications stored in a text file. At the start of each condition, a log file was created to record the timing of notification events. Messenger notifications were chosen as the response task, where the message requesting a response was prefixed with 'Please respond!'. In reality, smartphone users decide themselves whether a notification requires a response. Though it is possible to provide limited input to a SW or SE, we assume that smartphone users take action on their smartphone, an assumption also made by [1]. Therefore, the response task always required participants to click the 'Respond' button on the NB, as shown in Figure 2 (a).

In an initial test with 2 participants, we found experimentally that 25 seconds was the minimum time required to respond to a notification and resume typing without feeling overloaded. Both test participants found that the NB was the most demanding, as it required accessing the NB even when a notification could be ignored. With an interval of 25 seconds, 23 notification events were issued in a 10 minute typing task. The first 3 notifications of each condition were not considered in the results, and the remaining notifications were interleaved, with 10 ignored and 10 responses.

Six sets of 23 notifications based on real smartphone events were generated for the study, with examples displayed in each notification display in Figure 2.

Equipment

A Nexus 5 smartphone running Android 5.0 was used by all participants. Our notification scheduler app was installed, and notifications from this app were prioritised to ensure that no other notifications would display during the experiment. The default NB and LS were used as notification displays.

A Sony Vaio laptop running Ubuntu 12.04 OS was connected to a 12" monitor, USB keyboard and mouse, which acted as the desktop PC. The typing application was opened on the laptop in the Chrome web browser.

Linconnect,¹ an open source notification server for Android smartphones, was chosen to display DP notifications. As opposed to services like PushBullet which display notifications in the web browser, Linconnect integrates with system notifications, which can be customised with NotifyOSD, including the size, position, timeout and colour. Notifications were customised to appear for 10 seconds in the top-right corner, as in Figure 2 (d). The Linconnect server was installed on the laptop, and the client was installed on the smartphone, and both communicated via a shared Wi-Fi connection.

Our Cast Together application that is designed for social environments was used as the SD. A Google Chromecast connected to a 18" monitor was positioned to the right of the desktop monitor, as shown in Figure 1. Our client was installed on the smartphone to detect the notifications, and communicated with the Chromecast through a shared Wi-Fi connection. A pre-selected collection of photos displayed in the background, and notifications appeared in the top-left side, as displayed as in Figure 2 (c).

A Moto 360 SW and Google Glass SE were used as the wearable conditions, with screenshots displayed in Figure 2 (e) and (f). The Android Wear and My Glass applications were installed on the smartphone to pair with the devices via Bluetooth. Ambient mode was enabled on the SW, which acts as an e-ink display when the screen is dimmed. The head-up trigger for Google Glass was found to be the simplest way to display notifications by rotating the head up-

¹Linconnect client/server. <https://github.com/hauckwill/linconnect-server>

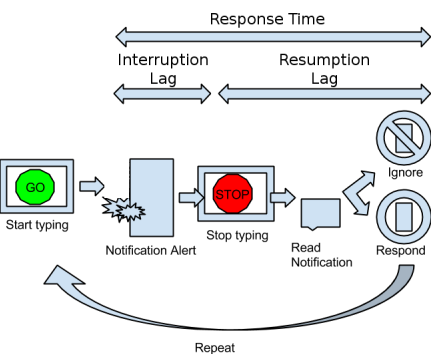


Figure 3: Flow of attending to a notification alert while performing a typing task.

Workshops

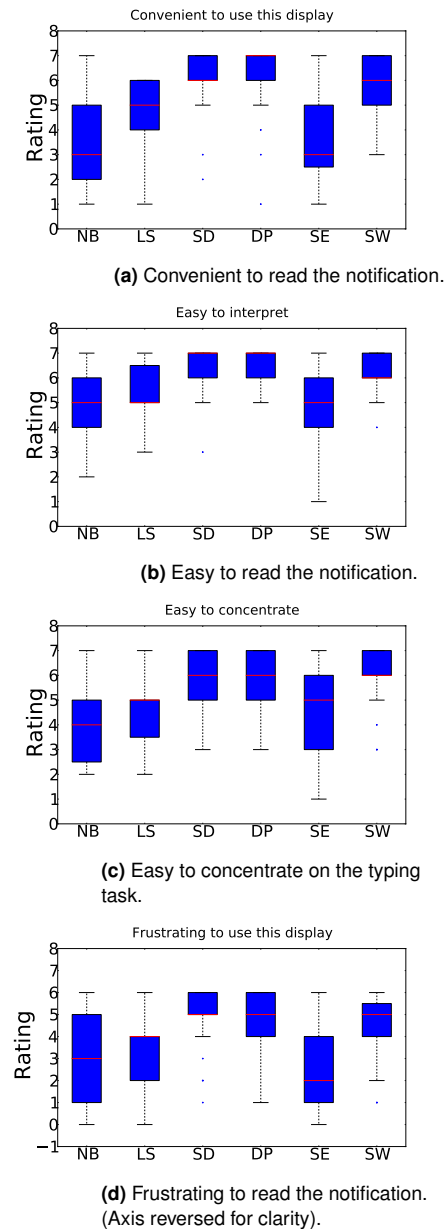


Figure 4: Subjective opinion. SD, DP, and SW are rated significantly higher than the NB, LS and SE. (For all figures, a high rating is best).

wards after an auditory alert arrived on the headset. A head angle of 10° was used as a sensitive trigger, and was tested with each participant before starting the SE condition.

Procedure

At the start of the experiment, a consent form and a preliminary questionnaire was presented. A short training task introduced the participant to the typing task and notification task. Next, the participant was asked to read the objective of the experiment, and clarified which notifications to respond to and which to ignore. The objective informed participants to respond to notifications in under 15s, and to resume typing quickly. A £20 incentive was awarded to the participant who responded accurately and who typed the most phrases.

At the start of each condition, a screenshot and short description introduced the notification display, which was set up by the experimenter. When the participant was ready, the typing task was started on the desktop, and the notification scheduler was started on the smartphone. The smartphone was positioned 15cm to the right of the keyboard.

The steps to a notification event are illustrated in Figure 3.

(1) First, the user starts typing, and (2) a notification arrives on the smartphone, with an audio alert and a vibration. (3) Then the user decides to stop typing, and the notification is read on the appropriate notification display. (4) If required, a response is given from the NB of the smartphone. (5) Finally, the user resumes the typing task.

After 10 minutes, the typing task ended and the user was alerted on the desktop. The file generated by the typing task was downloaded, and the participant was asked to fill out a short questionnaire. After all six conditions were completed, the participant was presented with a questionnaire to rank all notification displays in order of preference.

Measurements

All keystrokes were recorded with a timestamp in the text editor, which was downloaded as a log file at the end of each condition. Notification events were recorded with our notification scheduler app on the Android smartphone, and were stored in a log file at the end of each condition. Timestamps were recorded when the notification was displayed, the Respond button was clicked in the NB, and after screen on and screen off events. After each condition, subjective responses were recorded in a questionnaire, and conditions were ranked in order of preference in a final questionnaire.

Results

We report on the impact of notification display choice on subjective opinion and overall preference. A two-tailed Mann-Whitney U-test was used to test our ordinal data, with $p < 0.05$ and a normal distribution to calculate U for 30 participants, with $z \geq 1.96$.

Subjective Opinion

Subjective ratings are displayed in Figure 4. Participants rated smartphone displays significantly less convenient ($P < 0.001$), less easy to read content ($P < 0.001$) or concentrate ($P < 0.001$), and more frustrating ($P < 0.001$). The most common qualitative points that participants made are presented for each display in the following sections, and a summary of participant quotes is provided in the sidebar.

Notification bar. With the NB, many participants liked being ‘able to respond easily using the display method’ [P6] and ‘it is a common and straightforward method for reading notifications’ [P25], but disliked ‘having to unlock and manually look at every notification even though not all of them you needed to respond to. Also having to do that each time broke my rhythm of typing and made me lose my place a few times’ [P3]. Many participants acknowledged that ‘at the moment for most people this all there is available’ [P1], and ‘this method [is used] in my everyday life and I’m tired of it’ [P20].

Participant Quotes

Notification bar: ‘This method [is used] in my everyday life and I’m tired of it’ [P20].

Lockscreen: ‘It was faster than using the basic notification bar for non-urgent notifications’ [P11].

Situated display: ‘I could glance at the display to check the notification without my hands leaving the keyboard’ [P14].

Desktop pop-up: ‘Everything’s all in the one place. You only need to look away from the screen if the message is urgent’ [P7].

Smart eyewear: ‘Only I could see the notifications. Better privacy than when notifications are displayed on your laptop’ [P15].

Smartwatch: ‘Less distracting than I thought it would be. It was easy to glance at the screen and understand the notification without moving too much’ [P9].

Lockscreen. With the LS, participants ‘liked the fact that I could see the notification without unlocking the phone’ [P10] and ‘it was faster than using the basic notification bar for non-urgent notifications’ [P11], but disliked that ‘I still had to turn on my display to read it, distracting me from whatever I was doing’ [P20] and ‘you still had to take your hands off the keyboard’ [P27]. The LS could be used ‘pretty much anywhere, even though it might be quite obvious you’re checking your phone’ [P22] and ‘when I need a glance overview of notifications (check periodically without unlocking phone)’ [P8]. Several participants reported that ‘I do use this as my default, I suppose. But I don’t exactly like it’ [P9] and would use the LS ‘only where no other option was available’ [P6].

Situated display. Participants ‘liked that [the SD] didn’t interrupt what I was doing so much and felt it was easier to concentrate... It was less urgent to pick up the smartphone as I knew what the notification was about already’ [P13]. Several participants reported that ‘I could glance at the display to check the notification without my hands leaving the keyboard’ [P14]. Participants felt that it was ‘easy to concentrate on writing at the same time’ [P22]. However, participants disliked that ‘the background changed... I sometimes thought that something was trying to get my attention over there when it maybe wasn’t’ [P9] and ‘because the display was very big, it was hard to read the messages and therefore took some time to read it and was easily distracted.’ [P18]. Participants ‘would definitely use it either when I am working at home or at the office since I receive notifications regularly’ [P20].

Desktop pop-up. The DP made it ‘very convenient to look at the notification because it’s literally on the screen I’m already looking at’ [P24] and ‘everything’s all in the one place. You only need to look away from the screen if the message is urgent’ [P7]. Several participants thought that ‘it’s a bit disturbing when you are working, as notifications will frequently

pop up on the same screen’ [P5]. P13 ‘felt that I had to respond more urgently than the prior experiment [SD] as previously it was to the side of me and somehow I could almost prioritise more easily and finish my typing where as when it was on the monitor I felt I had to do it right then’. DP could be used in a ‘daily working situation’ [P5], and some participants ‘use something similar already (Pushbullet)’ [P27].

Smart Eyewear. Participants liked ‘not having to move my hands from the keyboard’ [P11], and ‘only I could see the notifications. Better privacy than when they are displayed on your laptop’ [P15]. Participants did not like ‘the narrow field of view’ [P3], ‘having to move my head up to trigger the display’ [P11] and ‘the notification did not appear immediately on the Glass screen’ [P26]. P24 found the ‘head gesture feel very unnatural and awkward, gesture detection was inconsistent leading me to view the notification on the phone instead’. Participants could imagine using SE while ‘doing a task that involved more complicated use of your hands than typing, like if you were wearing gloves or something that would make it harder to check on your phone’ [P11], ‘when outside walking about, not necessarily when inside using a desktop computer’ [P7] and ‘carrying out a task where I needed to pay attention to it, but where there wasn’t already a screen in front of me (cooking, walking)’ [P9].

Smartwatch. Participants liked that the SW ‘was outside your vision so wasn’t a distraction. The vibration was very short - let you know something was there but left you alone quickly’ [P8]. P1 liked that ‘I tend to look at my hands while typing, so it was easy to glance down to my wrist (easier than other methods)’. The SW was ‘less distracting than I thought it would be. It was easy to glance at the screen and understand the notification without moving too much’ [P9]. Several participants felt ‘it was annoying that you had to lift your hand to read the notification. This meant stopping typing. It was also quite heavy on the wrist, so it was a bit an-

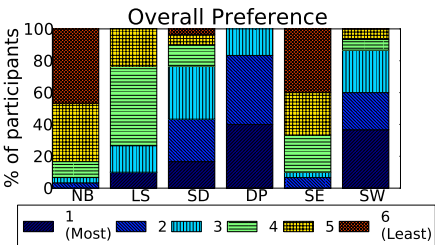


Figure 5: Overall preference.

Desktop Pop-ups (DP) are most preferred, and the notification bar (NB) is least preferred.



Figure 6: Cast Together is a situated display (SD) prototype designed to support multiple smartphone users in an intimate co-located situation, who can negotiate interruptions on a shared display without removing the smartphone from a bag or pocket.

Acknowledgements

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noying to type with' [P14]. Participants could imagine using the SW 'while hanging out with friends I would prefer using a fast method to check my notifications like this, rather than having to take out the phone of my pocket' [P10], 'receiving notifications in public when wanting to be discreet' [P1] and 'if I was out and didn't want to constantly check my phone in my pocket' [P14].

Overall Preference

The ranking of each display is displayed in Figure 5. The DP was preferred most overall (12/30). In final comments, participants shared that 'pop-ups were the best cause it was the quickest way to decide whether the notification was important or not' [P15], 'the desktop pop-up required least effort to read' [P14] and 'really liked the desktop and situated display as it was easy to interpret' [P30]. Many participants (10/30) preferred the SW most. In the final comments, P3 shared that 'the watch was my favourite, with its bright notification screen it was handy for seeing what needed my attention and did not interrupt with the task', and P7 stated 'need to get me a smart watch'. The preference of SW was surprising, as few participants expected to choose a wearable in the preliminary questionnaire. In addition to the concerns over the comfort of wearing a SW while typing, visual appeal was also considered to be important. P15 felt that 'the watch was great as well [but] the notifications were not that well displayed on it though'. The NB was least preferred, despite the majority of participants choosing smartphone displays in the preliminary questionnaire. Interestingly, the NB was not preferred significantly less than SE ($P=0.169$). Participants felt that '[SE] required the most [effort to read]' [P14], and 'apart from the Google Glass device, all notification methods seemed quite easy to read without disrupting my current task very often' [P26]. P9 acknowledged that 'some of the notification displays would have ranked differently had I not been using a computer at the time'. Figure 6 highlights

the application of our SD as a way for multiple smartphone users to negotiate interruptions in a social context.

Discussion

We presented our initial results from a comparison of six smartphone notification displays in a typing task, where notifications required a fast response or could be ignored. External displays were rated significantly higher than smartphone displays overall, despite requiring more actions to respond to a notification. The data collected will allow more detailed analysis of typing performance and resumption lag. This work is a controlled pre-cursor to the application of notification displays in social scenarios. Future work should consider the impact of notification display choice in a social setting with personal devices and notifications.

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