Lock n' LoL: Group-based Limiting Assistance App to Mitigate Smartphone Distractions in Group Activities

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ABSTRACT
Prior studies have addressed many negative aspects of mobile distractions in group activities. In this paper, we present Lock n' LoL. This is an application designed to help users focus on their group activities by allowing group members to limit their smartphone usage together. In particular, it provides synchronous social awareness of each other's limiting behavior. This synchronous social awareness can arouse feelings of connectedness among group members and can mitigate social vulnerability due to smartphone distraction (e.g., social exclusion) that often results in poor social experiences. After following an iterative prototyping process, we conducted a large-scale user study (n = 976) via real field deployment. The study results revealed how the participants used Lock n' LoL in their diverse contexts and how Lock n' LoL helped them to mitigate smartphone distractions.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords
Smartphone Usage, Smartphone distraction; Group activity

INTRODUCTION
Smartphones have stretched the boundaries of social activities by allowing users to exchange instant messages and easily share daily activities [11, 12]. However, smartphones can sometimes become a distraction in group activities. For example, conversations were found to be disrupted by frequent notifications or habitual checking of online contents. According to our preliminary survey (n=87), 77% of the respondents reported that they experienced distractions caused by smartphones in group contexts. Furthermore, the majority of the participants (90%) agreed that limiting smartphone usage is necessary in order to improve group activities.

Prior studies have demonstrated that limiting smartphone use can improve the quality of group activities. For example, Misra et al. [43] found that people who had conversations without mobile devices reported higher levels of connectedness and empathetic concern than those with mobile devices. In addition, people are more likely to feel social responsibility such as sympathy or engagement in social interaction when smartphones are absent [3]. However, self-regulation of smartphone use is still difficult in many cases due to its various functionality and high accessibility [26]. These difficulties support the need for a device or app to limit smartphone use.

In this paper, we present Lock n' LoL ("locking" smartphones to "laugh out loud" together). This application helps users focus on their group activities by allowing group members to limit their smartphone use together. In particular, it provides synchronous group awareness that all members are currently limiting their smartphones during a group activity. This synchronous limiting feature is motivated by the fact that an individual's smartphone usage can influence others' behaviors. For example, it is likely that the other members are tempted to engage in their phones or they may be also distracted by the other activities [19]. For this reason, Lock n' LoL allows a group of users to temporarily lock their phones in a synchronous manner. For Lock n' LoL design, we followed an iterative prototyping process. Two working prototypes were developed and tested in field trials (n = 20, n = 28).

We studied the in-situ experience with Lock n' LoL and evaluated its effectiveness through a field deployment study that holds a campus-wide Lock n' LoL campaign at a large university in Korea. We uploaded the app to the Google Play store so that anyone could install and use Lock n' LoL for free. During the course of the 25-day study, 976 users installed Lock n' LoL and their limit duration was over 10,000 hours.

In our study, we first discovered that the degree of perceived smartphone distractions was lowered following Lock n' LoL use. Second, we uncovered detailed patterns of group-based use limiting (i.e., how, when, whom, and what) to understand how and why Lock n' LoL either mitigated or failed to mitigate smartphone distractions. Finally, we performed a regression analysis to study how use limiting behavioral characteristics (i.e., activity, social relationship, temporal usage, and location of use) were related to an individual's engagement (e.g., daily use limiting duration and frequency of a user). The results indicated that while the regularity of the limiting events was important for the limit duration, the diversity of the limiting contexts was a stronger predictor of the limit frequency. Users who frequently limited their use tended to reveal their limiting behaviors in diverse situations for diverse purposes rather than frequent trials in limited contexts.

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BACKGROUND AND RELATED WORK

HCI Studies on Technological Distractions

Even though the benefits of multitasking in their overall performance have been reported [9, 21, 38, 46], frequent and unpredictable interruptions can cause people to make mistakes and reduce their efficiencies [8, 29]. Individuals who more frequently switch window screens tend to feel less productive at the end of the day [40]. In addition, the amount of multitasking and interruptions is significantly related to stress [39, 41]. Moreover, multitaskers often enter into a "chain of distraction" with PC use [21] and smartphone use [26, 31].

In the HCI and UbiComp field, researchers studied the practice of technological interruptions in diverse situations [33, 48]. Mehrotra [42] measured the amount of smartphone interruptions based on the phones' content and context (e.g., information about sender and receiver). Leiva et al. [33] demonstrated that interruptions caused either by incoming phone calls or by application switching could be costly. There have been many recent studies that infer opportune moments for interruptions that can lower distraction [6, 42, 53, 56].

These studies provided an excellent foundation for understanding technological interruptions, and for designing tools that help users cope with distractions. Earlier studies on managing technological distractions primarily focused on external stimuli from the technologies (e.g., notifications). However, technological interruptions can also be caused by internal stimuli, also known as self-interruption (or internal interruptions) that Individuals interrupt themselves during ongoing work [1, 10, 22]. According to the prior studies [26, 31], smartphone distractions occur both internally (i.e., habitual usage) and externally (i.e., notifications); the internally cued usage is primarily the result of smartphone functionalities and pervasive accessibility to online content. In addition, we should consider mobile distractions in the group contexts because individuals' usage can influence others' usage [43, 49]. In this study, we considered such smartphone distraction characteristics and developed a group-based limiting assistance to help individuals primarily focus on their group activities.

Negative Effects of Problematic Smartphone Use

The use of mobile devices in interpersonal social interactions has become much more prevalent, as such devices provide valuable functions [13, 44]. However, several studies have reported that smartphone distractions interfere with daily activities [2, 16, 34]. For example, smartphone usage can distract individuals from ongoing tasks such as studying, working, and driving [2, 34]. In addition, Oulasvirta et al. [47] and Bohmer et al. [7] revealed the sources of multitasking: the user's habit of checking updates and frequent content consumption (e.g., checking emails). Furthermore, Lee et al. [31] and Shin and Dey [51] analyzed a smartphone usage log data and identified problematic usages that resulted in negative effects like distractions from daily activities.

It is especially notable that mobile device use sometimes impedes interpersonal experiences by disrupting the introspective processes that accompany in-person social interaction. This disruption prevents one from understanding the psychological states of others and thereby empathizing with them [20]. Turkle [55] revealed that mobile technologies provide multiple spatio-temporalities, which can decrease the quality of face-to-face conversations as people attend to other interests/relationships instead of those individuals who are physically co-located. Gergen [11] noted that online technologies can shift from vertical relationships that require long-term effort and commitment, to horizontal relationships that indicate an expanded network of shallow relationships. Humphreys [19] discussed Goffman's cross talk by mobile phone use in public places. Cross talk is originally referred to as a conversation in which "one member during social interaction momentarily sustains exclusive talk with someone who is not in his/her companions" [14]. This may make other members feel socially vulnerable by triggering feelings of awkwardness and exclusion. Moreover, some studies demonstrated that the mere presence of mobile devices could negatively influence in-person social interaction by interfering with closeness, connection, and the relationship quality in dyadic settings [43, 49].

As such negative effects of mobile distractions have been observed, people's concerns with problematic usage have been increasingly reported [31, 51]. Typical users want to manage their smartphone usage to deal with interferences in their daily lives [32], and Salovaara et al. [50] reported that smartphone users often unavoidably or intentionally limit their use to deal with interruptions. In addition, Shin and Dey [51] found that study participants who had normal usage patterns self-reported that sometimes they used smartphones too much and had concerns about their usage. Thus far, many studies have revealed distractions due to mobile technology use, and their negative effects on daily activities and social relationships. This study extended this research area by examining smartphone distractions in group activities, and acquiring an understanding of their limiting behaviors with our limit assistance tool.

Supports for Self-Regulation of Smartphone Usage

For regular users, managing smartphone distractions is challenging. The participants in Lundquist et al.'s work [37] agreed that they needed to limit some of their smartphone use. In addition, smartphone users have tried several coping strategies for smartphone distractions such as physical separation and setting phones in airplane mode [26]. However, the effectiveness of these strategies tended not to last long, primarily due to users lack of self-regulation [26].

Therefore, HCI studies have been conducted to find computational tools for improving self-regulation of smartphone use. For example, Lee et al. [32] addressed the need for temporary non-use tools in which people actively regulated phone use under various situations. The concept of non-use has been extensively studied with various digital media such as SNS [4] and the Internet [17]. In addition, diverse tools for improving the self-regulation of smartphone usage have been proposed [25, 26, 30, 36]. These tools provide several helpful functions, such as screen and apps locking, usage amounts monitoring, and warnings sent when the usage amounts exceed set limits. Furthermore, some of the apps use social tools to boost social learning and motivation for the smartphone usage self-regulation via comparison [26].

Earlier works primarily focused on presenting an asynchronous awareness of group members' usage behaviors (e.g., presenting members' past limiting behaviors, such as the total amount of time limiting). Asynchronous awareness can be useful for activating competition to motivate usage-limiting behaviors and boost the effects of social learning. However, the group members who shared ongoing activities needed the support of synchronous awareness in order to allow them to manage smartphone distractions together. Our work allows group members to manage usage together, and to have interactions among themselves by synchronously requesting and granting smartphone use. Furthermore, we studied user experiences with our usage-limiting assistance tool in diverse situations, and extracted practical design implications.

PRELIMINARY STUDY ON SMARTPHONE DISTRACTION IN GROUP ACTIVITIES

As a preliminary study, we conducted a survey that consisted of questions answered on a four-point Likert scale regarding how smartphones distract from group activities and what people thought about the necessity of managing smartphone usage in group activities. Following each Likert question, we asked respondents to describe the reasons for their answers in an open-ended question. The survey was posted on online forums and SNSs in Korea. A total of 87 participants responded to the survey (28 females; ages: M = 25.45, SD = 7.75). To supplement the survey, we also interviewed seven participants (two females; age: M = 23.43, SD = 11.87) about their smartphones usage and its effects on their group activities.

Results

77.01% reported that they had experienced smartphone distractions during group activities (M = 2.90, SD = 0.70). Also, 90.8% responded that smartphone usage should be limited to improve group activities (M = 3.23, SD = 0.64). Distractions were specifically found to be triggered by externally cued usages such as push notifications with sound and vibration alarms. However, despite such notification disruptions, the participants simply appeared to forget to set their phones to silent mode for group activities. Some participants argued that there were situations in which they could not set their phones on a silent mode as they are expecting immediate responses. Another type of distraction during group activities resulted from the lack of self-regulation. Other respondents noted that they unconsciously picked up their smartphones, which disrupted ongoing conversations. Here, the problem usually occurred when their usage lasted longer than they had intended. They unconsciously began to check SNSs, and quickly became preoccupied with their phones. As a result, they paid less attention to their group members with whom they were interacting. This result is linked to prior works that found that stimulating content can lead to long usage [31].

In our interview sessions, we discovered that smartphones can also be used to facilitate group activities. Most cases were related to the smartphones' abilities to provide convenient information access. Particularly, the participants acknowledged the need to use smartphones to seek information (e.g., dictionary searches and class sites checks). Some of the participants commented that they sometimes used smartphones to resolve conflicts or find answers for disputes or discussions. In addition, smartphones can enable group members to engage in other online group activities, such as sharing photos and playing mobile games.

Design Implications

Based on our study results, we drew several design implications. First, we found that group activities were often distracted by external usage cues (e.g., notification alarms) and habitual checking patterns (e.g., checking status updates or online contents). Therefore, it appeared to be necessary to design intervention mechanisms to prevent these usage behaviors in order to minimize disruptions to socializing. Second, the study participants also reported the usefulness of smartphones in their group interactions. As smartphones provide diverse functions compared to a traditional cell phones, some aspects of group activities can be extended and facilitated (e.g., taking a photo or posting events onto SNSs). Therefore, slightly different from prior studies regarding cell phone distractions [49, 43], completely limiting smartphones would not be the best solution. Intervention mechanisms for limiting usage should be flexible in order to help users determine when (not) to allow smartphone use during group activities.

DESIGN OF LOCK N' LOL

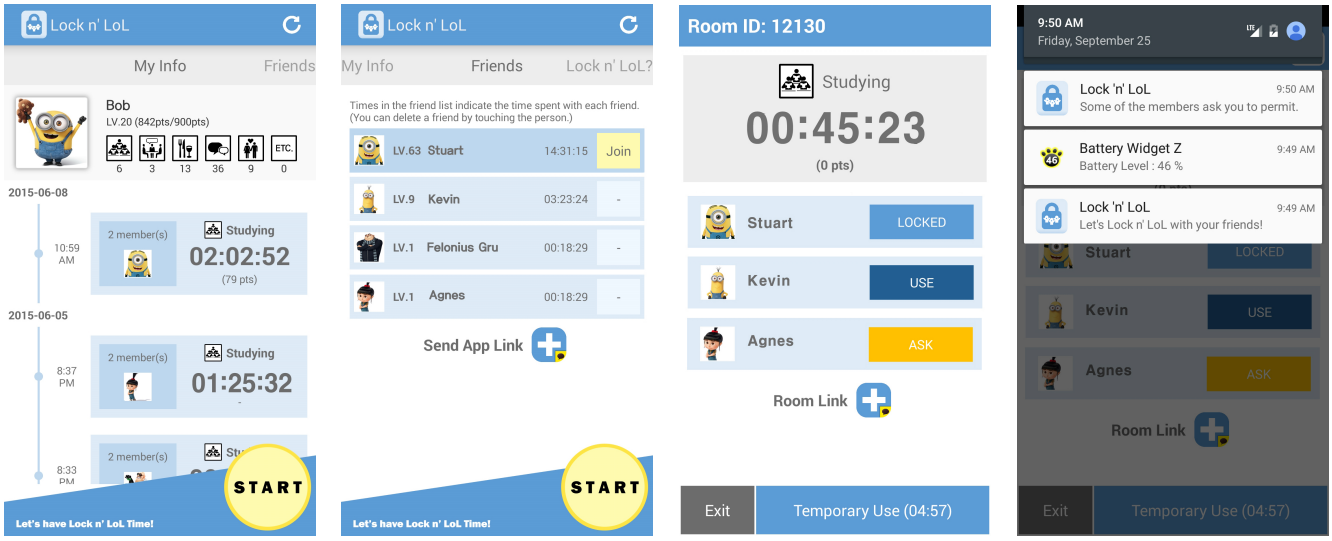
We present Lock n' LoL, a mobile app that allows users to limit their smartphone usage together and to focus on group activities. The key idea of Lock n' LoL is to foster group awareness that all members are currently limiting their smartphones during group activities. This synchronous limiting feature is inspired by the fact that an individual's usage can influence others' behaviors. For example, it is likely that the other members are tempted to engage in their phones or they may be also distracted by other activities [19].

Iterative Design Process

As part of our iterative prototyping, we performed two pilot studies. After rapidly building the first working prototype, we recruited seven undergraduate students from a large university in November 2014. We instructed them to use the app with their friends during their daily activities for a week. This snowball sampling resulted in seven groups with a total of 20 users (four females; ages: M = 21.2, SD = 1.06). We then interviewed the respondents to understand their overall user experiences with Lock n' LoL. After the interview data was analyzed, we prioritized all of the issues and improved the initial prototype. In February 2015, we conducted the second pilot study for two weeks by recruiting 28 users (12 groups; eight females; ages: M = 22.7, SD = 3.5). Similarly, we performed interviews to gather feedback for improvements.

Lock n' LoL Application Description

Figure 1 shows the final Lock n' LoL design. There are three tabs: 1) "My Info": statistics about a user's limiting behaviors and timeline of the previous limiting behaviors; 2) "Friends": a list of friends who have ever used Lock n' LoL together (also highlights co-location status); 3) "Group Limit Mode": a group's limiting room that displays all the members and their current status (e.g., locked or use). Users can activate a limiting



(a) My Info (b) Friends (c) Group Limit mode (d) Co-location reminder

Figure 1. User Interfaces of Lock n' LoL.

mode to lock their smartphones with others by clicking the start button at the bottom of their screens. In the following section, we explain the following three main features of Lock n' LoL: (1) *usage summary and limit behavior timeline*, (2) *group limit mode*, and (3) *co-location reminder*.

Usage Summary and Limit Behavior Timeline

Lock n' LoL records all limiting behaviors and displays them on the front page. We added this feature because people would be encouraged by being able to see their achievements retrospectively. This page allows users to track their previous limiting behaviors. In our early prototype, we had two separate pages that detailed users' statistics and group timelines. For instance, the page for statistics included the current week's total limit time, the weekly average usage time, top friends (ranked by time spent together), and top activities in which the user participated. The group timeline page displayed the user's past activities chronologically. In the second pilot study, we found that the statistics page was rarely used by the participants. Thus, these pages were merged. As a result, a quick statistics summary on a user's limiting behaviors was displayed in the upper part of the front page, and a timeline of the limiting behaviors was displayed in the bottom part.

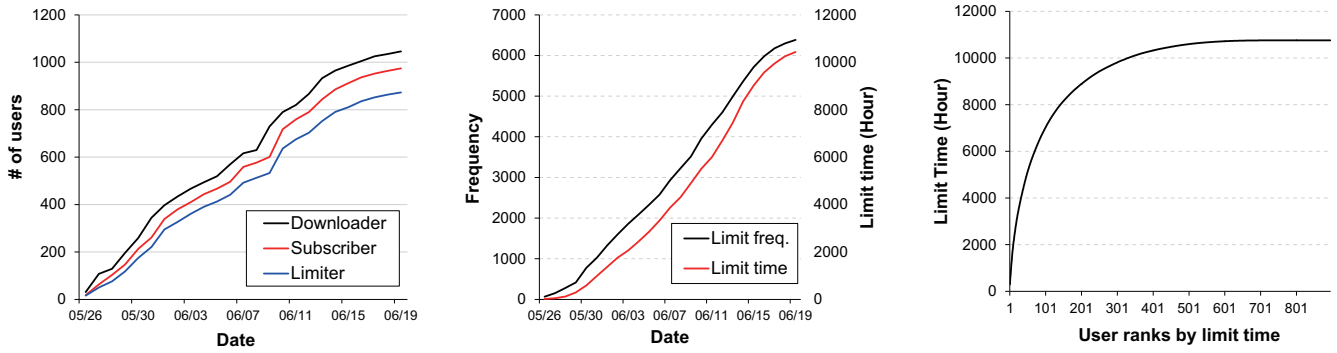
Group Limit mode

The group limit mode is the most essential aspect of Lock n' LoL. It enables a group of users to lock their smartphones simultaneously. To start the group limit mode, users simply tap the start button. They are then asked to create a new "room" or they can join an existing room. When creating a new room, users also choose the type of group activities (i.e., studying, working, eating, chatting, and dating). After entering a room, users can view the list of group members, members' limiting status, and room information (e.g., the room ID, and the elapsed time in the room). While a user is in a room, notifications are muted to reduce distraction. However, we allow users to answer incoming calls (this call answering feature was added after the first pilot study). To enter a room, our initial design only allowed users to type a room ID. After the second pilot study, a few participants suggested sending an invitation via mobile messaging (i.e., KakaoTalk), which allows them to send invitations to existing group chat rooms.

Lock n' LoL also supports a *temporary unlimit mode*. Our first prototype required users to obtain explicit permission to switch to the temporary unlimit mode in order to prevent its abuse. However, our design iteration found that acquiring explicit permission was too burdensome for short-term usage (less than one minute). We thus revised the system to offer users free access to the unlimit mode for cumulative five minutes after they start the group limit. We determined this five minute duration because it would be sufficient for occasional smartphone use during group activities and was reasonably accepted by users in the second pilot and field tests. When the five-minute allowance is depleted, users have to explicitly obtain unlimit permission from others. This procedure was designed to prevent the temporary unlimit mode from being exploited and thus falling back into *alone together* situations. According to our second pilot study, participants advised that group activities sometimes lasted for a few hours. They requested that we automatically recharge the five-minute allowance at the beginning of each hour. This feature was incorporated in our final prototype.

Co-location Reminder

The co-location reminder notifies users when two friends continue to stay in the same place in order to encourage users to limit their smartphone use with their friends nearby. This function was included based on the pilot study results. Some participants confessed that they often simply forgot to use the Lock n' LoL app during their group activities. Lock n' LoL periodically performs Wi-Fi scans and sends the SSID list and signal strength to the server. The server then calculates the Jaccard similarity between two scan result sets (e.g., the size of the intersection divided by that of the union of the scan result sets). Two smartphones are considered "nearby" when the Jaccard similarity exceeds a threshold value. The server sends push notifications to those devices. In addition, the list



(a) # of downloaders, subscribers, and those who tried use limiting at least once

(b) Limiting time and frequency

(c) Limiting time per user

Figure 2. Statistics of Field Deployment (Cumulative distributions).

of nearby friends is highlighted in yellow in the "Friends" tab. Users can join a room that a nearby friend has created by simply tapping on his or her name.

We wanted to push notifications in a timely manner because users may simply ignore the reminder if they are notified too early prior to meeting with friends. In addition, timely reminders can reduce false-positive cases, as too many alarms can annoy users. Therefore, compared to a previous study [27] that considered co-locations when two devices shared at least one particular Wi-Fi AP, our method has a more rigorous standard based on a threshold of Jaccard similarity in order to detect two devices at distances amenable to in-person social interactions. Based on the results of informal field experiments with four smartphones in twelve places, we determined a threshold of 0.6, which likely guarantees co-location reliably within 20 meters. This is sufficient for our applications, and we used this threshold in the final prototype. After the second pilot study, we set additional rules for reminders. If the group size is large, frequent notification could be generated whenever group churning happens (e.g., whenever a co-worker comes back from a bathroom). To deal with such situations, we limit notification delivery so that only one message per location is pushed in every six hours.

LOCK N' LOL EVALUATION

This section presents our study results from a large-scale field experiment. Our experiment was designed to answer the following three questions:

- Q1. Does Lock n' LoL help mitigate individuals' smartphone distractions?
- Q2. How did people use Lock n' LoL? When and where did they use it? With whom did people use it? What activities did people want to focus on while using it?
- Q3. What aspects of use limiting behaviors are related to its engagement?

First, we studied the effectiveness of Lock n' LoL in mitigating smartphone distractions. This analysis validated whether Lock n' LoL achieved its primary design goal. Second, we aimed to understand users' detailed usage patterns and analyzed usage data by examining various aspects of usage (i.e., how, when, whom, and what). The answers to these questions can allow us to understand how and why Lock n' LoL mitigated or failed to mitigate smartphone distractions. Finally, we performed a regression analysis to study how use limiting behavioral characteristics (i.e., activity, social relationship, temporal usage, and location of use) were related to an individual's engagement (e.g., daily usage duration and frequency).

In-situ Deployment Study Setup

Campaign design

We designed a field deployment study by holding a campus-wide campaign at a large university in Korea. We promoted the slogan "Let's lock our smartphones with Lock n' LoL and laugh out louder with our friends." We chose college students as our target user group because they adopt new technologies relatively well and have dynamic usage contexts, ranging from studying to socializing. We believe that our approach to the field deployment study can help us better capture users' real app usage by minimizing experimental biases. The campaign lasted for 25 days, from May 26 (after the mid-term exams) to July 19, 2015 (the end of the semester). We uploaded the app to the Google Play store so that anyone could install and use Lock n' LoL for free. We prepared a set of campaign advertisements such as online/offline posters. To improve bootstrapping, we offered promotional giveaways. Specifically, the first 300 users who achieved Level 5 in Lock n' LoL (which requires at least 90 minutes of use limiting) were compensated with a gift voucher worth about 5 USD. In addition, those who reached Level 5 received a chance to win a prize (i.e., one digital camera, three Bluetooth speakers, and five gift vouchers worth approximately 50 USD).

Data Collection

To answer our evaluation questions, we collected the following data. First, we asked the participants to complete a pre-survey at the time of registration. This included demographic information (i.e., age, gender, and job) as well as a customized Smartphone Distraction Scale (SDS). We used five questions on daily smartphone distractions, a subscale of the Smartphone Addiction Proneness Scale [24]. We customized the original scale by including daily activities; e.g., *"My daily activity performance (i.e., working, studying, or dating) dropped due to excessive smartphone use."* The higher the SDS score, the

more serious was the user's perceived smartphone distraction. Second, we collected Lock n' LoL app usage log data. The data contained a timestamped interaction history; e.g., when an activity was selected or when the group limit mode was enabled. Third, after the campaign we conducted an exit survey to understand the details of their in-situ user experiences. The survey contained several questions about usage context: e.g., the places where they usually executed Lock n' LoL, and the relationships between favorite members who frequently stayed in the group limit mode together. In addition, the SDS questionnaire was administered. Overall, 379 users completed the survey. These participants' demographic and usage characteristics did not significantly differ from those of the entire population. They were aged from 13 to 50 (M = 22.18, SD = 3.70), and 40.3% were females. The survey respondents' average limiting time per day was 89.98 minutes (SD = 130.27). Finally, we solicited short stories about how participants used Lock n' LoL, and 61 users submitted their stories via email.

Deployment Summary

Figure 2(a) illustrates the cumulative distributions of downloaders, subscribers, and those who tried use limiting at least once. The number of users continued to increase over the study period. Overall, a majority of the downloaders registered (93.1%, 976 of 1046 downloads), and most subscribed users tried use limiting with Lock n' LoL (89.6%, 873 out of 976 users). Most of the users were in their early 20s (M = 22.59, SD = 4.76). 37.3% of the users were females. This percentage reflected that fact that the study was held in a technical university in which the proportion of female students was approximately 20% at the time of writing. Most participants were either undergraduate students (52.7%) or graduate students (32.2%). While the study was primarily held at one university, there were also participants from other local universities and secondary schools. A small number of university staff and office staff also participated in the campaign. Overall, 976 users engaged in 10,365 hours of user limiting over the campaign period. Figure 2(b) represents the cumulative distribution of limiting time and frequency over the campaign period. As shown in Figure 2(c), 44.6% of the 976 users showed at least two hours of use limiting, and the mean duration of use limiting per user was noted as 91.4 minutes per day (SD = 123.81).

Distraction Analysis

We evaluated whether Lock n' LoL helped users to manage smartphone distraction. We first analyzed the distraction score differences before and after app use. Next, we analyzed the exit survey and short stories to identify the major usage themes and aspects helpful to mitigating distractions.

Distraction Score Changes

The mean SDS score was initially 3.30 (SD = 0.77). 83.4% of users had SDS scores higher than 2.0, indicating that a majority of participants suffered from smartphone distractions. After the campaign, we found a significant difference in these SDS scores ($p < .000$, Cohen's d = .993). The mean SDS score after the campaign was reduced to 2.36 (SD = 0.67), and 50.1% of users had SDS scores greater than 2.0.

Themes of Distraction Reduction

We investigated how Lock n' LoL helped users manage distractions by analyzing the survey data and short story submissions. We determined that the app helped users manage distractions in their primary activities and social interactions.

Distraction in a primary activity: Many of the respondents commented that Lock n' LoL helped to improve their performances in primary activities on which they needed to focus. The most prevalent activity was studying. Some of the users mentioned that their unregulated smartphone usage habits often distracted them while studying or taking classes. One respondent said, *"In a group study, I tended to use my smartphone if other members used their phones. However, after using Lock n' LoL, we all can focus better on our studying together."* (#29) Another respondent (#292) commented on the limit mode's helpfulness (locking apps). He said, *"I think I have a habit of frequently checking my smartphone. I often spent more time than I expected web browsing or messaging. Lock n' LoL's limit mode reminds me that I should focus on my work."* (#137)

There were also examples with other group activities. One office worker said, *"I am somewhat unpleasant whenever a person uses a smartphone during the meeting. Lock n' LoL helps us to concentrate on our meeting without hurting others' feelings."* (#41) In addition, one undergraduate student commented, *"Lock n' LoL use was helpful especially for concentrating on our chorus practice. We usually used smartphones when others in other sections practiced a song. However, we used Lock n' LoL and could focus on how others were doing. This helped us to facilitate our communication and perform better."* (#96)

Distraction in social interactions: The second prevalent responses were related to social interactions. We found that closer rapport [54] between group members was established after Lock n' LoL use. The respondents cited their effective states of mutual attention and positivity in the interviews. They also agreed that they were more aware of and coordinated better with others. One participant even stated, *"I like the time with Lock n' LoL because I could sense my partner's attention, and we had more eye contact."* (#7)

Most participants also agreed that they felt strong *entitativity* (perception as a social unit) [35] when using Lock n' LoL. This is a positive indication of successful collaborative smartphone self-regulation. One participant stated, *"When we use Lock n' LoL together, I often feel that we are doing something together, and this makes me feel at one with others."* (#15) Some participants felt that their main conversation topics evolved from online content to more personal matters. For example, one mentioned, *"We often watched YouTube or read online news articles together when we met, but we could talk about each other's everyday lives when using Lock n' LoL. I think this can improve our relationships."* (#3) In addition, many participants expressed that they listened better to each other during conversations because they were interrupted less. One respondent reported, *"In our conversation, expressions requesting additional information like 'what?' and 'pardon?' decreased because we focused on each other."* (#6)

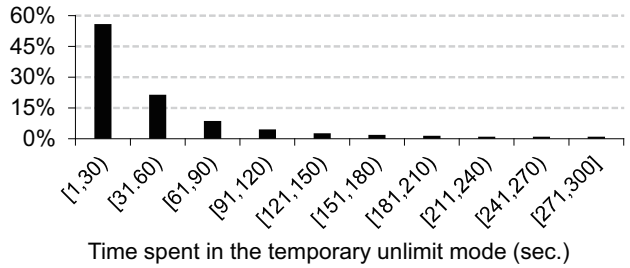


Figure 3. Distribution of time spent in the temporary unlimit mode.

Tool Support for Distraction Reduction

Our next questions focused on how Lock n' LoL helped users to manage distractions. We investigated usage of two key features: group limit mode and temporary unlimit mode

Group Limit mode: Many respondents (57.7%) cited that the group limit mode was the most helpful function. We found that the limit mode screen helped participants become aware of their smartphone usage during group activities. Most participants realized that they habitually checked their smartphones. They initially felt an urge to use the phone during the group limit mode. However, as they kept using Lock n' LoL, they were accustomed to use limiting and perceived an improvement in the quality of their group activities.

Respondents also reported that they could subdue their urge to use their phones during group activities. In particular, peer pressure was a strong factor that encouraged them to limit their usage during group activities. One respondent stated, *"I feel awkward if I use the phone alone because we agreed that we would limit phone use together at first."* (#23) Another respondent commented, *"Whenever I try to use the smartphone, I saw others' status in the group limit mode. Others seemed to be studying hard at the moment, so I decided to continue studying."* (#53) In addition, some of the respondents commented that limiting the smartphone use with others was enjoyable for them. One participant mentioned, *"My girlfriend and I enjoyed locking others' use [when they used the functions of asking/permitting to use]. This is surely a stronger method than verbal instruction like 'you should stop using the phone', but I think that it looks more natural."* (#57)

Temporary unlimit mode: The temporary unlimit mode was also deemed to be useful, with 33.5% of the respondents suggesting it was most helpful mode in Lock n' LoL. We determined that the mode sufficiently addressed the need to answer urgent emails/messages/calls and seek information. In our survey, respondents primarily used the temporary unlimit mode for checking emails (51.6%), responding to SMS and IM (19.1%), and web browsing (15.9%). The remainder of the apps used during the temporary unlimit mode included camera and game apps. Our Lock n' LoL usage log data also indicated that many participants frequently used the temporary unlimit mode. During the campaign period, 976 users had used the temporary unlimit mode 15,069 times. In addition, in 44.3% of the group limiting instances (6,383), the temporary unlimit mode was activated, and the users used it an average 2.36 times per limit instance.

We found that most users perceived five minutes for the temporary unlimit mode as a precious resource. One respondent said, *"I had a feeling that I should not waste the five minutes allowance. Once I finished the app use that I really needed to use, I immediately returned to the group limit mode."* (#120) Most respondents agreed that the five minute duration was appropriate. Our log data also supported this. Figure 3 shows the distribution of time spent in the temporary unlimit mode. In many cases, a session time for the temporary unlimit mode tended to be short, for example, less than one minute (M = 50.2 sec. SD = 63.38). Furthermore, participants made temporary unlimit requests to other members only 3.1% of the time.

Lock n' LoL Usage Context

We explored the details of Lock n' LoL's diverse usage contexts to understand users' limiting practices. We analyzed Lock n' LoL usage contexts as follows: (1) which activities the users wanted to focus on; (2) with whom they stayed in the group limit mode with; (3) when they engaged with the limit mode; and (4) where their limiting behaviors occurred.

Which Activities?

We analyzed the activities in which users reported while limiting their use. Lock n' LoL allows users to select one of the six activities, namely studying, working, eating, chatting, dating, and etc., when they started a group-limit mode. Table 1 shows the distribution of activity selection. "Studying" represented 80% of the selections. The skewness is attributed to the fact that a majority of the users were students. In the exit survey and short stories, we were able to determine that students frequently used the app in classes and group studies.

Next, we studied the activity selection diversity by using an entropy metric. For a given user u, we denote the probability of selecting an activity a as $p_{u,a}$. This probability is calculated by dividing the number of u's selections on an activity a (denoted as $C_{u,a}$) by the sum of $C_{u,a}$ for all activities. The resulting equation is shown as follows:

$$ActivityDiversity_u = \frac{-\sum_{a \in A_u} p_{u,a} \cdot \log_2 p_{u,a}}{\log_2 |A|} \quad (1)$$

Where A_u is a set of activities that user u chose, and $|A|$ represents the number of activity categories (six in our case). Intuitively, higher numbers represent greater randomness; the entropy is maximized when the user uniformly selects all the activities. As a result, most of the users showed the skewed selection of one or two activities (M = 0.19, SD = 0.22). In fact, 69.3% of the users' entropy values were less than 0.3. Interestingly, there were still a significant number of other users who selected diverse activities.

We found that the limit session time varied depending on the activity. Table 1 shows the mean limit session time per activity. A limit session for studying or working tended to be approximately 100 minutes, while a limit time for a chatting or eating activity lasted approximately 40 minutes. Interestingly, the "etc." activity revealed the longest session time. According to our exit survey, users usually selected this category for participating in club activities, watching movies, or exercising.

	Activities					
	Studying	Working	Eating	Chatting	Dating	Etc.
% of selections	80.27%	4.11%	3.51%	3.59%	3.88%	4.62%
Limit minutes per session	99.38	98.57	43.76	37.18	70.54	200.39

Table 1. Activity selection results.

	Night 00:00~05:59	Morning 06:00~11:59	Afternoon 12:00~17:59	Evening 18:00~23.59
Limit duration (hours)	2764.28	1588.81	2652.29	3426.58
Limit frequency	3,620	2,238	4,437	5,533

Table 2. Diurnal usage.

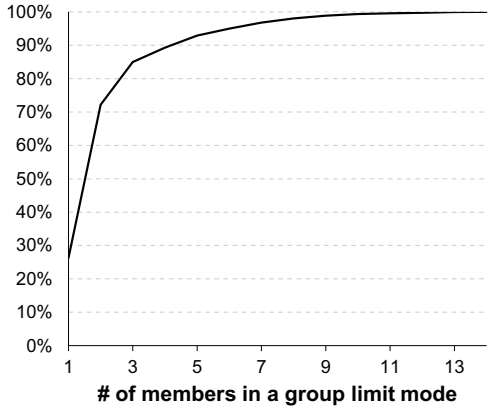


Figure 4. Cumulative distribution of the number of members per group limit mode.

With Whom?

We were curious as to how many members participated in the "group limit" mode. We first calculated the number of members in the group limit mode. Figure 4 shows the cumulative distribution. Here, we only considered the limit trials that lasted more than one minute to exclude any cases of initial trials or user errors. Overall, users preferred to limit usage with other people (alone: 26.26% *vs.* >= two members: 73.63%), which could possibly be due to how we framed the campaign. The most prevalent group size was two or three members. The frequency of group limit mode usage tended to decrease as the number of users increased.

In our exit survey, we asked the participants to identify their relationships with those with whom they frequently activated the group-limit mode through five checkboxes about representative relationships. As the results, notable relationships included friends (53.1%), couples (17.2%), club members (16.6%), co-workers (9.4%) and family members, such as siblings (3.7%). Similar to the activity selection diversity, we calculated the entropy with regard to relationship diversity. The results showed that most of the users tended to focus on one or two relationships ($M = 0.18$, $SD = 0.24$); they were likely friends, couples, and club members.

When and Where?

We analyzed diurnal and weekly usage patterns. Overall, usage amounts during the weekends were longer than those during the weeks (week: $M = 1113.2$ hours, $SD = 125.47$ *vs.* weekend: $M = 1415.52$ hours, $SD = 75.23$). In addition, usage increased during nights and evenings (18:00 – 06:00), as shown in Table 2. These temporal patterns were possibly related to the primary activities during those periods. As illustrated earlier, the primary activities included mostly studying, club activities, and working. These activities generally occurred after the participants' daily routines were completed.

We analyzed the common places for group limiting and the frequency of co-located use limiting. In the exit survey, we asked "Where did you usually limit smartphones with Lock n' LoL?" The most common places were study rooms (e.g., libraries; 42.6%) and classrooms (14.8%). Also listed were places for socializing such as cafes (15%) or restaurants (8%). The diversity of common places for group limiting tended to be skewed into one or two places (but, relatively more diverse compared with the results for activities and relationships). The average entropy value was 0.24 (SD = 0.24). Next, we analyzed whether the group-limit mode was activated in co-located or remote situations. Even when members are physically separated, they can still use Lock n' LoL together to focus on the same activity in different places. We analyzed WiFi-fingerprints from the Lock n' LoL usage log data. The group limit attempted was considered a colocation if at least one fingerprint overlapped between two group members. Surprisingly, the majority of group limits were performed remotely, whereas only 23.8% occurred in a co-located setting. While co-location frequency was low, our later statistical analysis indicated that co-location was a critical factor for continued service engagement.

Predictors of Engagement

We performed a regression analysis to study how use limiting behavioral characteristics (i.e., activity, social relationship, temporal usage, and location of use) were related to an individual's engagement (e.g., daily usage duration and frequency of a user). We first considered two independent variables representing limiting engagement: (1) the duration of the group limits per user/day and (2) the frequency of the group limits per user/day. We normalized the duration since the users had heterogeneous start dates. Next, the usage behavioral characteristics reported in the previous section were used as independent variables as follows:

- **Activity:** Activity selection rate (*A_StudyRate*, *A_WorkRate*, *A_EatRate*, *A_ChatRate*, *A_DatingRate*, *A_OtherActivityRate*) and activity diversity (*A_ActivityDiversity*). For the activity selection variables, we divided the number of activity selections by the total number of the limit trials.
- **Relationship:** The average number of members in the group-limit mode (*R_GroupSize*), proportions of relationships (*R_FriendRate*, *R_CoworkerRate*, *R_ClubmemberRate*, *R_FamilyRate*, *R_CoupleRate*); the diversity of relationships (*R_RelationshipDiversity*); and the proportion of co-located members for limits (*R_ColocatedRelationship*).

	Daily Limit Duration		Daily Limit Freq.	
	Beta	Sig.	Beta	Sig.
P_Gender	-	-	-.109	.021
A_StudyRate	.218	.001	.193	.002
A_OtherActivityRate	.156	.004	-	-
A_ActivityDiversity	.216	.000	.265	.000
R_ClubRate	.144	.003	-	-
R_FamilyRate	.125	.008	-	-
R_RelationshipDiversity	-	-	.175	.001
R_ColocatedRelationship	.180	.000	.103	.030
T_MorningRate	.203	.000	.115	.016
L_ClassroomRate	.161	.001	.112	.046
L_LocationDiversity	-	-	.100	.091
R^2	.203 ($p < .000$)		.195 ($p < .000$)	

Table 3. Multiple regression analysis results: Predictors of Engagement (For P_Gender, female and male are coded as zero and one, respectively).

- **Temporal usage:** The proportion of limiting time during weekdays over the entire limiting time (*T_WeekRate*) and diurnal usage proportions (*T_NightRate*, *T_MorningRate*, *T_AfternoonRate*, *T_EveningRate*).

- **Location:** The proportion of the favorite location choices in the survey (*L_StudyroomRate*, *L_ClassroomRate*, *L_CafeRate*, *L_RestaurantRate*, *L_LoungeRate*), and the location selection diversity (*L_LocationDiversity*).

A series of multiple linear regressions were conducted based on the engagement of limiting behaviors with Lock n' LoL (i.e., daily limiting time and frequency). We used the stepwise method for the variable selection. All the regression models were significant, and their R-squared values were comparable to those of earlier studies [23, 52]. We noted that our regressions models were safe from multicollinearity. The Variance Inflation Factor (VIF) for every independent variable was lower than the benchmark 10 [15, 28], which indicated multicollinearity. The highest value was 1.975. Table 3 shows the summary of our regression analysis results.

Several Lock n' LoL usage patterns significantly reflected the duration of limiting time with Lock n' LoL. First, we found that three relational usage variables (i.e., ColocatedRelationship, Family, and ClubMembers) were significantly and positively related to the limit duration. This could indicate that the participation of the members who met regularly and physically contributed to longer limiting behaviors. In addition, relationships such as family and club members were more engaging possibility due to meeting pattern regularities.

The diversity of activity selection was positively related to the duration of limiting time; users' attempts to diversify its usage scenarios positively influenced the duration. Furthermore, we found that those who more frequently limited smartphone use in the morning (06:00 – 11:59) likely revealed a longer period of overall limiting behaviors. The limit attempts in the classroom were the strongest predictors of longer limiting duration. In sum, the duration of the limiting behaviors was considerably related to repeated schedules (e.g., taking classes, club-activities) and regular offline meetings (i.e., colocation, family, and club members), possibly with diverse activities.

The frequency of limiting behaviors was also significantly Lock n' LoL usage patterns. In one regard, some usage variables, such as the use in classrooms, co-location, and morning hours, were positively correlated with the limit frequency as in the duration model. This is probably due to the high correlation between the limit frequency and the limit duration (corr. = .701, $p < .000$). Conversely, unlike with the duration, the frequency was significantly correlated with the gender variable, i.e., females tended to show more frequent limiting behaviors. More importantly, we found that diversity (i.e., activity, relationship, and location) was important for predicting the frequency of limiting behaviors. In sum, the usage patterns related to the limit frequency were similar to those of the limit duration. While the regularity of the limiting events was important to the limit duration, the diversity of the limiting contexts was a stronger limit frequency predictor. Users who frequently limit their use tended to show their limiting behaviors in diverse situations for diverse purposes rather than frequent trials in limited contexts.

DISCUSSION AND CONCLUSION

Dealing with Technology Distractions

We measured the users' active engagement in limiting behaviors with Lock n' LoL during the campaign. Our campaign results indicated that many smartphone users experienced smartphone distractions; however, they were willing to manage these distractions in their diverse situations. This aligns with the results of prior surveys regarding smartphone distractions [26, 32].

In addition to smartphone distractions, several other technological distractions exist in our lives. This phenomenon could become more serious with the advance of these ubiquitous technologies. Therefore, we believe that it will become increasingly important for designers and researchers to address these technological distractions. In particular, it would be interesting if technological distraction studies considered the different characteristics of these diverse devices (i.e., PCs, smartphones, or smartwatches). As the number of devices around users increases, it could be necessary to provide interactive tools for easily managing diverse distractions from multiple sources.

Engaging in Group-Limiting Behaviors

Our regression analysis results showed that several usage patterns were significantly related to engagement in limiting behaviors. In particular, the engagement in limiting behaviors was related to regularity such as repeated schedules (e.g., taking classes, club activities). Therefore, offering a timely reminder about regular events and meetings can be helpful for encouraging limiting behaviors and forming limiting habits. Location-aware techniques can be utilized to detect particular places in which limiting behaviors frequently occur and provide timely recommendations when users enter the location. However, the designers of such reminders would need to be careful that the reminders themselves do not distract users.

We also determined that the relationship factor was considerably important to limiting behaviors. For example, those who had regular offline meetings (i.e., co-location, family, and club members) were likely to show longer periods of limiting behaviors. In addition, we found that some users cited difficulties with enabling the group limit mode due to the strong power-distance (the extent to which the less powerful members expected that power was distributed unequally [18]). For example, an academic teacher obligated his middle school students to install Lock n' LoL, and used it to monitor/control their usage during the class. Even though the teacher's intention was good, these students might not have enjoyed the app. Another case involved a graduate student who wanted to use Lock n' LoL with his seniors or advisors. However, due to hierarchical social cultures in Korea, this kind of usage became mandatory, and they tended to feel too much pressure from seniors or advisors. Further studies should be centered on the design of effective group limiting assistance tools when power distances exist among the group members.

Supporting for Temporary Non-Use Behaviors

Our formative study indicated that many people were concerned about possibly missing important messages/functions when smartphone usage was limited. Furthermore, smartphones are sometimes necessary for group activities. Thus, it is not always effective to entirely limit their use, and it is important to balance enforcement with flexibility. In our case, for flexibility, we proposed the group limit mode that allows a user to decide to start or quit, but used peer-pressure to limit usage. Also, as the prior study suggested [26], we put significant effort into creating a design that allowed users easily decide (not) to use a smartphone based on situations rather than just simply locking the screen. We conducted an iterative design process, resulting in flexible assistance for limits according to user feedback (Ver. 1: allowing for screen checks, receipt of incoming calls, and use with other's permission; Ver. 2: temporary self-use for five minutes per limiting session; Ver. 3: temporary self-use for five minutes per hour). In our exit survey, most of the users were satisfied with this feature while some users reported that they desired a more refined control for the degree of flexibility. For example, one user wanted to be allowed to use particular apps related to productivity (e.g., dictionary/map). It would be interesting to study refined settings for limiting smartphone usage.

Furthermore, balancing enforcement with flexibility would be related with the duration of limiting behaviors. In our case, limiting behaviors occurred mostly for group activities that typically tended not to last a long time (67.8% lasted less than 90 minutes). In prior work about email disruption [21], the participants were asked to mute their email notifications for a week. In this case, their concerns and inconvenience would be relatively more serious thna ours; their study results showed that the participants tended to turn on the notification setting again after the limiting experiment. Therefore, the duration of targeted limiting behaviors should be considered in designing limiting assistance tools.

Regarding this, we extended discussions in conventional non-usage studies [5, 17] that primarily focused on identifying users who decided to stop using the technology and on understanding their motives. We addressed the needs of understanding the "users" who opted to become "non-users" depending on the situation. Earlier technology non-usage smartphone users tended to still remain "users," even though they demonstrated limiting behaviors in particular contexts. Therefore, to better understand the practice of smartphone non-usage, it may be helpful to consider both when users need to use the technology and when they want to limit the usage.

Limitations and Future Work

The generalizability of our work could be limited because it was carried out at a single site in Korea. Hence, additional research in various sociocultural backgrounds is required. However, we believe that Lock n' LoL is not limited to Korea and can work well in other nations. For example, a prior study showed that maintaining smartphone self-regulation is challenging among Korean college students [26], and we note that usage limiting behaviors are also observed in other nations as well (e.g., PhoneStack [45]). There are also other studies performed in different nations, showing that limiting smartphone use can improve the quality of social interaction such as closeness and connection [43, 49].

In addition, our study results should be carefully understood because most of the participants were college students even though we found that Lock n' LoL tends to work well with some other groups such as couples, families, and co-workers. Further studies should certainly be conducted with differently targeted users to confirm whether Lock n' LoL works well in other group settings. For example, we found that Lock n' LoL may need some improvements for particular groups. As we discussed, some user groups, such as teacher-middle school student or boss-worker mentioned their difficulty of enabling the group limit mode due to the power-distance. Also, it would be interesting if group specific study performed such as limiting smartphone usage among couples. For example, we found that either of a couple in our study usually plays a role of initiating the group limit by sending verbal requests via instant messaging. Also, some couples mentioned that the group limit in separated places at midnight makes them relieved because they felt that a partner focuses on one another.

Finally, it would be interesting to analyze how the participants' overall smartphone usage has changed through Lock n' LoL use. For analyzing overall usage, it is required to install logging software to participants' smartphone. In this study, we decided to exclude this to minimize experimental bias due to privacy concerns from usage logging. However, further study with overall usage data can more reveal how the participants limit and use their smarpthones in their daily lives.

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