Exploring Micro-usage of Smartphones in the Presence of Smartwatches

Jonathan Chung
jono.chung@mail.utoronto.ca

Daniyal Liaqat
dliaqat@cs.toronto.edu

Sajjad Siddiqui
sajjad.siddiqui@mail.utoronto.ca

Group 13: Wear Distraction

ABSTRACT

A contextual study was conducted where smartphone micro-usage of experienced smartwatch users was tracked for a week. This is followed by tracking the same users' smartphone micro-usage without their smartwatch. The analysis of smartphone micro-usage was split into: glance, review and engage, where glance and review corresponds to micro-usages. Glance refers to interactions without the user unlocking their smartphone and reviews refers to interactions with unlocking.

The study revealed that the median duration of smartphone glance interactions was 30% longer and the frequency of glance interactions was 80% smaller when the users had smartwatches. The median duration and frequency of review interactions were not significantly affected by smartwatches.

The results suggest that overall, smartwatches reduces the glance micro-usage of smartphones substantially. The results may be suggesting that users perform tasks that require a short amount of time directly on their smartwatch instead of their smartphone.

Author Keywords

Mobile; Wearable; Distraction; Micro-usage

INTRODUCTION

Recently mobile computing has been trending towards a new class of computing known as wearable computing. One form of wearable computing that has been gaining traction is the smartwatch. This can be partially attributed to the release of Android Wear [1] and the Apple watch [2]. In 2015, about 40 million smartwatches were sold worldwide and it is estimated that by 2019, 100 million smartwatches will be sold annually [10]. Smartwatches can be being used to track fitness activity and biological signals such as heart rate. However, the most prominent marketing point of these devices is that they can reduce smartphone usage by allowing access to information or initiating interaction directly from the smartwatch [2].

Notification and smartphone usage literature has coined the term "micro-usage" to describe brief bursts of interaction with a smartphone. Micro-usage accounts for about 40% of all smartphone interactions when the device has been unlocked [12]. Micro-usages are mainly task-oriented interactions such as checking the time, calendar or social applications (e.g., Facebook, Whatsapp etc.) [12]. However, with the emergence of smartwatches, micro-usage patterns of smartphones are expected to change. A typical interaction with a smartwatch may be as follows: the user receives an email, they check the email on their watch, notice that it is a spam message, and deletes the email straight from their watch. Alternatively, if the email requires immediate attention, the user could view the email in detail on their smartphone. The smartwatch could reduce micro-usage by reducing the time it takes to perform certain tasks. Alternatively, by being easier and quicker to access, a smartwatch, could increase the frequency at which users access their watch, therefore, increasing micro-usage.

In this paper, the effect of a smartwatch on micro-usage were studied by conducting a contextual study. The study was primarily to confirm the validity of Android wear and apple watches marketing claims based upon measures defined by notification and smartphone usage studies. Specifically, the differences in smartphone micro-usage between users when they used smartwatches and when they did not were compared.

This paper is organized as follows: First, we give an overview of relevant literature and studies. Next, we describe our predictions and hypothesis based on the existing studies. The methodology outlining our study is presented next, followed by our results. This paper is concluded by a discussion of the results, conclusions and future directions of this study.

EXISTING STUDIES

In recent times, a wide range of contextual studies on smart mobile device usage has been conducted. Bohmer [8] conducted a large scale longitudinal study exploring multiple aspects of mobile usage. Bohmer explored the duration of usage, types of application used (e.g., communication, games, news etc), time of application usage and different applications used within a session (i.e., from the time the device is unlocked to it being locked again). The results suggest that, about 50% of the time the first application used within a session are communication applications (e.g., messaging, social networking). In addition, the most probable transition between applications within the same session is towards a communication application. This study triggered a large number of studies exploring the nature of notifications, distraction and micro-usage of mobile devices.

The exploration of notifications, distraction and micro-usage can be categorized into two types of studies: (1) those that examine general behaviors, (2) those that propose novel methods of displaying, addressing and dismissing notifications and (3) specific studies on smartwatches.

General Behavior

Pielot et al. [13] conducted a study to investigate the nature of notifications. The authors estimate that on average, users receive 65 notifications per day and respond to most notifications within minutes. Pielot argued that since the majority of notifications arise from communication applications, social pressures force users to attend to notifications promptly. In addition, Pielot et al. indicated that many users feel that notifications are overwhelming, annoying and stressful.

Ferreira et al. [12] coined the term "micro-usage" and provided a detailed investigation of it. The authors showed that micro-usages are generally less than 15 seconds and mainly due to addressing a notification of new emails. The data shows that the majority of micro-usages are performed when users are home alone. Ferreria's team also provided a framework for obtaining contextual data called the AWARE framework [3].

Banovic et al. [6] investigated short mobile usage sessions. The authors categorized these short interactions as:

- **Glance**: Turning the screen on and then off without otherwise interacting with the device (ex. checking the time)
- **Review**: Performing some short interactions (ex. reading a text message)
- **Engage**: Spending substantial time on their smartphone (ex. writing an email)

This categorization is unique because the "glance" interaction has not previously been studied. Interestingly, Banovic et al. found that almost 46.6% of device usage was for the glance interaction. (The glance and review interactions defined by Banovic fit Ferreiras' [12] definition of micro-usage.)

The results and discussions of studies exploring behavior regarding notifications provide strong examples of experimental design. For example, the studies discussed ran longitudinal studies for 1 week to 3 months while the users' mobile activities are being logged. In addition, these studies can provide sample experimental variables such as: application category, usage category and usage time.

Novel Methods of Notifications

Based on the finding that most interactions are "glance" interactions, Banovic et al. [6] prototyped a novel lock screen called "ProactiveTasks". ProactiveTasks provided options for the users to address notifications rapidly within the lock screen.

Shirazi et al. [14] studied the effects of pushing mobile notifications to desktops. For example, a new email will generate a notification on the smartphone and a notification on the users desktop/laptop. The results suggest that using desktop notification increases the time it takes a user to click a notification.

Studies on novel methods of notifications provides insights on how different technologies can alter mobile usage. The studies conducted compared two groups: one with the proposed novel method and one without. The evaluation metric compares the two groups to conclude on the usability of the system.

Smartwatch studies

Bolle et al. [9] presented different methods to handle notifications on smartwatches. This includes: (1) using on-screen buttons, (2) swiping from the edges of the screen and 3) drawing gestures on the screen. The user study compared the micro-usage of the phone with the three different methods of interaction. The authors reported that the application micro-usage increased by 5% however the general micro-usage decreased by an average of 5%.

Desarnauts [11] conducted a subjective study interviewing users with the Apple smartwatch. The author found that the typical duration of smartwatch interactions is in the order of seconds (in contrast: interactions with a PC is in the order of hours and a smartphone is in the order of minutes). The participants reported that they use their smartwatch 2 to 5 times per hour. In addition, Desarnauts conducted survey about the applications used on a smartwatch.

Brown et al. [7] conduced a study where they used a wearable camera to monitor the smartwatch usage of 12 participants over 34 days. They found that the average smartwatch interaction lasted 6.69 seconds. The most common reason for interacting with the smartwatch was to check the time and the second most common was to respond to a notification.

RESEARCH QUESTION AND HYPOTHESIS

To the best of our knowledge, no contextual or longitudinal studies have been conducted comparing user's smartphone micro-usage with and without a smartwatch.

The research question is as follows: **How does a smartwatch affect smartphone micro-usage?**

The hypothesis are:

1. When micro-usages are separated into the *glance*, *review* and *engage* interactions, *glance* interactions on the smartphone will decrease greatly because *glance* interactions will be mostly directed towards the smartwatch
2. The use of a smartwatch will decrease the proportion of *review* interactions on the smartphone because certain *review* interactions can be directed towards the smartwatch
3. The proportion of *engage* interactions (that is not a part of micro-usage) will remain the same regardless of whether or not the user has a smartwatch because these longer and more intensive interactions are not well suited to the smartwatch

METHODOLOGY

The methodology section is separated into describing the participants, apparatus, experiment design and procedures, and finally the analysis software.

Participants

Seven individuals affiliated with the University of Toronto as either students or alumni volunteered to participate in this study. The participants were tech savvy individuals. Six of the participants are graduate students from the Systems and

Networking lab and one participant is a recent graduate in Economics. All seven participants were experienced Android wear smartwatch and Android based smartphone users with at least 2 months of experience with the devices. The Android based smartphone and smartwatches were also their primary choice of smart devices.

The participants used their smartphones like a typical consumer (e.g., limited special accessibility usages, no external hardware etc.) and they were accustomed to a wide variety of applications including: email, messaging (e.g., SMS, WhatsApp, Telegram, Line etc), utilities (e.g., alarm clock, calendar), games etc.

Apparatus

Android Smartphones and Android Wear Smartwatches were used in the study. The Android smartphones were running Android 4.3 or higher (this is a requirement of the smartwatch). The smartphones used in the study were also required to have Bluetooth functionality to allow a connection between smartwatches and the smartphones. In addition, all the smartphones had a MicroUSB port to transfer data from the device to the experimenters computer. Approximately 400 KB of disk space is required per day of study (roughly 6 MB in total).

The primary source for data collection was using the AWARE [3] logging tool which was installed on all smartphones. AWARE requires a minimum of Android 2.3.3.

Participants used their personal smartphones and the following smartphones were used: four LG Nexus 5 phones, a OnePlus One phone and two Samsung Galaxy S4 phones. In addition, the following smartwatches were used in the study, two Motorola Moto360 watches and five LG G watches.

Experiment Design and Procedures

Data from the participants was collected over the duration of two weeks. During the first week, the participants conducted the experiment with their smartphone and smartwatch as usual. Establishing a baseline usage for each participant with a smartwatch. After the first week, the users' were asked to not use their smartwatches and use only their smartphone. The data from the second week was compared to the baseline during the first week.

Prior to the experiment, the participants were debriefed with:

1. This experiment will be conducted over the course of two weeks. Within the first week, use your smartwatch and smartphone as usual. After one week, there will be a short progress meeting and you will only use your smartwatch until the end of the week.
2. The data that is logged. This includes the screen on/off time, device unlock/lock time, application launched/closed time, notification received time, etc.
3. The data storage method. Data will be stored on the participant's device and copied after the the first week and again after the second week
4. Any privacy concerns that the participant may have. Personally identifiable information will not be taken (i.e., the user's name will not be recorded), the contents of the application usage will not be monitored (e.g., contents of emails or messages will not be logged) and the data mentioned in (1) will be accessible only to the experimenters
5. Should anything out of the ordinary happen the experimenters contact information will be provided
6. Data will be encrypted and securely stored on the experimenter's' computer. The raw data will be destroyed after it has been analyzed and the analyzed results will be retained for the final report of this course, and possibly for a future publication or poster

If the participant agreed with these arrangements, a consent form was signed and the AWARE framework was installed and configured on their smartphone. Finally once again, the participants were instructed to use their mobile devices as usual.

After the first week, the participants visited the experimenter's office and the data on the smartphone was collected. During this time, the participants were instructed not to use the smartwatches for the coming week. After the second week the participant were required to attend another short meeting, data was copied and removed from the participant's' device and the logging application was also removed. The participants were thanked for their time and troubles for participating in the study.

Measures

The AWARE framework was used to log the events of the smartphone. The events were categorized into one of the three interaction (glance, review and engage) based upon: Glance: if the screen was on but the device remained locked. Review: if the screen was on, the device was unlocked, and duration of which the screen was on was less than or equal to two minutes. Engage: if the screen was on, the device was unlocked, and duration of which the screen was on was greater to two minutes.

In addition, the effects of notifications were studied. The following conditions must be met to associate events to the notification:

1. If the screen of the smartphone was turned on within three minutes of receiving a notification, then this is counted as the notification causing the "screen on" event. The window of 3 minutes was chosen because Pielot [13] found that the average response time of a notification is 2 minutes.
2. If an app is launched while a notification from the same app exists.

Finally, the time of which the screen was turned on and the number of applications that were opened between the device's screen on and screen off was recorded.

The main measures were the median duration (difference between the timestamps when the screen was turned on and turned off) and frequency of the events that satisfy certain test conditions. The main measures were calculated for the smartphone usage with and without the smartwatch per participant (note: no data from the smartwatch was tracked). The following test conditions were applied to the measures:

- No test conditioning

- Permute between the interaction types (glance, review, engage)
- Permute between notification presence and interaction type

Analysis Software

The AWARE framework stores data in SQLite [5] databases. A custom script was written, in Python 3.5, to extract data from the databases and create a CSV file per participant. The script imports the required tables and columns from different databases and creates an output object which translates to a row in the CSV file. The script sanitizes the data and discounts any abnormalities present. For example, a "screen on" event that subsequently appeared within five seconds after a "screen off" event is discounted. Also, there are certain notifications that are logged by the AWARE framework that are not visible to users such as "Download Manager" or other system notifications. These notifications have been filtered from the data. The script also categorizes interaction time to Glance, Review, or Engage (described in the measures section). It also keeps track of all the application categories launched during the interaction. After going through all events, a CSV file is saved.

A script to aggregate the CSV files from all participant was written in R [4]. Data exploration including: data filtering, test conditions and plot generation, was also completed by scripts written in R.

If the contextual data exploration analysis revealed differences in smartphone usage when the user had a smartwatch compared to without a smartwatch. A factorial experiment with 2 within subject factors was conducted to determine the effects of smartwatches on the micro-usage. The within-subject factors are: with a smartwatch and without a smartwatch. In addition, Student's T-tests were used to test the percentage difference of smartphone micro-usage with and without a smartwatch.

RESULTS

In this section, an exploration of the data as described in the methods section is conducted. This is followed by statistical analysis to test the differences between the measures with and without a smartwatch.

Data Exploration

In this section, the duration and frequency of usages are studied. Firstly a density plot of the duration of interactions is shown in Figure 1. The figure shows the log of duration because while most durations are fairly short some interactions can last hours (for example, the longest duration in our dataset was 3 hours and 6 minutes long).

Figure 1 shows that, while there are variations between participants, the log mean is close to 2.5 seconds. As there log duration is approximately a Gaussian distribution, the duration must be a long tailed or skewed Gaussian. Taking the mean of the interaction duration as a measure will be an overestimation of the average per participant therefore it is more appropriate to examine the median.

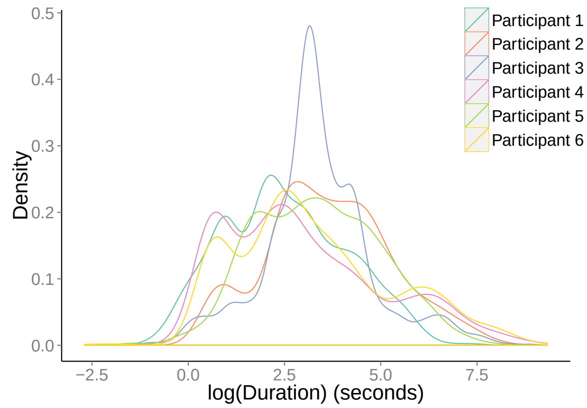

Figure 1. Log of duration in seconds of all interactions

The following analysis investigated the relationship between the number of application opened during an interaction and the frequency at which that happens. Figure 2 shows the plots for this measure with and without a smartwatch.

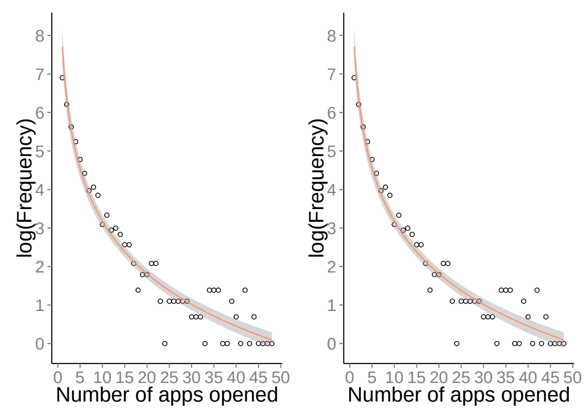

Figure 2. The number of application opened during an interaction versus the frequency at which that happens. With smartwatch is shown on the left and without a smartwatch is shown on the right

The results of Figure 2 suggest that: 1) it is more common for users to open fewer applications and this lies in an exponential delay, 2) this phenomenon does not differ between users with and without smartwatches.

Figure 3 shows that the more applications opened during an interaction, the longer the interaction will be.

Based on Figures 2 and 3, we can say that the duration of an interaction is inversely proportional to the frequency. Intuitively, longer interactions are less frequent than shorter interactions. This can also be seen in Figure 4, where the proportion of interactions that fall under the three categories of interactions, glance, review, and engage were presented.

In order to gain some insight on the differences in the interactions between the participants, all the interactions are aggregated per participant to provide an overarching picture of the data. The median duration and the frequency of the interactions are displayed in Figure 5.

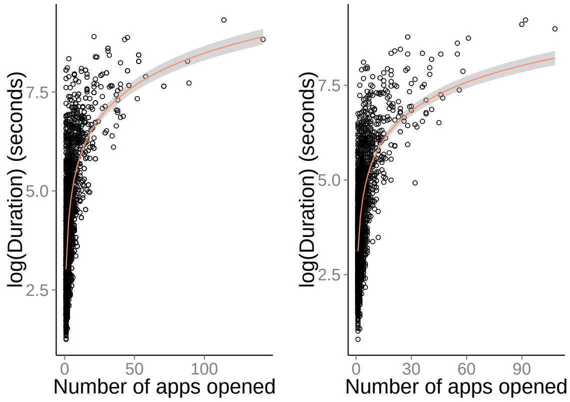

Figure 3. The number of application opened during an interaction versus the duration of the interaction. With smartwatch is shown on the left and without a smartwatch is shown on the right

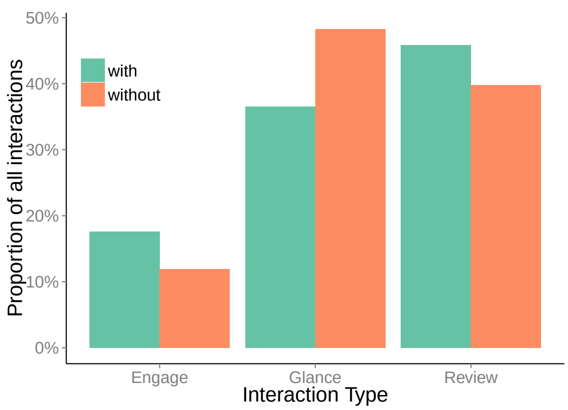

Figure 4. The proportion of interactions that fall into the glance, review and engage category, with and without a smartwatch

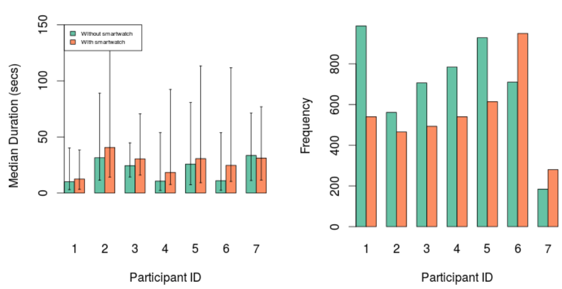

Figure 5. Median duration and frequency of interactions

The results from Figure 5 shows that the median duration of usage varies dramatically between participants. For example, the median duration of participant 1 is less than half compared to participant 2. Although usages between participants vary, Figure 5 shows that the median duration is consistently higher when participants use a smartwatch.

In addition, on the right of Figure 5 the frequency of interactions also vary dramatically between participants. We can observe that the majority of participants had a fewer interactions on the smartphone when a smartwatch is present. Contrary to the median duration, the frequency decreases when a smartwatch was introduced.

To reduce the effects of the individual participant usage, the percentage difference between usage with and without a smartwatch was calculated. The mean and standard error of the percentage difference was calculated for all the participants. Figure 6 presents an overview of the percentage difference between the smartphone usage with and without a smartwatch.

Figure 6 shows that the median duration all interactions was approximately 30% larger with a smartwatch and the frequency was approximately 30% smaller with a smartwatch. In order to gain some further insight into the data, the interactions are separated into the glance, review and engage interaction.

We can observe that the percentage difference in the median duration is substantially shorter compared to the overall usage (with a smartwatch: overall 26.9 secs; glance 6.7 secs, without a smartwatch: overall 21.0 sec; glance 8.2 secs). According to Banovic's study [6], the median duration of the glance interactions is shorter compared to the overall usage (note that the glance duration is not restricted by the interactions duration, it only depends on whether the smartphone was unlocked).

Compared with the glance interaction, the median duration of the review interaction is substantially longer (with a smartwatch: glance 6.7 secs; review 24.6 secs, without a smartwatch: glance 8.2 secs; 27.6 secs). As the review interaction is bounded by a maximum of 2 minutes, we can observe that the duration heavily skewed towards shorter interactions (this is also shown in Figure 3).

The most interesting observation is the change in median duration between having and not having a smartwatch. In the glance interaction, participants had approximately 30% longer median duration and had almost 80% smaller frequency of events when they had a smartwatch. In the review interaction, no substantial differences in the median duration was observed when the participants had a smartwatch. However, the frequency of review interactions decreased by approximately 30%. In addition, the standard error of the engage even frequency between the participants was large. Figure 2 and 3 depicts very scarce data for points with long durations (equivalent to points with very few interactions). As such, the duration and frequency of the engage interaction should be disregarded.

Analysis of the glance, review and engage interaction revealed tendencies in the data. The effects of receiving a notification were explored. Firstly, categories of applications triggering and the notification is explored.

Inline with existing studies, Figure 7 shows that most notifications are triggered by messaging application. Figure 7 divides messaging into SMS messaging (labeled messaging) and online messaging such as WhatsApp and Skype (labeled Social/Messaging). Interestingly, only two participants had health related notifications, however, for these two participants health notifications were a significant source of notifications.

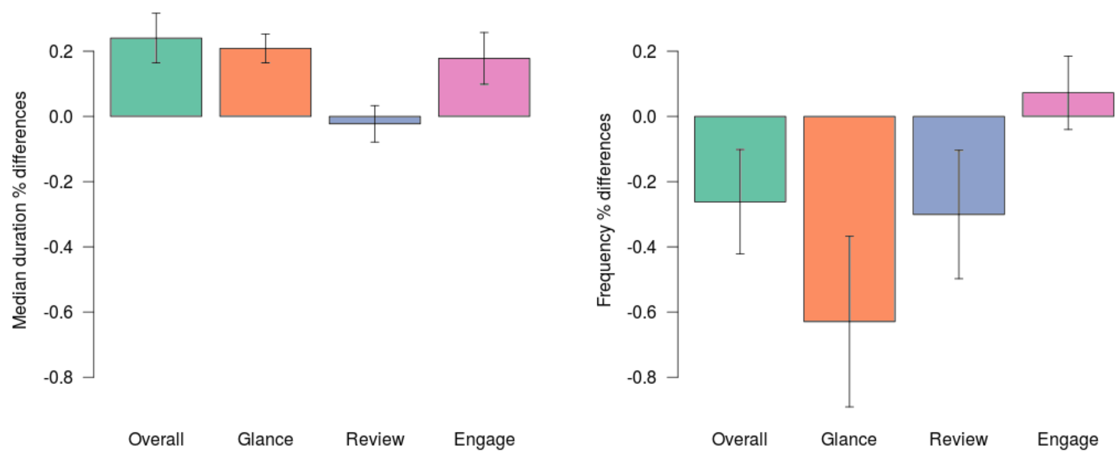

Figure 6. Overview of percentage difference

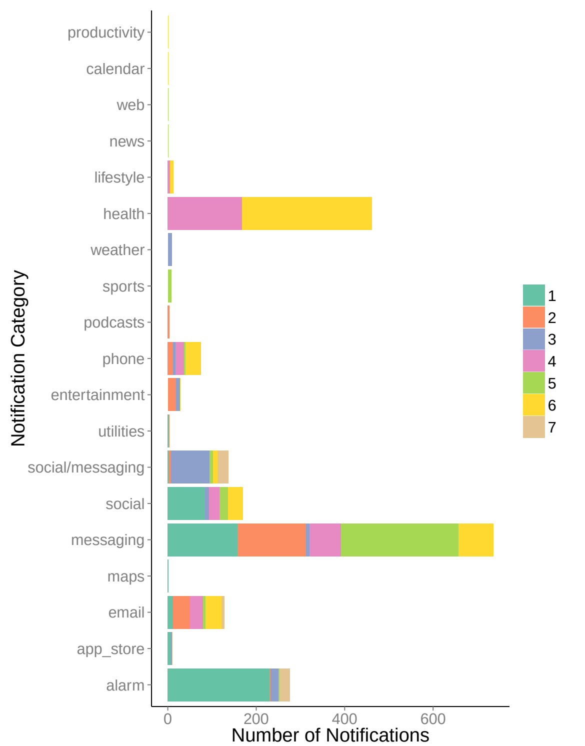

Figure 7. Category of applications that trigger the notification

These notifications were all concentrated to a period of roughly one hour on certain days, suggesting that the participants were working out at that time and the notifications were related to their workout(ex. rest timer, running tracker, etc.).

An analysis of the median duration and frequency was conducted. Only the data for the glance and review interaction events are shown as the previous analysis revealed that the information lies mainly within these interactions.

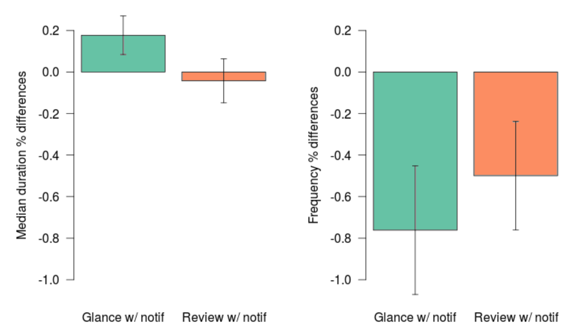

Figure 8. Median duration and frequency of the glance interaction after receiving a notification

Figure 8 shows that the percentage change in median duration of the glance interaction after receiving a notification is smaller compared to the glance interaction without receiving a notification (with notifications: 17.7%; without notifications: 20.8%). This may be suggesting the glance interactions triggered by receiving a notification requires more of the user's attention. The trends of the review interaction with and without a smartwatch remain similar compared to the previous analysis.

As expected, the proportion of glance interactions that are triggered varies depending on the participant and on the type of the alert. We can observe that for participant 1, approximately 50% of their glance interactions are triggered by a notification. On the other hand, almost 75% of the glance interactions are triggered by notifications for participant 3. Suggesting that the majority of glance interactions are triggered by notifications.

Therefore, significant differences were not observed compared to the previous analysis.

Putting the information of the median duration and frequency together, we can conclude the the majority of glance interactions are triggered by notifications. These interactions require more attention from the users as the median duration is longer.

We can observe that the effects of notifications on the review interaction does not differ substantially with and without a smartwatch. In addition, the changes in interaction frequency with and without a smartwatch is approximately equivalent to not receiving a notification. This reflects on the fact that if a notification is important, the user will have to address it over the smartphone regardless of the smartwatch.

Statistical analysis

The median duration and the frequency of the glance, review and engage interactions were studied. In the statistical analysis section, the effects of smartwatch on the measures will be explored.

Using ANOVA with repeated measures, no significant differences were found between the median duration of all smartphone interactions ($f = 0.004$, $p = 0.846$). The same tests were applied to the frequency of all the interactions and no significant differences were observed ($f = 5.014$, $p = 0.055$).

In the data exploration section, more insights were observed when the interactions were split into glance, review and engage interactions. However, large variations between participants were observed and the percentage difference between the usage with and without a smartwatch was used. In this section, the student's T-test was used on the percentage difference.

T-test revealed that the median duration of the glance duration was significantly larger when the users had a smartwatch ($t = 4.15$, $p = 0.00895$). In addition, the frequency of glance interactions was significantly smaller when the users had a smartwatch ($t = -4.01$, $p = 0.01024$). No significant differences were found in the median duration of the review interactions ($t = -0.814$, $p = 0.4524$) and the frequency ($t = -1.650$, $p = 0.160$). However, significant differences were found in the median duration of the engage interactions ($t = 5.460$, $p = 0.00280$). No significant differences were found in the frequency of the engage interactions ($t = 0.163$, $p = 0.877$).

DISCUSSION

This study produced a very interesting data set, with many insights into how participants use their smartphones with respect to their smartwatches.

The results confirmed the first hypothesis, which stated that the frequency of glance interactions would be reduced. The data showed a significant decrease in glance frequency. However, the median duration of glance interactions was increased. While counter-intuitive at first, this can be explained by examining how the smartwatch is used. Lets say a participant with a smartwatch receives a notification and check their watch. At this point, the user can either dismiss or respond to the notification from the watch, or turn on their phone. Intuitively, if the notification is simple to deal with (ex. dismiss a text message), the user will complete the interaction on their watch. This reduces the number of times they have to turn on their phone compared to if they did not have a smartwatch. However, if the notification requires a bit more time but can still be achieved without unlocking the phone (ex. reading a longer text message, mark an email as read) then the user will turn on their phone. This results in an increase in the median duration of glance interactions. Another type of interaction which could reduce the frequency of glance interactions on the phone would be checking the time. One limitation in the data collection was that data could only be collected from the smartphone. Therefore, smartwatch usage can only be inferred through the change in usage when participants did or did not have a smartwatch. Work is underway to enable screen usage and application/notification monitoring on smartwatches on the AWARE framework. This would allow direct measurement of smartwatch usage rather than having to infer it.

The second hypothesis was rejected by the data. The hypothesis predicted a decrease in review interactions on the smartphone. However, the data showed no significant difference between the frequency or duration of review interactions when participants had a smartwatch versus when they didn't. The reasoning behind the hypothesis was that some review interactions could be completed on the smartwatch. While, this is true, it seems that for anything other than the most simple interactions, users opted to use their smartphone.

The data suggests that the opposite of the third hypothesis is true. The median duration of engage interactions was increased when users had a smartwatch. It is difficult to explain this result and it may be due to chance. Engage interactions were more rare than glance or review interactions so it is more difficult to make concrete claims about engage interactions.

Pielot et al. [13] reported that users receive an average of 65 notifications per day and that most notifications are responded to within minutes. Our participants ranged from an average of 17 notifications per day to 246 notifications per day, with a mean of 128 notification per day and a standard deviation of 91. Additionally, most users replied to at least 50% of their notification within a minute. One explanation of this could be that our participants were all younger, graduate students, who likely use their phones than an average person.

CONCLUSION AND FUTURE DIRECTION

A study was conducted with seven participants who were Android smartphone and smartwatch users. Participants' usage of their smartphone was monitored using the AWARE framework over the course of seven days during which they used their smartwatch as they normally would. For the next seven days, participants were told not to use their smartwatch and the usage of their smartphone was again recored. The results suggest that the frequency of glance interactions decreases while the duration of these interactions increases when participants are not using a smartwatch. There is no signification difference in the frequency or duration of review interactions and a increase in the duration of engage interactions, but no change in frequency of engage interactions.

REFERENCES

1. Android Wear. http://www.android.com/wear/
2. Apple Watch - Apple (Canada). http://www.apple.com/ca/watch/
3. AWARE | Android Mobile Context Instrumentation Framework. http://www.awareframework.com/
4. R: The R Project for Statistical Computing. https://www.r-project.org/
5. SQLite Home Page. https://sqlite.org/
6. Nikola Banovic, Christina Brant, Jennifer Mankoff, and Anind Dey. ProactiveTasks: The Short of Mobile Device Use Sessions. In *Proceedings of the 16th International Conference on Human-computer Interaction with Mobile Devices & Services* (2014) *(MobileHCI '14)*. ACM, 243–252. DOI: http://dx.doi.org/10.1145/2628363.2628380
7. Barry Brown, Stefania Pizza, Donny McMillan, and Airi Lampinen. On Time: The Smartwatch in vivo. In *ACM* (2016).
8. Matthias Bohmer, Brent Hecht, Johannes Schoning, Antonio Kruger, and Gernot Bauer. Falling Asleep with Angry Birds, Facebook and Kindle: A Large Scale Study on Mobile Application Usage. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services* (2011) *(MobileHCI '11)*. ACM, 47–56. DOI: http://dx.doi.org/10.1145/2037373.2037383
9. Laurens Bolle, Robin De Croon, and Erik Duval. Optimizing Smartphone Micro-usage with Smartwatch Notifications. In *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct* (2015) *(MobileHCI '15)*. ACM, 947–950. DOI: http://dx.doi.org/10.1145/2786567.2794313
10. Tony Danova, 2015 Jan. 7, 392 5, and 1. Apple Watch Will Control Nearly Half Of The Entire Smartwatch Market By 2017. http://www.businessinsider.com/wearable-computing-market-statistics-2015-1
11. Bernard Desarnauts. Seconds at a time. https://medium.com/wristly-thoughts/seconds-at-a-time-e8762b223476#.bkv5qo19j
12. Denzil Ferreira, Jorge Goncalves, Vassilis Kostakos, Louise Barkhuus, and Anind K. Dey. Contextual Experience Sampling of Mobile Application Micro-usage. In *Proceedings of the 16th International Conference on Human-computer Interaction with Mobile Devices & Services* (2014) *(MobileHCI '14)*. ACM, 91–100. DOI: http://dx.doi.org/10.1145/2628363.2628367
13. Martin Pielot, Karen Church, and Rodrigo de Oliveira. An In-situ Study of Mobile Phone Notifications. In *Proceedings of the 16th International Conference on Human-computer Interaction with Mobile Devices & Services* (2014) *(MobileHCI '14)*. ACM, 233–242. DOI: http://dx.doi.org/10.1145/2628363.2628364
14. Alireza Sahami Shirazi, Niels Henze, Tilman Dingler, Martin Pielot, Dominik Weber, and Albrecht Schmidt. Large-scale Assessment of Mobile Notifications. In *Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems* (2014) *(CHI '14)*. ACM, 3055–3064. DOI: http://dx.doi.org/10.1145/2556288.2557189