Interaction Restraint: Enforcing Adaptive Cognitive Tasks to Restrain Problematic User Interaction

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Abstract
We propose an interaction restraint that aims to degrade interactivity of a device, for example, by asking users to perform a mandatory cognitive task whenever they start an interaction. This mechanism is designed to help users to self-reflect upon their interaction intent with the devices, and thus they can break the habit of unconscious frequent access to their smartphones. We perform a preliminary study to understand the design requirements of the cognitive tasks and develop a high-fidelity prototype. Our field trial clearly documents that a positive influence of interaction restraints on deterring habitual frequent use of smartphones.

Author Keywords
Interaction restraint; behavior restraint; smartphone overuse.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
Recent mobile devices are equipped with powerful application processors to provide fast and instant responses to users. This kind of high responsiveness, however, may lead people to engage in habitual and

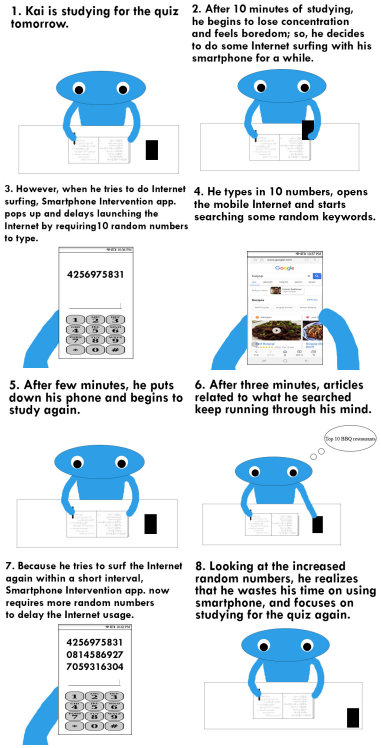


Figure 1: Storyboard that shows a Smartphone Intervention app activation while studying.

frequent interactions, which often result in losing focus on their work [9] and social bonds around them [11]. There are several popular ways of mitigating such problems such as warning overuse [7] and blocking interaction [5, 6].

In this paper, we explore the feasibility of a novel intervention mechanism called an *interaction restraint* that aims at degrading interactivity of a device to help users reflect upon and refrain from problematic usage behavior. As a case study, we consider an interaction restraint placed in the beginning of an app launch. In other words, when a problematic interaction is observed (e.g., checking Facebook too frequently), the user is interrupted with a cognitive task that needs to be completed in order to resume app use.

This simple idea has a theoretical basis on a recent cognitive model of cravings called the elaborated intrusion theory of desire [3]. Kemps et al. [4] showed that such cravings could be suppressed if users are distracted to other tasks due to the mutual competition of cravings and other tasks for limited working memory capacity. Therefore, enforcing users to perform a light cognitive task at that moment of user interaction can change 'automatic interaction' to be 'conscious interaction' by intentionally slowing down user interaction and thereby suppressing use craving.

We performed a preliminary user study to understand the design requirements of the cognitive tasks and iteratively developed a high-fidelity prototype. Our short-term field trial with seven users demonstrated that such cognitive tasks effectively deterred users from habitual frequent usage of smartphones. Our findings demonstrate the efficacy of interaction restraints for positive behavioral changes. We discuss further directions for future work on the design of interaction restraints.

Related Work

Unlike traditional desktop computing devices, smartphones allow instant access to a large amount of content at anytime and anywhere. They fluidly support micro-interactions that take only several seconds from initiation to completion [1]. Smartphone usage provides instant gratifications to users (e.g., socializing, pastimes, information seeking, and entertainment). Such gratifications are known to reinforce frequent checking behaviors [8, 10]. This kind of frequent checking likely happens as part of a user's multi-tasking behavior such that a user's attention often gets distracted from ongoing tasks, thereby making a negative impact on his or her cognitive performance [12].

There are some prior studies related to regulating the negative smartphone use. Kim et al. [6] showed that in work contexts, coercive intervention could help users to better regulate digital device use. Ko et al. [7] presented Lock n' LoL, a mobile application that aims to help people focus on their social group activities. Similarly, Kim et al. [5] designed a location-based service that reminds students of locking their phones in college classrooms. Unlike prior methods such as warning and blocking, our proposal aims to place some cognitive burden on user interaction as a nudging mechanism to encourage self-reflection/regulation. The difficulty of cognitive tasks is adaptively modulated based on the seriousness of problematic usage. We hypothesize that performing such a cognitive task helps break the habit of constantly seeking instant gratification, which is the major cause of unconsciously frequent access to smartphone usage.

App Usage Interval	Number of Inputs
~ 1 min.	100
1~5 min.	89
5~10 min.	72
10~15 min.	58
15~20 min.	29
20~25 min.	14
25~ min.	5

Table 1: Parameter table that represents usage interval time versus total required numbers to type in.

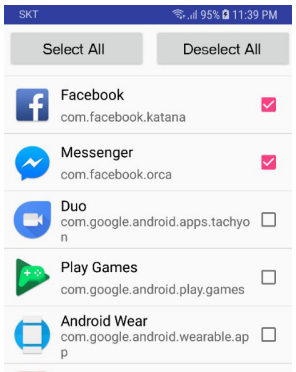


Figure 2: Configuration of installed apps where users are allowed to select any apps to be intervened (including select and deselect all button).

Preliminary Study

We interviewed thirteen participants to investigate how people considered our intervention method. Their average age was 23.15 (sd =1.91), and 9 were male. Our design goal was to suppress frequent usage known to have detrimental effects on cognitive performance due to frequent distractions from ongoing tasks. We designed a cognitive task of inputting number. We created a detailed scenario describing how the intervention method works in a paper prototype as shown in Figure 1. Then, we explained our paper prototype to each interviewee in the beginning of the interview. We asked about the three aspects of our intervention: 1) intervention target, 2) workload assessment and 3) workload variation. Here, the intervention target included determining the coverage of intervention (e.g., entire smartphone or specific apps). This probing helped us understand users' initial response and their preferences to employing interaction restraints. Workload assessment was to check how users thought about the intervention method of the number inputting task, and what the proper workload for the number inputting task would be. Workload variation was to understand users' preferences on varying task workload based on the seriousness of problematic usage. In the case of frequent checking, the interval from last access could be used as a measure for seriousness. In this case, we asked users for their opinions about increasing the workload based on the level of seriousness.

Results

For the intervention target question, most participants mentioned that social media were habitually used the most. One participant said, *"I often use Facebook mobile app, and my time flies when I am checking how my friends are getting along."* Another participant said, *"I usually do Facebook and Instagram a lot, and would like to get some intervention on apps that I lose track of time and immerse myself in."*

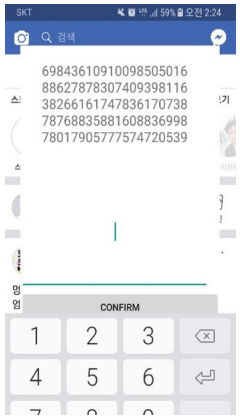
Regarding the workload assessment, all participants except for two answered "Not that burdening" since they typically thought it looks 'familiar' and 'simple.' One participant said, *"It is just like typing in a password for unlocking a smartphone, so it's pretty familiar."* Participants also recommended alternative tasks such as including alphabet characters and employing physical activities like stretching.

Some participants expressed positive opinions for imposing a penalty of increasing the number of digits to type based on the time interval from the last access. Interestingly, many suggested that there should be maximum and the minimum digits so that the workload is predictable. One participant said, *"Task intensity should be renewed when users do not use the app for a certain period of time"* (P4), and another participant commented, *"Intensity has to be maximized when the usage interval is below a certain limit."* (P2) This preliminary study found that users preferred to have interaction restraints on specific apps with which their usage is deemed problematic and the workload of cognitive tasks to be estimable with limits (i.e., min/max digits).

System Design

Based upon the results of our preliminary study, we designed the cognitive task for the interaction restraint and constructed an intervention system prototype that enforces a cognitive task when starting a set of apps that needs usage moderation.

(a) Minimum intensity



(b) Maximum intensity

Figure 3: Two restraint tasks that require the minimum (five) and the maximum numbers to type in respectively depending on the app usage interval.

We let users select any mobile apps to be intervened in our intervention system as shown in Figure 2. The chosen apps are monitored by our app usage-tracking feature. Whenever the chosen apps are used, the intervention system interrupts users by asking them to perform a cognitive task.

In our prototype, a cognitive task is a simple digit input work. Task workload is set based on the time interval between the last and the current time. We vary the workload by adjusting the number of digits: the shorter the number of digits, the higher the workload as shown in Table 1. We also set the min/max intensity threshold of the task. An example of minimum intensity (level 1: usage interval =< 1min.) and maximum intensity (level 6: usage interval > 25min.) is presented in Figure 3.

Field Trial

Setup

We designed a field trial to analyze the usage behaviors of an interaction restraint and its effectiveness of regulating app usage. We recruited seven participants from a large university. Their average age was 21.57 (sd =2.15), and 4 were male. We screened the participants by selecting those who thought that they needed self-regulation on smartphone usage. All participants were asked to choose any media apps to regulate (e.g., social media, YouTube). After this process, they were asked to use their phone as usual in their daily lives.

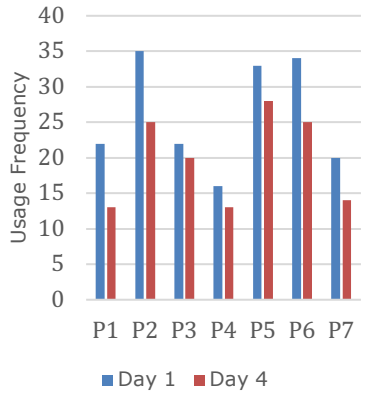
We collected usage log to analyze usage patterns. The major logging information includes start/end time and time interval between the last use and the current use. When a user faces a cognitive task, we recorded the time spent for the task. We divide a user behavior; here, resistance refers to the case that a user enters the prompted numbers instead of stop using. In contrast, adaptation means that a user decides not to use the smartphone anymore and turns off the screen when the user faces the task. We differentiate resistance from adaptation by checking whether the screen-off event has occurred afterwards.

At the end of the field trial, we conducted an exit interview to analyze the practical influence of an interaction restraint on the smartphone usage patterns. We transcribed the interview data and performed a thematic analysis.

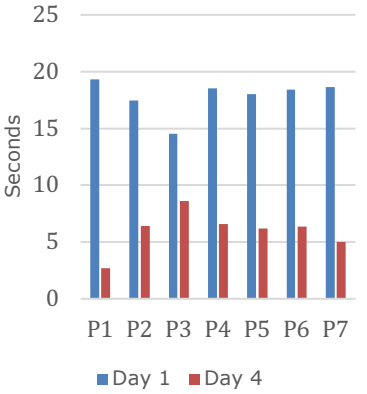
Results

First of all, we found a positive effect of an interactive restraint on the participants' usage patterns. Most participants chose Facebook and YouTube as the target apps that need self-regulation due to their frequent usage. Those participants all agreed that due to such apps they could not focus on their tasks and even had a sleeping problem.

We analyzed how participants reacted to the interaction restraint. Our results showed that the stages where participants gave up typing varied from level 2 to level 6, and most participants felt burden on level 3 (29 digits to enter). One participant said, *"I felt some pressure when I was required to type in numbers more than two lines"* (P5), while the other said, *"I felt burden even when the numbers are only two lines."* (P1) The highest task difficulty was level 6. Our interview showed that this task was attempted mainly due to out of their curiosity rather than real use purpose. Although the perceived burden of task difficulty differed among



(a) Total Usage Frequency



(b) Average Time Staying on Restraint Tasks

Figure 4: Usage Frequency and Time on Restraint Tasks

individuals, most participants tended to give up performing the task as the difficulty level increased.

We then checked whether our interaction restraint had a positive influence on self-reflection and usage awareness. During the interview, we presented an app usage frequency chart to the participants as shown in Figure 4(a) and a graph that indicates the total amount of time spent on the restraint task as shown in Figure 4(b). App usage frequency of all participants decreased on the last day when compared to the first day. We analyzed the total amount of time staying on a restraint task screen, and its correlation with the self-reflection of participants. Through a data analysis, we found that the task time decreased for all participants in comparison with that of the first day. The largest time decrement was 17 seconds, while the least was 6 seconds. Our participants commented that the interaction restraint effectively increased users' awareness of smartphone usage by making user interaction cognitively conscious. One participant said, *"Before the experiment, I unconsciously executed apps without much awareness, but after looking at the number input screen, I am now very conscious of using apps."* (P4) Other participant said, *"When I look at the intervention app icon, a pressure from typing in a random number comes to my mind, which makes my app usage more conscious."* (P3)

Furthermore, we found that our interaction restraint helped our participants self-reflect on their daily usage behaviors. One participant said, *"I realized that I had been using Facebook way too much after I installed this restraint app; I decided to fix my usage habit while using this app."* (P1) Other participant said, *"Seeing a lot of digits on the task screen, I felt that I had been wasting my time too much on playing with the smartphone."* (P6) Some other opinions were *"Every time when I saw many numbers on the screen, I felt guilty"* and *"This app made me have a high level of self-consciousness."* (P2)

Discussion and Conclusion

Our results showed that an interaction restraint in the form of number inputting with varying workload can successfully interrupt the problematic "multi-tasking" attempts that divert users' attention to those apps in need of self-regulation (e.g., Facebook). Our current interaction restraint intervenes the beginning of app usage. This timing decision is based on the prior study results on interruptibility literature [2], but it is possible to interrupt users at different moments (e.g., page transition, app switching). The workload was adaptively set based on the time interval from the last access to the app. Given that perceived workload varies widely among users, it is important to personalize the workload setting. We set the min/max bound to help users to estimate the workload, and yet it works as a tool for "nudging" on usage regulation. However, some situations may require high cognitive focus, and thus, users may prefer a coercive interaction restraint that can completely block the app for a specific time period.

Limitation and Future Work

The generalizability of our work is limited because we carried out a small-scale field trial for only a short duration (four days). Thus, it is necessary to design a controlled experiment to validate the benefits of the interaction restraint mechanism in an extended usage setting. In addition, there should be longitudinal field study to see whether such restraints effectively change their actual behaviors in natural settings.

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