A Notification Based Nudge for Handling Excessive Smartphone Use

Partha Sarker[1*], Dipto Dey[1*], and Marium-E-Jannat[2]

[1] Shahjalal University of Science and Technology, Sylhet, Bangladesh
dipdey093@gmail.com, parthasarker3@gmail.com
[2] University of British Columbia, Vancouver, Canada
jannat.16.11@gmail.com

Abstract. Excessive use of smartphones is a worldwide known issue. In this study, we proposed a notification-based intervention approach to reduce smartphone overuse without making the user feel any annoyance or irritation. We did a user study (n = 109) where we found that 19.3% of the participants are unwilling to use any smartphone usage limiting application because a) they do not want their smartphone activities to get restricted or b) those applications are annoying. Following that, we devised a hypothesis to minimize smartphone usage among undergraduates. Finally, we designed a prototype for android named "App Usage Monitor" and conducted a 3-week long experiment through which we found proof of concept for our hypothesis. In our prototype, we combined techniques such as nudge and visualization to increase self-awareness among the user by leveraging notification.

Keywords: Smartphone Addiction · Excessive Smartphone Use · Smartphone Usage Behavior.

1 Introduction

With the advancement of smartphone technology, people's engagement with it is increasing proportionally. In almost every aspect of one's life, smartphones are being used, such as for exchanging opinions, communicating with friends and relatives, and getting news and updates about any sector. Thus, smartphone overuse is rarely generated by the phone or tablet itself, rather our ability to instantly connect to the games, applications, and online worlds using it.

Although smartphone applications have compelling ways of improving our lives along with preventing and treating conditions like diabetes [1] and alcoholism [5], but if used excessively, it can lead to physical and mental health problems, including vision disorders, signs of joint pain, neck pain [15], sleep problems, and addiction to smartphones [14,16]. Individuals' time spent on social media networks may have psychological consequences. Many therapists have noticed indications of anxiety and despair in those who use social media networks

* Equal Contribution

excessively [25]. Furthermore, excessive use of smartphones has negative consequences on our social interactions, such as reducing the quality of conversation [18,22], lowering the attention span and making companions uncomfortable.

Researchers have been designing various usage controlling applications to tackle this overuse issue. These applications mainly utilize strategies such as blocking, nudge, visualization, and cognitive burden. Despite the applications being effective, the user experience is often unpleasant. In a study, participants reported that restriction on smartphone use causes frustration and irritation due to potential inconveniences [9]. Okeke et al.[19] nudged the user by using repetitive vibration to reduce their smartphone use. Although they successfully reduced digital consumption, the majority (26/31) of the participants found the vibrations to be irritating during their experiment.

In this paper, we hypothesized that people are unaware of their smartphone usage, which leads to smartphone overuse. Based on the hypothesis, we created an android prototype named "App Usage Monitor" where we introduced a very subtle and user-friendly intervention approach. The prototype makes use of notifications to deliver necessary information about the application's respective usage. Notifications are delivered based on the specified target for individual applications (Fig. 1). If a notification is selected, a detailed usage graph is shown (Fig. 2), which helps the user increase self-awareness as self-reflection has been proved to be very successful in mitigating technology overuse. People can acquire insights into their time management by visualizing application usage history [20]. To better understand the design requirements for our prototype, we first performed an online preliminary survey with 109 undergraduate participants (68.8% male, 31.2% female). Then, with 16 undergraduate volunteers (81.25% male, 18.75% female), we conducted a 3-week-long field research. The result from the experiment showed that notification has the potential to be a powerful weapon against excessive smartphone use. The combined result of our preliminary survey and experiment also revealed the lack of self-awareness among undergraduate students.

2 Background and Related Works

According to the techniques used by the researchers, we divided the existing works into the following categories-

2.1 Blocking

Such works depend on limiting user interaction with the device by restricting certain or all apps and activities. In AppDetox [17], users can create rules for individual applications and restrict their access according to the rule. Let's Focus [7] follows a location-based approach where interaction with the smartphone is blocked within a classroom. Lock n'Lol [12] and NUGU [13] restricts a group of people from using their smartphones to increase concentration and self-regulation within the group.

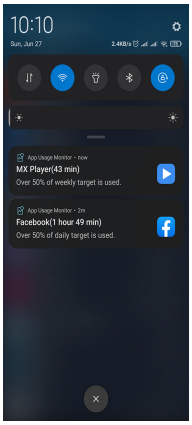

Fig. 1: Usage Notifications

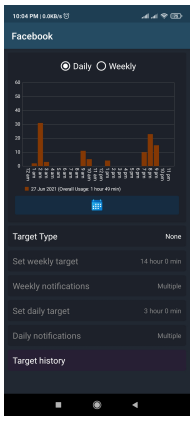

Fig. 2: App Details Activity

2.2 Burden

In recent years, burdening has gained popularity among researchers. The goal here is to discourage unnecessary smartphone use by making the user give extra effort to do certain activities on their smartphone. Interaction Restraint [21] and LocknType [10] make the user type a long number before launching certain applications on their smartphone. Time Off [3] shows animation on the top of the screen with notifications and vibrations during smartphone overuse. Kim. et al. [8] uses a lockout system that only unlocks when the reason for smartphone use is stated.

2.3 Nudge

A Nudge is an easy and cheap way to avoid intervention that can change people's behavior predictably without restricting their choices. Good Vibrations [19] uses repetitive vibration as a nudge to alert the user during smartphone overuse. MyTime [6] is another application that displays a popup on the screen when the user-defined usage limit is crossed. Aditya et al. [23] designed a desktop browser extension that nudges the user to control social media addiction.

2.4 Visualization

Using visualization to make the user more self-aware has been proved to be very successful during past studies. TILT [4] is an android application that uses a graph to deliver overall smartphone usage and the number of unlocks to the user. LockDoll [2] is an Arduino-based doll that waves its hands to alert the connected group of people about their smartphone use. TimeAware [11] and meTime [24] are desktop applications designed to display how a user spends their time across different applications to increase awareness.

In this study, we combined both nudge and visualization techniques to create an effective intervention. We designed a working prototype where notification is used to deliver real-time usage information about individual applications present on the smartphone. The prototype also has a detailed usage graph for individual applications with past information to make it easier for the user to self-reflect and minimize their smartphone activities.

3 Preliminary Study

We performed a preliminary study to better understand smartphone usage behavior and mindfulness among undergraduate students. The survey was made using Google Form. There were three types of questions on the survey. At first, we asked the participants about the understanding of their smartphone use. After that, we inquired about limiting smartphone usage, and the last part of the survey contained questions about their smartphone usage pattern and behavior, which will later be cross-checked with the actual usage data collected via "App Usage Monitor" to realize the users' insight about their smartphone use. In the end, we were able to gather 109 undergraduate participants who freely completed our survey (68.8% male, 31.2% female), ages ranging from 20 to 26.

After investigating the survey response we found that the majority of the participants (69.7%) felt that they overuse their smartphones. But among them, when asked how they limit(or try to limit) their smartphone usage, 38.5% said they did not even try to limit their smartphone usage. And for the rest, staying away from the phone is the most popular way to limit smartphone use unless we consider the responses of participants who didn't even try to limit it.

Among all of the participants, only 20.2% of the participants ever used any usage-limiting app. The primary issue that kept them from using any usage limiting app is that they do not want their smartphone usage to get restricted. Upon asking the participants who stopped using usage limiting applications about their reason, they replied that those apps were bothersome and not practical.

In the usage behavioral section, 62.4% answered that they spend most of their time on smartphones doing social activities while 47.7% said they use Facebook the most. 42.2% of the participants think that they spend more time on their smartphones in the Evening (Table 1).

Even though most participants did not use or know about any usage limiting app, a fair number of participants gave their negative thoughts about restrictive measures and thought them to be irritating. Although restrictive interventions have proven to be quite successful in mitigating excessive smartphone usage, the purpose is lost if nobody uses them. To overcome these limitations, we have come to the following design objectives for an optimal intervention method:

- Should not interrupt the current workflow on the smartphone
- Should not be annoying or burdening
- Should be subtle yet effective
- Should work with little user interaction

4 App Usage Monitor Design

We developed a prototype named "App Usage Monitor" targeting android platform while Firebase realtime database was used to store usage data of our participants.

After opening the prototype, a list of all the applications present on the smartphone along with the usage time and last access time is shown (Fig. 3). Upon selecting an app from the application "App Details" activity is launched. In this activity (Fig. 2), a detailed view of usage and all the target and notification configuration is shown to the user. This prototype is normally fully customizable, but for the sake of the experiment, we automatically set all the parameters to automate the experiment.

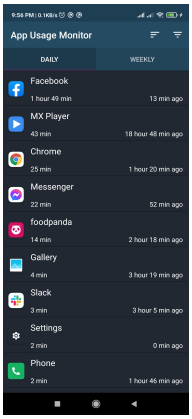

Fig. 3: Main Activity

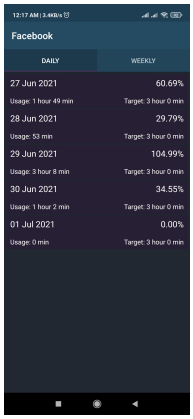

Fig. 4: Target History

By clicking on the "Target History" button at the bottom of the "App Details" activity, the user can see a list of all the previous targets and usage for that application (Fig. 4).

5 Field Experiment

5.1 Experiment Design

We designed a 3-week long experiment where the first week functioned as the baseline week, during which no intervention was used. We provided usage notifications in the second week which we called the intervention week and tracked how smartphone usage patterns changed relative to the baseline week. The third week's goal was to examine changes in smartphone usage behavior when usage notifications were no longer sent.

When the prototype is first installed in the target device, the 0^{th} week starts. The reason for starting with the 0^{th} week is to wait for the next Sunday to

come which marks the first or baseline week. During the whole experimentation period, we disabled manual target and notification settings. All the target and notification settings change automatically based on the usage and the phase of the experiment they were in. In the 1st or baseline week, the targets were set to none, so the participants never received any notification in the baseline week.

During the intervention week, daily and weekly targets for individual applications were automatically set. The daily target was calculated by simply taking the average of that particular application's total daily usage in the baseline week and the weekly target was 7 times the daily target. There was a lower limit of 1 hour and an upper limit of 4 hours for the target so that users wouldn't get too many or too few notifications. All the notification options were also checked so that the user starts getting notifications from 50% usage of the target.

And in the final week, all the targets and notifications were turned off to observe the participants' usual usage behavior after the intervention period.

5.2 Demographic

Based on the criteria we discussed in the earlier section, we were able to gather 33 (26 males, 7 females) volunteers who were willing to participate in the experiment at the beginning. However, not all of them completed the whole experiment for unforeseen reasons. In the end, 16 participants (13 males, 3 females) remained who completely cleared the experiment. All the participants were undergraduate students from various universities in Bangladesh, and their average age range was 20 to 26 years.

5.3 Data Collection

We hosted our prototype in Google Play Store, then shared it among our participants. Because of some inconsistencies in the android's alarm manager API, some participants' baseline week, intervention week, and review week lasted longer than 1 week. So, before performing the analysis, we had to do some post-processing to make our data-set ideal for evaluation. We took the last 7 days of usage data from the baseline week and the first 7 days of usage data from the intervention and review week and filtered out the rest.

6 Result Analysis and Discussion

By analyzing the usage log of participants over 3 experiment weeks and comparing them with the survey response, we found strong evidence in favor of our hypothesis and some interesting usage patterns among undergraduate students. We divided our findings into three following parts.

6.1 Usage Notification Reduces Smartphone Use

Our results indicate that the time participants spent on the smartphone were considerably decreased by providing app usage information via notification. 75%

of our participants' usage decreased in the intervention week compared to that of the baseline week. As we can see from Fig. 5, in the baseline week, the average weekly usage per participant was 41 hours 26 minutes and 47 seconds. However, after receiving notifications on the intervention week, participants' average usage went down to 38 hours 57 minutes and 22 seconds leading to an overall usage reduction of 6.01%. Nevertheless, when the usage notification stopped showing in the review week, the average weekly usage went up to 42 hours 26 minutes and 51 seconds (8.23% increase compared to intervention week) which is almost equal to the average usage time of the baseline week that further assists our hypothesis. Fig. 5 shows the overall smartphone use across three experiment weeks.

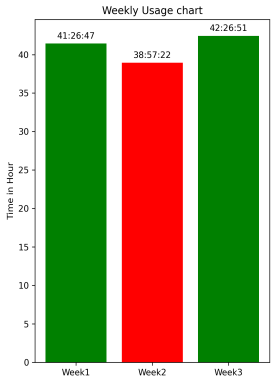

Fig. 5: Usage Bar Graph of Three Experiment Week

6.2 Low Self-Awareness

By comparing the survey response with the actual usage log collected from the participants who completed the 3-week long study, we found a clear lack of self-awareness among the undergraduate smartphone users. For the comparison to be fair, we only sampled the usage data from the baseline week since there was no intervention, and the main purpose of the baseline week was to be the point of reference for the other experimentation weeks. After analyzing the survey response and the usage log, we found that among all the participants, 62.5% had higher average daily usage than their estimated average daily usage on the survey. Half (50%) of the participants were wrong about the application they used the most on their smartphones. 56.25% of the participants' estimation about the parts of the day (Table 1) they use their smartphone the most from the survey did not match their actual usage history, thus implies that the undergraduate

students not only lack self-awareness about their smartphone usage but also lack a good understanding about their overall smartphone usage behavior.

Table 1: Parts of the Day

Neme	Time Range
Morning	6am-12pm
Afternoon	12pm-6pm
Evening	6pm-12am
Late at Night	12am-6am

6.3 Smartphone Usage Behavior

We found a wide range of application usage among our participants in our study. However, among all of these apps, social media apps were the most popular among undergraduates. Fig. 6 depicts the participants' most frequently used programs based on their average daily usage. Facebook was the most popular app, with about 1 hour 24 minutes and 26 seconds of average daily usage time. The most launched application among our participants was also Facebook (Fig. 7). In our study, we discovered that undergraduate students use their smartphones the most at "Evening" and the least at "Morning". Fig. 8 illustrates the frequency of smartphone use according to parts of the day (Table 1).

7 Design Recommendation

The existing intervention designs' major flaw is that they are very aggressive. Many smartphone use mitigation technologies restrict access to applications and specific activities to minimize smartphone usage. To discourage the user from using smartphones, several tools utilize cognitive load to add extra burden when using the smartphone. This type of intervention might work in a controlled experiment environment where participants are required to use the mitigation tool for the whole experiment duration and give off promising results.

Some methods aren't forceful, but they're so quiet that the user doesn't even notice their presence. Users should directly interact with these applications in these circumstances in order to reap the benefits. Google's "Digital Wellbeing" project is an excellent example of this type of effort.

So, before designing smartphone usage mitigation systems, the researcher must find the sweet spot between restrictiveness and being quiet, and go on from there. In this age of ease, rather than seeking to reduce smartphone overuse by making smartphone usage unpleasant, we should look at how we can make smartphone use more comfortable while yet limiting excessive smartphone use.

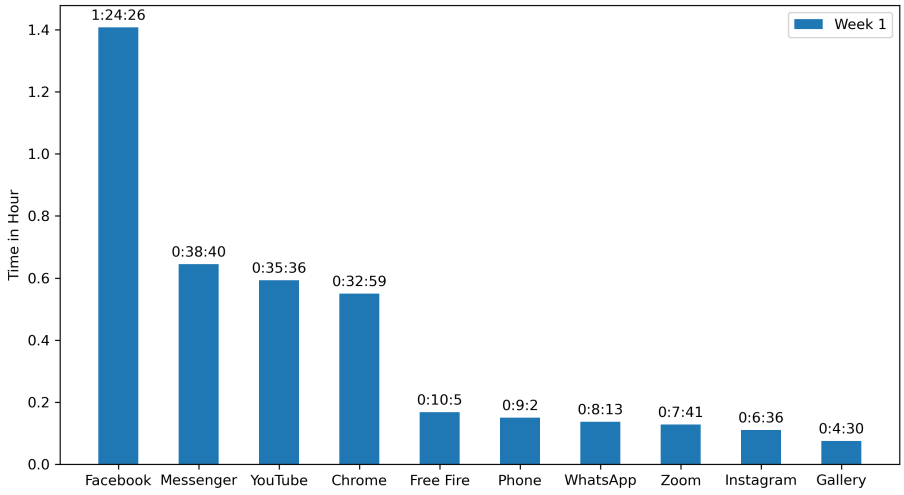

Fig. 6: Top 10 Used Applications in First Week (Average Daily Use Time Based)

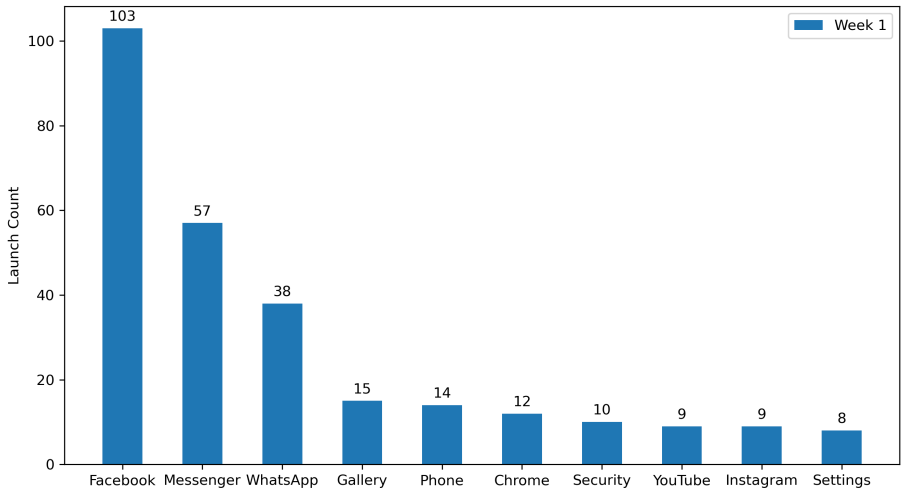

Fig. 7: Top 10 Used Applications in First Week (Average Daily Launch Count Based)

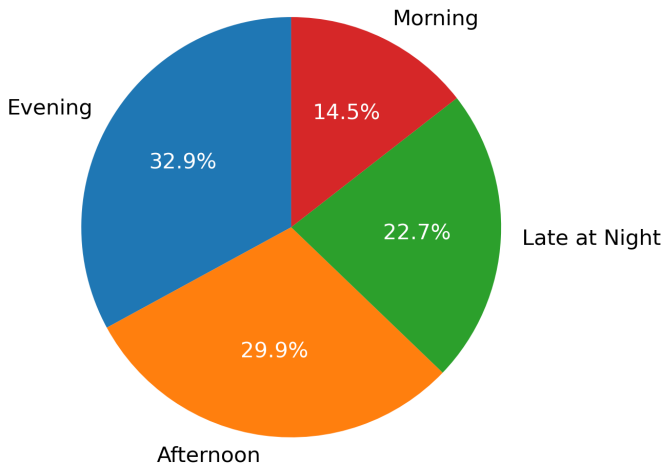

Fig. 8: Smartphone Using Frequency According to Parts of the Day

8 Conclusion

In this article, we conducted comprehensive research on how we can alleviate the worldwide issue of excessive smartphone usage among undergraduate students. Initially, we investigated the consequences of excessive smartphone use. After that, we reviewed several previous works and conducted a user analysis. We surveyed 109 undergraduate students to better understand their smartphone use habits. Then, based on the literature review and user study, we hypothesized the lack of self-awareness among the undergraduate students and proposed a notification-based smartphone mitigation prototype "App Usage Monitor" to minimize excessive smartphone usage among undergraduate students. To prove our hypothesis and understand smartphone usage behavior, we conducted a 3-week long experiment with 16 volunteers.

The result revealed that most of the participants' opinion about their own smartphone usage was wrong which verifies our hypothesis. The result of the experiment also showed a significant decrease in smartphone usage among the participants when the intervention was applied compared to their usual usage. So we can say that making the user more self-aware reduces excessive smartphone use.

Finally, we think subtle and familiar interventions can be used to create powerful tools for mitigating various technology overuse. We hope to see more works that try to achieve smartphone usage mitigation via unforced techniques.

References

1. Årsand, E., Muzny, M., Bradway, M., Muzik, J., Hartvigsen, G.: Performance of the first combined smartwatch and smartphone diabetes diary application study. Journal of diabetes science and technology **9**(3), 556–563 (2015). https://doi.org/10.1177/1932296814567708, http://dx.doi.org/10.1177/1932296814567708
2. Choi, S., Jeong, H., Ko, M., Lee, U.: Lockdoll: providing ambient feedback of smartphone usage within social interaction. In: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. pp. 1165–1172 (2016). https://doi.org/10.1145/2851581.2892445
3. Chow, K.K.: Time off: designing lively representations as imaginative triggers for healthy smartphone use. In: International Conference on Persuasive Technology. pp. 135–146. Springer (2018). https://doi.org/10.1007/978-3-319-78978-1_11
4. Foulonneau, A., Calvary, G., Villain, E.: Stop procrastinating: Tilt, time is life time, a persuasive application. In: Proceedings of the 28th Australian conference on computer-human interaction. pp. 508–516 (2016). https://doi.org/10.1145/3010915.3010947
5. Gustafson, D., Mctavish, F., Chih, M.Y., Atwood, A., Johnson, R., Boyle, M., Levy, M., Driscoll, H., Chisholm, S., Dillenburg, L., Isham, A., Shah, D.: A smartphone application to support recovery from alcoholism: a randomized clinical trial. JAMA psychiatry **71**(5), 566–572 (2014). https://doi.org/10.1001/jamapsychiatry.2013.4642, http://dx.doi.org/10.1001/jamapsychiatry.2013.4642
6. Hiniker, A., Hong, S., Kohno, T., Kientz, J.A.: Mytime: Designing and evaluating an intervention for smartphone non-use. In: Proceedings of the 2016 CHI conference on human factors in computing systems. pp. 4746–4757 (2016). https://doi.org/10.1145/2858036.2858403
7. Kim, I., Jung, G., Jung, H., Ko, M., Lee, U.: Let's focus: location-based intervention tool to mitigate phone use in college classrooms. In: Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers. pp. 101–104 (2017). https://doi.org/10.1145/3123024.3123165
8. Kim, I., Lee, U., Cha, N.: Exploring context-aware proactive blocking for distraction management. In: Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers. pp. 1202–1207 (2018). https://doi.org/10.1145/3267305.3274108
9. Kim, J., Jung, H., Ko, M., Lee, U.: Goalkeeper: Exploring interaction lockout mechanisms for regulating smartphone use. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies **3**(1), 1–29 (2019). https://doi.org/10.1145/3314403
10. Kim, J., Park, J., Lee, H., Ko, M., Lee, U.: Lockntype: Lockout task intervention for discouraging smartphone app use. In: Proceedings of the 2019 CHI conference on human factors in computing systems. pp. 1–12 (2019). https://doi.org/10.1145/3290605.3300927
11. Kim, Y.H., Jeon, J.H., Choe, E.K., Lee, B., Kim, K., Seo, J.: Timeaware: Leveraging framing effects to enhance personal productivity. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. pp. 272–283 (2016). https://doi.org/10.1145/2858036.2858428
12. Ko, M., Choi, S., Yatani, K., Lee, U.: Lock n'lol: group-based limiting assistance app to mitigate smartphone distractions in group activities. In: Proceedings of

the 2016 CHI Conference on Human Factors in Computing Systems. pp. 998–1010 (2016). https://doi.org/10.1145/2858036.2858568
13. Ko, M., Yang, S., Lee, J., Heizmann, C., Jeong, J., Lee, U., Shin, D., Yatani, K., Song, J., Chung, K.M.: Nugu: A group-based intervention app for improving self-regulation of limiting smartphone use. In: Proceedings of the 18th ACM conference on computer supported cooperative work & social computing. pp. 1235–1245 (2015). https://doi.org/10.1145/2675133.2675244
14. Lee, H., Ahn, H., Choi, S., Choi, W.: The sams: Smartphone addiction management system and verification. Journal of medical systems **38**(1), 1–10 (2014). https://doi.org/10.1007/s10916-013-0001-1
15. Lee, S., Kang, H., Shin, G.: Head flexion angle while using a smartphone. Ergonomics **58**(2), 220–226 (2015). https://doi.org/10.1080/00140139.2014.967311, http://dx.doi.org/10.1080/00140139.2014.967311
16. Lin, Y.H., Chang, L.R., Lee, Y.H., Tseng, H.W., Kuo, T.B., Chen, S.H.: Development and validation of the smartphone addiction inventory (spai). PloS one **9**(6), e98312 (2014). https://doi.org/10.1371/journal.pone.0098312, http://dx.doi.org/10.1371/journal.pone.0098312
17. Löchtefeld, M., Böhmer, M., Ganev, L.: Appdetox: helping users with mobile app addiction. In: Proceedings of the 12th international conference on mobile and ubiquitous multimedia. pp. 1–2 (2013). https://doi.org/10.1145/2541831.2541870
18. Misra, S., Cheng, L., Genevie, J., Yuan, M.: The iphone effect: The quality of in-person social interactions in the presence of mobile devices. Environment and Behavior **48** (07 2014). https://doi.org/10.1177/0013916514539755
19. Okeke, F., Sobolev, M., Dell, N., Estrin, D.: Good vibrations: can a digital nudge reduce digital overload? In: Proceedings of the 20th international conference on human-computer interaction with mobile devices and services. pp. 1–12 (2018). https://doi.org/10.1145/3229434.3229463
20. Pammer, V., Bratic, M., Feyertag, S., Faltin, N.: The Value of Self-tracking and the Added Value of Coaching in the Case of Improving Time Management, pp. 467–472 (01 2015). https://doi.org/10.1007/978-3-319-24258-3_41
21. Park, J., Sim, J.Y., Kim, J., Yi, M.Y., Lee, U.: Interaction restraint: Enforcing adaptive cognitive tasks to restrain problematic user interaction. In: Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems. pp. 1–6 (2018). https://doi.org/10.1145/3170427.3188613
22. Przybylski, A.K., Weinstein, N.: Can you connect with me now? how the presence of mobile communication technology influences face-to-face conversation quality. Journal of Social and Personal Relationships **30**(3), 237–246 (2013). https://doi.org/10.1177/0265407512453827, http://dx.doi.org/10.1177/0265407512453827
23. Purohit, A.K., Barclay, L., Holzer, A.: Designing for digital detox: Making social media less addictive with digital nudges. In: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems. pp. 1–9 (2020). https://doi.org/10.1145/3334480.3382810
24. Whittaker, S., Kalnikaite, V., Hollis, V., Guydish, A.: 'Don't waste my time': Use of time information improves focus. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. pp. 1729–1738 (2016). https://doi.org/10.1145/2858036.2858193
25. Woods, H., Scott, H.: #Sleepyteens: Social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. Journal of Adolescence **51**, 41–49 (08 2016). https://doi.org/10.1016/j.adolescence.2016.05.008