Using Haptic Feedback to Combat Social Media Addiction on Mobile Devices

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1 Abstract

Excessive mobile phone use is a pervasive problem that can negatively impact mental health and wellbeing. Traditional push notifications that limit screen time are often purely visual and quickly dismissed, offering little resistance to overuse. In this paper, we present a haptic feedback system that alerts users to screen time limits via physical vibrations, specifically for applications that employ algorithmic content curation and infinite scrolling. Our research involved developing a hardware-based device that produced haptic notifications when the user exceeded a specified time limit on their chosen mobile application. Two experimental studies were conducted to observe the effects of the device.

In the first study, the device simulates the notification frequency of Apple Screen Time and evaluates its effectiveness in reducing app usage among six participants, all of whom already utilize Apple Screen Time to limit their phone use. Results indicate that haptic notifications reduced the daily use of participants' target apps by 12% on average. In the second study, haptic notifications were triggered every minute beyond the overall screen time limit. Results gathered indicated that increasing the frequency of haptic notifications led to even greater reductions in application usage at on average 25%. However, in both studies, participants went beyond their daily app usage limits, and there was an increase in usage of alternative applications after the app limit was reached.

Overall, this study contributes to the growing body of research on digital wellbeing and provides insights into the effectiveness of haptic feedback as a means of promoting healthier mobile phone usage habits. While our results show promise, we conclude that though haptic notifications can help reduce mobile phone usage, addressing the underlying design of applications that facilitate excessive use may be essential in solving the problem in its entirety.

2 Introduction

As mobile phones become an instrument of everyday life and social media becomes more and more pervasive, many find themselves dependent on their devices. Moreover, designers themselves capitalize on these human tendencies, reinforcing addictive design practices such as infinite scroll [1] to display a never ending stream of stimulation. Numerous studies unveil the negative effects that phone and social media addiction impose on physical health, mental health, and overall well-being including depression, anxiety, sleep disorders, and negative self-esteem [2]. This came to a prominent head during the COVID-19 pandemic,

when isolation forced exclusively virtual interactions and exacerbated “doomscrolling”, a term coined to describe the act of compulsively scrolling through negative online feeds despite experiencing extreme negative emotions [3]. In response to this, screen time monitors and miscellaneous “digital wellbeing” applications have grown in popularity as a means for users to limit their technology usage. Typically these applications allow users to set timers such that they are notified once they have reached a specified amount of time on a chosen app. Notifications are generally in the form of purely visual pop-ups, which are quickly dismissed by the user and thus allows behavior to continue uncorrected.

As an alternative to push notification based methods, we will introduce a system that utilizes haptic feedback to indicate screen time limits. Haptic feedback, the use of touch to communicate, has been a well-established paradigm in HCI. Many studies explore the use of haptics in voluntary physical motion in order to guide or correct movement, such as in playing a musical instrument [4] or in human motion coordination [5]. However, few studies address how haptics can be used to motivate implicit behavioral change. These few studies often feature external wearable devices that vibrate in response to certain actions, such as the FatBelt, a belt that vibrates in response to overconsumption to motivate weight loss [6].

Currently, haptic feedback in mobile devices is simply used to emphasize notifications; we see little use cases in which haptic feedback is used to convey meaningful information. Thus, we seek to explore how we can centralize behavioral response and feedback on the mobile phone itself. Numerous studies show the efficacy of vibrations in capturing human attention. For example, studies have shown that of auditory, visual, and tactile phone notification modalities, vibrations are easiest to perceive for users [7], and reaction time to tactile stimuli is 34% shorter than visual stimuli [8]. Thus, we hypothesize that non-dismissable phone vibrations will serve as a more consistent and disruptive cognitive cue to close an app than a purely visual cue, thereby interrupting the addictive ease of infinite scroll.

2.1 **Existing Software**

In recent years, developers have created a variety of apps aimed at helping individuals limit their screen time usage. However, while exploring these monitoring apps, we observed that many of them were intended to improve productivity or allow parents to monitor their children’s screen time rather than focus on well-being. For instance, the team behind MINISTOP 2.0 designed an app for parents to document their children’s diet, physical activity, and mobile device usage [9]. While MINISTOP 2.0 prioritized improving children’s physical health, it did not make explicit efforts to emphasize the importance of social well-being. Another app that focuses on parental monitoring, called Shiny, helps users manage their daily activities in hopes of bettering their physical and mental health as well as their academic performance [10]. Although both apps addressed screen time, they simply provided diagnostics for device usage and did little to actively affect user behavior.

We then continued our search for software that was created for a wider demographic, rather than just children. This led us to find Usage Tracker, which more closely studies the relationship between social media use and mental health [11]. It provides data visualizations to help users understand their habits, which can also be shared with health providers. Thus, the developers of Usage Tracker argue that it can potentially be used to diagnose mental disorders based on people’s interactions with their social media apps. Still, the app simply monitors usage patterns to generate visual feedback. Based on our exploration of existing software,

we seek to address the gap in information surrounding the efficacy of incorporating haptic feedback in screen time monitoring apps.

2.2 Apple Screen Time

Given the pervasiveness of mobile phone addiction, many digital wellbeing tools have emerged in recent years. One of the most popular is the Apple Screen Time feature which is built into all Apple devices. This feature measures users' "screen time" throughout the day, keeping track of time spent on their device as a whole as well as time spent on specific applications.

In addition to simply tracking screen time, users may also set personalized daily time limits for any app or website on their phone. Once their time limit is reached, their interface will be overtaken by a popup warning (Figure 1). Users may choose to close the app or ignore the warning and continue to use the app. If the warning is ignored, it will reappear every 15 minutes beyond the app timer limit.

Because of the wide availability of Apple Screen Time, we will be utilizing the feature to collect data surrounding our study participants' mobile device usage to inform our statistical analysis.

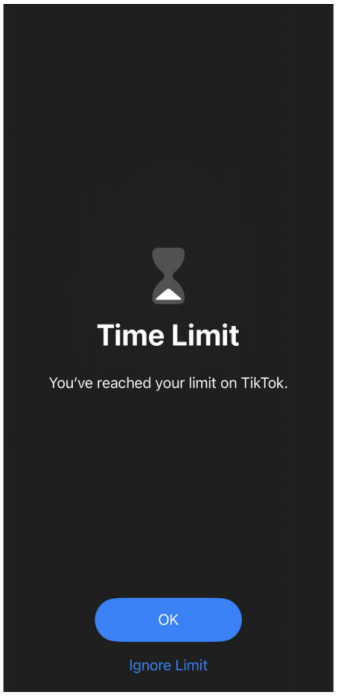

Figure 1: Apple's Screen Time notification that alerts users once they have reached their chosen app time limit.

3 Methods

3.1 Participant Recruitment and Screening

We received n=14 responses to our initial survey, all of whom already utilized Apple Screen Time to limit their app usage. All respondents were in their early-20s, and gender was evenly represented with a balanced distribution of male and female participants.

The majority of respondents expressed overall dissatisfaction with Apple Screen Time. Participants were asked to rate the efficacy of the setting on a scale of 1 to 5, with 1 indicating ineffectiveness and 5 indicating high effectiveness. Seven participants rated the setting as ineffective, giving it a score of 1 or 2, while five participants rated it as neutral, giving it a score of 3. Moreover, 10 of our participant responses indicated that they often continued to use their apps beyond Screen Time's warnings, finding it too simple to exit. Participants also remarked that "It's too easy to override," "I usually just ignore them," and "I don't find them to be efficacious".

In the initial survey, participants also indicated their current Apple Screen Time settings and general usage patterns, which we used to inform the vibration settings for our haptic device and further screen our participants. The majority of our participants indicated that they have an existing time limit on TikTok or YouTube. Thus, in our experiment, we proceeded to test only these two mobile applications due to their use of infinite scrolling and algorithmically supplied content which make it particularly easy for users to spend more time than anticipated on the application.

EXPERIMENT 1: MIMICKING APPLE SCREEN TIME

Of our initial 14 respondents, we invited n=6 participants to continue on with our first study. These 6 participants were chosen from further screening of their app usage patterns, such that they exhibit a tendency to “binge” use these applications and have difficulty following their app limit warnings. For the sake of our study, we define a “binge” to occur when users surpass the designated time limit on their app during a single session.

EXPERIMENT 2: INCREASED NOTIFICATION FREQUENCY

After completing Experiment 1, we invited n=2 new participants from our initial pool of n=14 survey respondents to continue on with our second study. Once again, these participants reported a tendency to “binge” use their target app and reach their app time limit in a single sitting. These participants were not informed in any capacity about the procedure or results of Experiment 1 so as to not introduce bias.

3.2 Prototype

For both experiments, our prototype consisted of an arduino compatible microcontroller, haptic motor driver, coin vibration motor, and lipo battery in order to create a haptic motor control device. The device was programmed to vibrate at the participant’s specified time limit in accordance with the participant’s Apple screen time limit and the methodology of the experiment—either every 15 minutes or every minute. The device is mounted to the back of the participant’s phone through an adjustable 3D printed enclosure as shown in Figure 2. The participant will be responsible for manually turning the microcontroller switch on and off each time they open and close the app.

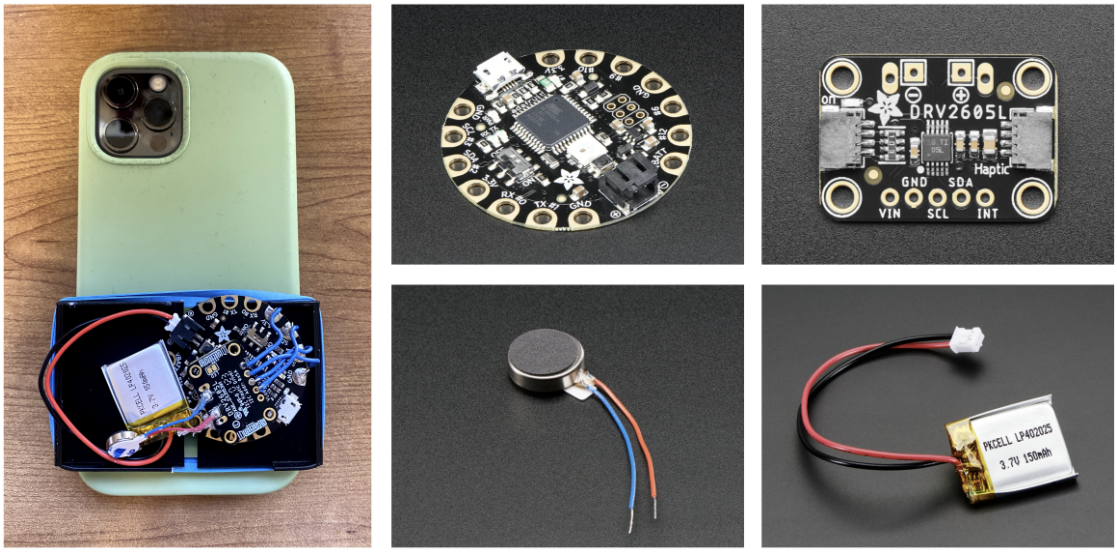

Figure 2: Prototype components - 3D printed casing on iPhone (left), arduino compatible microcontroller (top left), haptic motor driver (top right), mini coin motor (bottom left), and lipo battery (bottom right).

3.3 Experimentation

EXPERIMENT 1: MIMICKING APPLE SCREEN TIME

Baseline screen time data was gathered from each participant, as measured by Apple's Screen Time feature. Participants shared both their overall daily screen time and their app specific (either TikTok or YouTube) screen time via Google Form submission the day before beginning the experiment. While using the device, each participant disabled their target application's existing Screen Time app limit such that the effects of the haptic device may be isolated.

Each participant downloaded an iOS automation to run on their device using Apple's Shortcut application such that when their target app is launched, they are reminded via push notification to turn on the prototype. Similarly, upon closing the target app, participants are prompted once again via push notification to switch off the prototype. In addition to this, the automation also records each time the participant launches and closes the target app in order to gather the specific length of time an app is used for.

Each participant had the prototype for a single day. The prototype was programmed to reflect each participant's existing app limit for the target application. Once the participant reaches their app limit on the target application, the prototype emits haptic feedback, vibrating for 10 seconds. Beyond this, the prototype vibrates for ten seconds once again for every 15 minutes of additional usage. This behavior mimics that of Apple Screen Time's app limits which presents a notification upon the completion of an app limit and again with every 15 minutes of additional usage.

Upon completion of the experiment, participants once again submitted their screen time data for the day in addition to the app specific screen time for their target application via Google Form. Screenshots of the Apple Screen Time interface were required in the form to minimize response bias.

EXPERIMENT 2: INCREASED NOTIFICATION FREQUENCY

Experiment 2 follows the same preliminary set up as Experiment 1; the same baseline screen time data was gathered from each participant via Apple's Screen Time feature, an Apple Shortcut automation collected specific app session data, and participants used the prototype for a single day. Moreover, the prototype was programmed to reflect each participant's existing app limit for the target application and vibrated for 10 seconds once the participant reached their app limit.

With this experiment, we introduced variation in the recurring notifications beyond the initial app limit. Unlike Experiment 1 and Apple Screen Time, the prototype will vibrate for ten seconds every minute of additional usage.

Participants submitted their screen time data for the day in addition to the app specific screen time for their target application via Google Form as in Experiment 1.

4 Results

EXPERIMENT 1: MIMICKING APPLE SCREEN TIME

Given that the prototype is programmed to send app limit notifications at the same frequency as the participants' existing Screen Time notifications, participants' baseline screen time data is utilized as the

control. This allows for the comparison of app usage before and during the prototype implementation such that the impact of haptic feedback on target app usage may be measured.

In order to account for day-to-day differences in mobile phone usage, both the duration of target app usage and the ratio of target app usage to total screen time is compared to baseline participant behavior. Throughout the experiment, five out of the six participants exhibited a decrease in the ratio of target app usage to total screen time, with an average reduction of 12.657%. Across all six participants, an average reduction of 9.624% was demonstrated (Figure 3). The ratio of target app screen usage to total screen time exhibited a standard error of 0.0326.

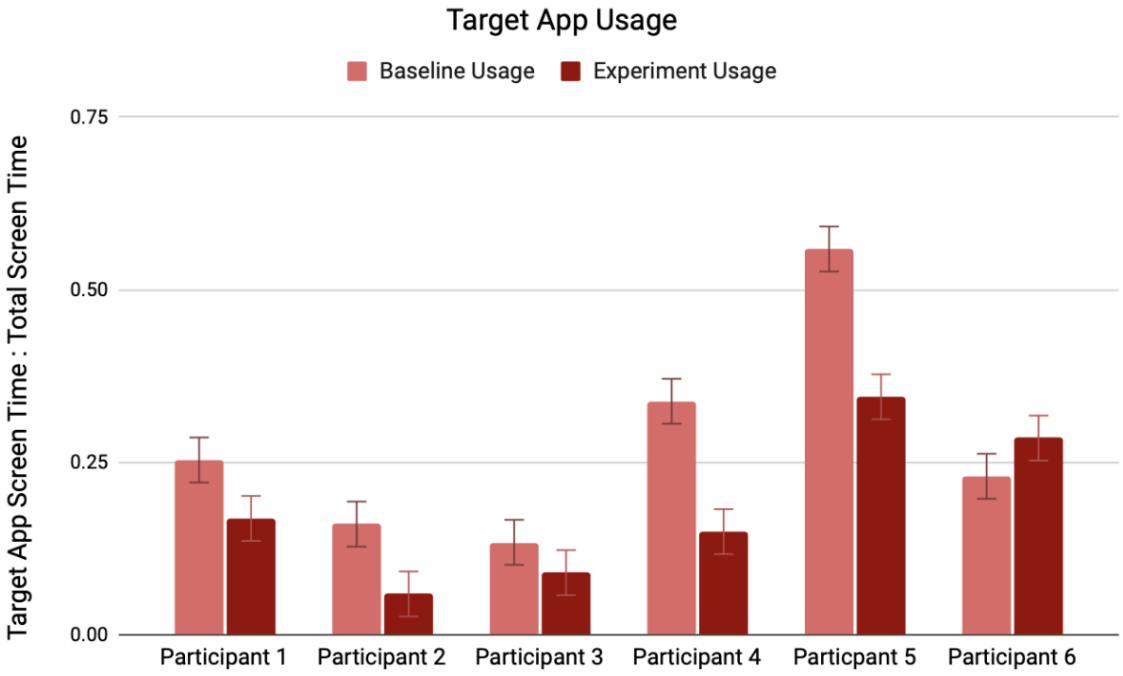

Figure 3: Five out of the six participants showcased a reduction in the ratio of target app usage to total screen time.

Before the start of the experiment, the baseline screen time data for all six participants indicated that their most used application was the target application. Throughout the experiment however, four out of the six participants showcased a switch in the application with the longest usage. For two out of these four participants, their most used application during the experiment were other apps that—similar to their target applications—rely on algorithmically supplied content, namely YouTube and Netflix. Conversely, the other two participants switched to Messages as their most frequently used app throughout the experiment.

Apple's Screen Time setting and the haptic prototype both emit notifications once a user reaches their app limit and subsequently after every fifteen minutes of additional usage. In addition to measuring participants' total screen time and target application usage, the number of times participants were notified in these 15

minute intervals was also measured. Four out of the six participants received fewer app limit notifications when using the haptic prototype than they did when receiving Screen Time's push notifications (Figure 3). This indicates that during the experiment, four out of six participants better adhered to the app time limit and less frequently ignored or dismissed their target app limit. On the other hand, the remaining two participants experienced no change. Of those participants who ignored app limit notifications less frequently, the average decrease in notification frequency was 2.5, while an overall reduction of 1.667 was observed across all participants (SE = 0.7103) .

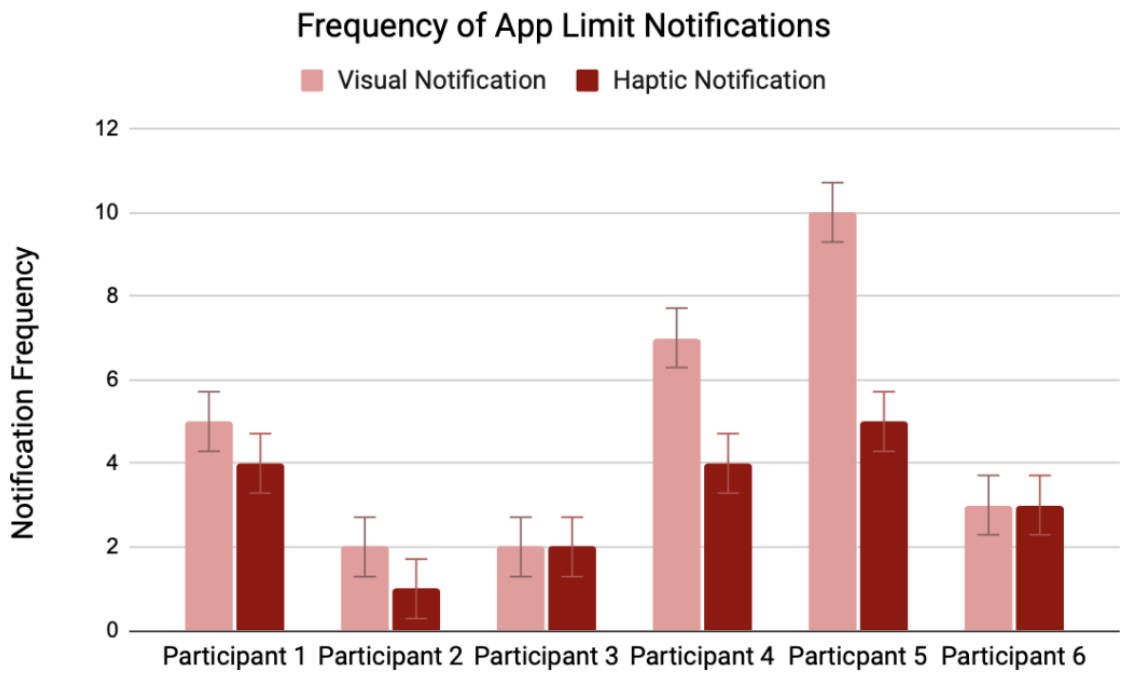

Figure 4: Four out of the six participants less frequently ignore app limit notifications when receiving haptic notifications in comparison to push notifications.

While a majority of study participants experienced reductions in the ratio of target app usage to total screen time and frequency of app limit notifications, all six participants used their targeted application beyond their set limit, as observed in both baseline and experimental data.

EXPERIMENT 2: INCREASED NOTIFICATION FREQUENCY

Beyond the initial prototype which mimics the notification frequency of Apple's Screen Time setting, further data was gathered for the prototype version which emits haptic notifications for every one minute of additional use beyond one's app limit.

While reductions in both the ratio of target app usage to total screen time and the frequency of app limit notifications were observed with the first version of the prototype, even greater reductions were demonstrated with the introduction of the prototype's second version (Figure 5). When emitting haptic notifications for every minute of usage beyond the set app timer as opposed to every fifteen minutes, two out of two participants experience a decrease in target app usage by an average of 25.868% (SE = 0.068). As observed in both baseline and initial experimental usage however, both participants similarly continued to use their target app beyond their set limit.

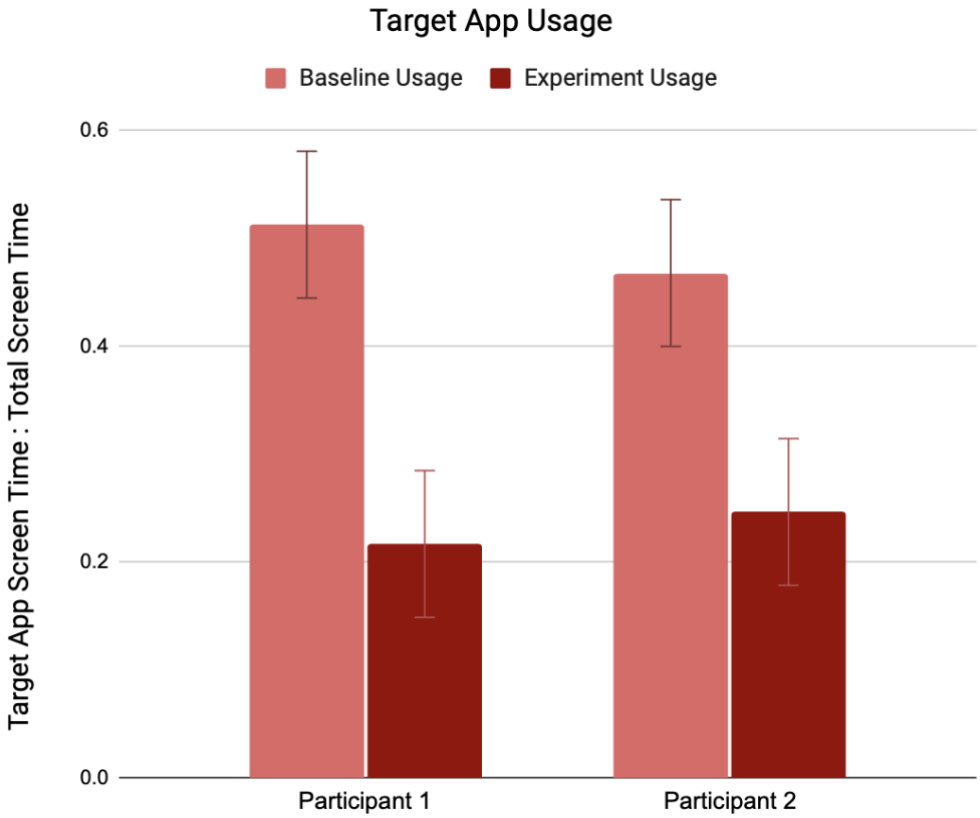

Figure 5: The ratio of target app usage to total screen time reduces by an average of 25.868% across participants when receiving haptic notifications for every minute of target app use beyond the set limit.

5 Discussion

Overall, this study observed a reduction in the ratio of participants' target app usage to total screen time in addition to a reduction in the frequency of app limit notification dismissals by participants. Despite this, participants continued to use the targeted app beyond its set time limit, both before and during the experiment. This raises the question: is it realistic to expect users to entirely stop using an app once they reach a certain time limit? Is the only way to ensure this happens by locking the app entirely? As opposed to expecting app limits to function as strict guidelines, it may be useful to instead look towards app limits as *nudges* that facilitate digital wellbeing.

During exit interviews, one participant noted that "I'm not necessarily strict on myself when it comes to screen time. I use app limits, but I don't always feel the need to listen to them. I don't think that this makes them useless though… Sometimes I don't even realize how long I've been on an app for, but the screen time notifications, whether I listen to them or not, help keep me in check by reminding me that time is passing by".

While the second version of the haptic prototype demonstrated drastic decreases in target app usage, one participant receiving notifications every minute expressed that “The vibration notifications were honestly just too distracting and annoying for me to continue using the app. I probably would have continued scrolling if my phone wasn’t vibrating so much… It just felt kind of dumb for me to stay on the app while my phone was more or less vibrating constantly”. Rather than relying on bothersome design tactics to push users in a certain direction, designers should instead prioritize developing holistic solutions that address the underlying causes of mobile phone addiction.

On one hand, designers can easily explore the idea of increasing the frequency or richness of notifications, such that users are more inclined to decrease their screen time. Using design to *annoy* users into making certain decisions however may not be appreciated or appropriate in all cases. While the incessant beeping of a car’s seatbelt warning ensures that drivers are safe, this kind of relentless approach may seem overbearing in the context of screen time.

Also noteworthy is the observation that two out of the six participants decreased their use of the target app while also increasing their use of alternative applications that are similarly designed to facilitate overuse. It may be the case that participants turned towards these alternative platforms—namely YouTube and Netflix—to compensate for the lack of content consumed through their target application. On the other hand, two other participants showcased increases in time spent on the Messages app. Not fueled by infinite scrolling or algorithmically curated content, it is unclear whether these participants just so happened to increase their Messages usage during the experiment or if they found themselves using the app to fill some sort of void that was created by the decrease in target app usage. While current experimentation suggests that haptic notifications may be effective in decreasing one’s screen time, it is possible that this sort of approach is merely a band aid solution to excessive mobile phone use.

6 Study Limitations & Future Work

Though we would have preferred to implement a software based mobile application, due to security and permission barriers imposed by Apple, we were unable to secure access to their APIs within the short timeframe of the course. Thus, we had to pivot to a hardware-based implementation that required manual input to turn on and off and added significant bulk to the participant’s mobile phone. This set-up process and difference in natural phone grip may have introduced some inaccuracies in our data collection, since with these confounding variables generating friction to start the application, participants may have been more aware of their phone usage and modified their behavior as a result. It is entirely possible to localize this functionality on the mobile phone itself, and developing a mobile application would not only make the system more accurate, cost-effective, and accessible, but also reduce participant error by eliminating the need to manually switch the haptic device on and off. In addition, it would streamline the data collection and analysis process.

With more time, we would aim to extend the duration of our studies to better understand the formation of habits among our participants as well as increase the sample sizes of the studies. By observing participant behavior for a longer period of time, we could gain a deeper understanding of how habits are formed after participants have had time to become accustomed to the device and the vibrations it produces. Literature suggests that habits typically take several weeks or months to form [12], and we believe that this extended study duration would provide valuable insights into the effectiveness and long-term impact of our device on behavior change and habit formation. Moreover, testing our device with additional participants or for a longer

period of time would lead to more accurate data and provide more statistical significance to our analysis, particularly in regard to our study extension of only n=2 participants.

Based on our findings that observed a general decrease in app usage with vibrational notifications, future studies could build upon our findings to discern how to best integrate haptic stimuli in app notifications. Additional areas to examine could involve determining the optimal time interval to send haptic notifications or determining the efficacy of different vibrational patterns in enforcing screen time limits. This could have significant implications for promoting healthier device usage habits, as well as provide valuable insights for developers looking to integrate haptic feedback into their mobile applications.

In our experimentation, we focused solely on physical haptic stimuli in order to isolate its effect and draw comparisons with Apple Screen Time. By doing so, we were able to gain a deeper understanding of the specific impact of haptic stimuli on behavior change in screen time management. However, future studies may also investigate the use of visual notifications in combination with haptic notifications for screen time limit warnings. Literature suggests that human observers can detect combinations of multisensory signals faster than each of the corresponding signals presented separately [13], indicating that the use of both visual and haptic notifications may lead to heightened perception and potentially more effective behavioral change.

7 Conclusion

Preliminary experimentation suggests that haptic feedback may be an effective method in discouraging excessive mobile phone usage. Because haptic notifications engage a sense beyond sight and are less easily dismissible than push notifications, they may be more successful in capturing users' attention. Using a haptic prototype that replicated the frequency of Apple's Screen Time app limit notifications, five out of six participants demonstrated a decrease in the ratio of target app usage to total screen time, with an average reduction of 12.657%. When increasing the frequency of haptic notifications after the completion of one's app limit, even greater reductions were observed in the ratio of target app usage to total screen time. With these reductions however, also emerged an increase in usage of alternative applications fueled by algorithmically supplied content for two out of six participants.

Because of their design and employment of infinite scroll and algorithmically curated content, applications like TikTok and YouTube easily lend themselves towards overuse. These design tropes alter behavior, allowing for users to easily spend much more time than anticipated scrolling and consuming content. And while haptic notifications may be an effective nudge towards digital wellbeing, they do not currently show promise towards entirely preventing excessive app usage. Attempting to combat behavior-altering design with opposing behavior-altering design though may not be fruitful in terms of solving the problem in its entirety. While haptic notifications and other digital wellbeing tools can help reduce mobile phone usage, it may instead be essential to address the underlying designs themselves that facilitate excessive use.

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