

FamiLync: Facilitating Participatory Parental Mediation of Adolescents' Smartphone Use

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ABSTRACT

We consider participatory parental mediation in which children engage with their parents in *activities* that encourage both parents and children to participate in co-learning of digital media use. To this end, we developed FamiLync, a mobile service that treats *use-limiting* as a family activity and provides the family with a virtual public space to foster social awareness and improve self-regulation. A three-week user study conducted with twelve families in Korea (17 parents and 18 teenagers) showed that FamiLync improves mutual understanding of usage behavior, thereby providing common grounds for parental mediation. Further, parents actively participated in use-limiting with their children, which significantly increased the children's desire to participate. As a consequence, parental mediation methods and parent-child interaction in relation to smartphone usage changed appreciably, and the participants' smartphone usage amount significantly decreased.

ACM Classification Keywords

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

Author Keywords

Adolescents' smartphone overuse; parental mediation; participatory learning

INTRODUCTION

The recent explosive increase in smartphone adoption and use by adolescents has been accompanied by sharp concerns about the negative aspects of unregulated smartphone usage, such as sleep deprivation [1], and attention deficit [14, 35]. As a result, many parents have some level of anxiety and discomfort regarding their children's use of smart devices, although, for personal enrichment, they want their children to be competent with digital tools. Because a large proportion of youth engagement with new media occurs in the context of home and family life, parents seriously desire to guide and regulate their children's participation in this new media ecology [12, 19, 45]. Many studies have reported that appropriate parental mediation can mitigate the negative aspects of digital media [10, 37]

and help to develop digital literacy (or practical abilities in the use of digital devices) [3].

Given that the use of smartphones by young people often causes disruptions in school and family life, parents are anxious to counter such distractions from activities that they believe are more important such as schoolwork, household chores, and other productive activities [19]. The results of a preliminary survey conducted by us (105 parents in Korea) showed that most parents rely on restrictive rule-setting—for example, asking their children to limit smartphone use while they are having meals, studying, or in bed—to achieve their objective. However, many parents have difficulties guiding their children's smartphone use, and they often face conflicts with their children as over-engagement and various usage needs in diverse contexts make it difficult for parents to consistently enforce restrictive rules. Moreover, the personal and portable nature of smartphones make parental supervision challenging. Although some parents utilize parental apps that provide various kinds of restrictive functions (e.g., remote monitoring, blocking), we have found that such intrusive software tools often intensify conflicts, thus, reducing the effectiveness of such tools.

In this paper, we discuss how participatory parental mediation of smartphone usage by adolescents can overcome restrictive and unilateral mediation approaches. Clark [12] stated that one emergent parental mediation approach in the digital age is *participatory learning*, in which children engage with parents in *activities* that encourage both parent and child to participate in co-learning of digital media use. This method allows parents to maintain a positive parent-child relationship through *conversations* and to learn *from*, as well as *with*, their children. Such collaborative approaches have been found to be effective in diverse parenting scenarios, such as Internet services [31], and smart tablet use [18].

However, several unique characteristics of smartphone usage make existing participatory strategies difficult to use. Sharing usage contexts is required to provide understanding of usage behavior that can facilitate family conversations (equivalent to looking at the same computer screen together) [18, 31]. But smartphone use is primarily individual and mobile, such that usage contexts tend to be less social, as pointed out by Had-don [16]. Furthermore, as shown in our survey, self-regulation of smartphone usage is a challenging task for teenagers, as well as for *distracted parents* [41].

To overcome these obstacles, we developed FamiLync, a participatory parental control service that considers *use-limiting*

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as a family activity—e.g., while having dinner together, parents and teens are not using their smartphones. Use-limiting was chosen because it is the most extensively used rule for parental mediation according to our survey, and it effectively addresses the major concerns of parents about disruptions to school and family life. FamiLync contains a virtual public space for the family in which social awareness on smartphone use is maintained (i.e., usage/limiting statistics, checking app information). It also provides a use-limiting tool that helps family members to regulate their own usage (i.e., by locking screens and selectively blocking notifications).

We developed FamiLync by performing iterative prototyping involving several rounds of low-fidelity prototype tests and one high-fidelity prototype test round (four families in Korea, $n = 11$). In order to evaluate the effectiveness of FamiLync, we conducted a user study (twelve families in Korea, $n = 35$) for three weeks. In the user study, we quantitatively and qualitatively investigated changes in parental mediation of smartphone usage after FamiLync use. Our results showed that members of the family were able to better recognize their usage patterns with FamiLync's self-monitoring support. FamiLync improved mutual understanding of usage patterns and facilitated discussions on each member's smartphone usage, which provided common grounds for usage intervention. We found that parents typically allowed their children increased independence on smartphone usage (e.g., use location and content type), and they actively participated in use-limiting with their children, which significantly motivated their children's continued participation. Overall, FamiLync significantly reduced smartphone usage amounts and facilitated improvements in parent-child interaction and parental mediation of smartphone usage.

BACKGROUND AND RELATED WORK

We reviewed related work on parental mediation in the use of various media, as well as recent human-computer interaction (HCI) studies related to parental mediation. We also examined various types of parental controls and usage-limiting software.

Parental Mediation of Media Use

Studies on parenting and media usage have evolved over time. Early studies primarily focused on understanding parental strategies to regulate television viewing and video game playing. Parenting styles regarding television viewing [3, 46] can be classified into three: (1) *active mediation*—actively discussing positive and negative aspects of the media while watching television together; (2) *restrictive mediation*—setting rules that restrict usage, such as the amount of viewing time; and (3) *co-viewing*—staying with the child while watching television without commenting upon the content or its effect. These three parenting styles are similarly observed in parental strategies to regulate video game playing [20, 39].

The advent of Internet technologies has resulted in parental regulation of media use becoming more challenging. Livingstone [31] showed that, unlike the case with a television, it is difficult to make Internet use a shared activity because of constraints related to usage (interactive and multi-tasking), physical (smaller screen), and location (small room). Such characteristics lead to very different mediation strategies:

(1) *active co-use*—actively engaging in helping and regulating Internet use (e.g., rule-setting and guidance); (2) *interactional/technical restriction*—restricting online interactions (e.g., banning chats) and/or enforcing such restrictions using filter software; and (3) *monitoring*—intermittently checking a child's Internet activity. Further, Nikken [39] identified a style of supervision in which parents allow children's computer use when they are present because the location of use is typically fixed in the case of computers.

A few recent studies have investigated methods of regulating the use of mobiles by teenagers [12, 16, 33]. Haddon [16] stated that, the portability, utility, and personal nature of smartphones, have resulted in children spending more time online, and parental surveillance becoming more challenging. In an exploratory study of Italian families, Mascheroni [33] found that children tended to negotiate, resist, or ignore parental mediation of their smartphone use. Conflicts often arose because of parents' lack of shared understanding, technology competence, and experience in parental mediation of smartphone usage [12]. Understanding media usage by children is critical for effective parental mediation because media ecologies frame the technological and social context for media usage (e.g., communicating, producing, and sharing). Ito et al. [19] showed that children's engagement in digital media can be characterized by friendship-driven usage (e.g., social networking sites, instant messaging) and interest-driven usage (e.g., online gaming). Consequently, *participatory learning*, in which children engage with parents in *activities* and both parents and children participate in co-learning of digital media use [12] is an emerging parental mediation approach in the digital age. In this paper, we demonstrate the feasibility of implementing participatory parental mediation smartphone use by adolescents via computer-mediated services.

HCI Research Related to Parental Mediation of Media Use

In recent years, there has been significant growth in the use of online media (e.g., social networking, mobile games) and smart devices (e.g., smartphones, smart tablets), which makes parental mediation even more challenging. Along with these changes, HCI researchers have investigated the complex nature of parental mediation [48] and also attempted to design new parental mediation software [18, 43]. Yardi and Bruckman [48] performed a study on parental strategies regarding social media use by teens and identified the rules of regulation. They emphasized the importance of balancing the needs of parents to monitor and manage usage with the needs of children to maintain the agency and autonomy that children need to develop into self-dependent adults. This observation led them to propose the concept of a digital window through which children's online activities are shared with parents, while private details remain hidden, in order to strike a compromise between parental control and autonomy of the children; this design trade-off is known as social translucence [15]. This concept motivated our research into parental mediation of smartphone use, but we significantly extended it by considering the unique challenges of smartphone use by teenagers and a theoretical framework for participatory parental mediation.

ParentNet is an online social network site that allows parents to share information about their children's social media us-

age [43]. ParentNet adopted popular features from well-known social networking services and developed additional custom features such as school feeds. Studies conducted with focus groups following actual deployment at a private middle school revealed that parents appreciated its function of keeping up with changes in social media and updates in school policies, but they did not contribute significantly to ParentNet owing to lack of time and the conversion from existing school communication platforms required. Hashish et al. [18] designed We-Choose, a parental mediation tool for controlling content on the smart tablets of young children aged six to eight years. Unlike existing restrictive methods of mediation, We-Choose supports collaborative rule-setting by facilitating discussion on the appropriateness of apps, and helping children to review their choices and reinforce learning with an educational game. They found that the collaborative approach promoted discussions and made the education process more enjoyable and approachable. However, these studies would be directly applied to the regulation of teens smartphone usage because of the difference in the characteristics of smartphones as opposed to smart tablets (such as portability, functionality, and personal nature). Our goal is to enable participatory parental mediation by implementing a virtual public space for social awareness on smartphone use, and a support tool for assisting in use-limiting to improve self-regulation of smartphone use and to foster social interactions.

Parental Control and Usage Limiting Apps

We examined ten popular parenting apps in the Google Play Store (i.e., MoMoLang, KidsManager, MyKidsTalk, Tele-Keeper, xKeeper, KidsCare, Kytetime, NetNanny, Qustodio, and SmartSheriff) and identified two key features: remote monitoring and remote locking. Monitoring features allow parents to remotely monitor a child's smartphone usage, such as total amount of usage time and the usage amount per app. There are several parental apps that support content monitoring (such as the checking of URLs and messages) and context monitoring (such as identifying a child's location). Locking some specific apps by remote control is also quite prevalent. This feature is related to rule-setting; most of the parental apps allow parents to set detailed rules, such as blocking use for certain times of the day or selecting the apps to be locked.

Our work differs from existing parental control software in that our aim is to implement participatory parental mediation. In our system, all family members share their usage in the family's virtual public space (called the family dashboard)—we carefully considered the trade-off between visibility and privacy of family members. Furthermore, we extended the earlier studies on limiting technology by providing a tool that allows family members to limit their usage together and to easily browse usage statistics and unknown apps. The concept of virtual public space and use-limiting activities raises interesting research issues pertaining to how computing technologies can facilitate effective parenting strategies.

In addition to parental control, there are mobile applications designed to limit smartphone use. Recently, significant attention has been paid by the HCI community to understanding and assisting methods of limiting technology use (or even non-use) in diverse domains [6, 7]. As regards limiting smartphone

usage, AppDetox [32] allows users to establish usage-limiting rules by specifying apps and locking times. NUGU [24] allows groups of people to engage in limiting their smartphone use by sharing their usage information. SAMS [27] provides useful functions for monitoring and locking usage, involving interaction with clinicians who can treat the problematic usage behavior. There are also several mobile apps that aid self-regulation and limiting of smartphone use by adopting diverse intervention mechanisms, such as pop-up alarms, locking apps/screens, self-monitoring, and encouraging motivation (e.g., cheery messages or photos). Although these services offer various strategies for limiting smartphone use, they were not designed for parental mediation. In contrast, our work builds upon these services to demonstrate the feasibility of participatory parental mediation.

PRELIMINARY STUDY

We performed a preliminary study to better understand parental mediation on teenagers' smartphone use, and from this, we draw several practical design implications. We conducted an online survey of parents who have teenagers in order to understand the general parenting methods on their children's smartphone use. Our survey content consisted of three parts (using a Likert scale and open-ended questions). We first asked about parenting contexts, such as parents' primary concerns and their parenting methods. We then inquired about the parental app usage. We finished the survey with demographic questions. The survey was posted in two large Korean online communities, i.e., Clien (IT portal) and 82cook (food/cooking). We had 105 valid participants who completed all of the questions. The participants consisted of 10 males and 95 females (age: $M = 43.24$, $SD = 4.01$). The high level of mothers' participation reflects that mothers' role is critical for parenting since mothers mostly structure children's activities and enforce the family rules and regulations [19]. Their children's average age was 14.55 years, and most of the children had used a smartphone for about three years.

Parental Mediation of Smartphone Use

A large fraction of the participants (77.14%) agreed that they had concerns about their children's smartphone use. The primary concerns were related to their children's unregulated smartphone usage (85.71%), which can potentially disrupt sleeping, studying, and family time. Another prevalent concern was that children have easy access to harmful content through their smartphones (54.29%). These concerns often led the parents to mediate their children's smartphone use. Most of the participants (78.10%) reported that they have experiences of mediating their children's smartphone use.

We asked the participants about their primary parenting methods with an open-ended question. Two researchers conducted affinity diagramming on the responses, and found that most parents relied on restrictive rule-setting to regulate usage. There were diverse conditions in which restrictive rules were set regarding time of day, total amount of usage time, types of content, and locations of use, which were consistent with the earlier study [48]. In particular, limiting use based on time of day (usually associated with some activities) is the most widely used method; e.g., limiting smartphone use while studying or in bed. Most parents verbally instructed their children

to enforce the rules. There were also families that employed parental apps (e.g., blocking usage), and physical separation (e.g., putting a phone in a shared space such as a dining table).

We then investigated the effectiveness of the parental mediation strategies. We asked parents to gauge the effectiveness on a five-point Likert scale: 40.86% answered “neutral” and 38.71% answered “(strongly) ineffective.” In a subsequent question, we asked for the detailed reasons. Most of the parents reported that it is often difficult to enforce the rules because of their children’s rebellious attitudes. Furthermore, they concurred that their children were already highly dependent on smartphone use: “*We have rules, but he cannot finish within time when playing games.*” Some of the parents expressed difficulties owing to smartphones’ unique characteristics (i.e., their portable and personal nature). Parents cannot always enforce rules because smartphones can be used almost anywhere and anytime, and face-to-face interactions typically occur only at home. Furthermore, the children often tended to ask for exceptional use. For example, they often request use permission to look up a dictionary, to contact friends for homework, and to check class announcements, which often leads to conflicts and makes strict rule enforcement difficult. As a result, 69.52% of the participants reported that they have had conflicts with their children due to smartphone use.

In contrast, 20.43% of the participants reported that their methods were (strongly) effective. Most parents commented that the rules were typically set collaboratively (e.g., usage planning, discussing negative aspects of overuse), and the children made an effort to follow the rules. The parents also needed to demonstrate good usage behavior, as one parent commented, “*When parents are with their child, they should not use their smartphones or at least use it in a planned way.*”

Parental App Use

The second part of our survey was about the use of parental control apps. Among our participants, 27.62% reported that they had used a parental app at least once. There were diverse responses concerning the effectiveness of the parental apps: effective (27.59%) and ineffective (36.84%). Parents commented upon the helpfulness of remote and real-time parental controls (monitoring and locking) that allow them to monitor or block the child’s usage anytime and anywhere. However, parents complained that it was not easy to install and maintain the parental apps on the child’s smartphones. Some parents stated that their child became very rebellious when they tried installing the app. Another parent commented that her child strongly disliked the sense of being monitored. As shown earlier, due to the exceptional use requests, it is difficult to set stable rules, and thereafter the parents are demotivated to keep mediating their children’s smartphone use.

Summary and Design Implications

Our study showed that parents’ primary concern about their children’s smartphone use was related to distraction in studying, family time, and sleeping. We found that most parents relied on restrictive methods based on time of day, total amount of usage time, types of content, and locations of use. However, many parents perceived their parenting methods (including

parental control apps) as less effective, mainly due to difficulties in compelling the child to follow the restrictive rules (e.g., the teenagers’ rebellious behavior) and the contextual characteristics of smartphones (e.g., personal/social reasons, portability of use).

Our results also showed that collaborative rule setting was effective for self-regulating media usage. This collaborative method has been also found effective in diverse domains such as Internet [31], and smart tablets [18]. As suggested by Yardi and Bruckman [48], collaborative approaches can be effective for balancing parental control and child autonomy. Furthermore, Clark [12] showed that an emerging parental mediation approach in the digital age is *participatory learning* in which children engage with parents in *activities* that foster interpersonal relationship rooted in dialogue (similar to the parental strategy of active mediation) as well as individual and collaborative creativity. This approach encourages both parents and children to participate in co-learning about media use—parents maintain a positive parent-child relationship through *conversations* and aim to learn *from* as well as *with* their children. The participatory learning framework significantly extends Bandura’s social learning theory of parenting that views parents as role models [4].

Prior studies were focused on shared devices such as computers and tablets to enable participatory parenting (e.g., We-Choose [18]). However, there are two unique characteristics related to mediation of smartphone use that make existing participatory strategies difficult to use. First of all, sharing usage contexts (e.g., looking at the same screen together) is necessary to improve the mutual understanding that facilitates social interactions [18, 31]. But smartphone use is usually individual and mobile, such that usage contexts tend to be less social, as pointed out by Haddon [16]. As shown in the survey, self-regulating smartphone usage is a challenging task for teenage children. Likewise, self-regulation is considered to be challenging to *distracted parents* as well [41]. In the next section, we present a mobile service that is designed to deal with these issues and enable participatory learning in parental mediation of smartphone use.

FAMILYNC DESIGN

We introduce FamiLync, a participatory parental control service. FamiLync considers *use limiting* (not executing/using smartphone apps) as a family activity in which each member self-monitors their own usage and tries to self-regulate their usage. FamiLync provides a family with a virtual public space through which social awareness of smartphone use (e.g., usage/limiting statistics, checking app info) is maintained, and a use limiting tool through which use limiting activities can be effectively performed, thereby leading to continued participation of self-regulated smartphone use.

For the software design, we used iterative prototyping that includes several rounds of low-fidelity prototype tests and one round of a high-fidelity prototype test. For the latter, we conducted a week-long field trial with four families in Korea (five parents and six teenagers). To hire participants, we contacted a high school teacher, and he introduced four families to us. The four families used the early prototype for a week, and were invited to focus group interviews. In the focus

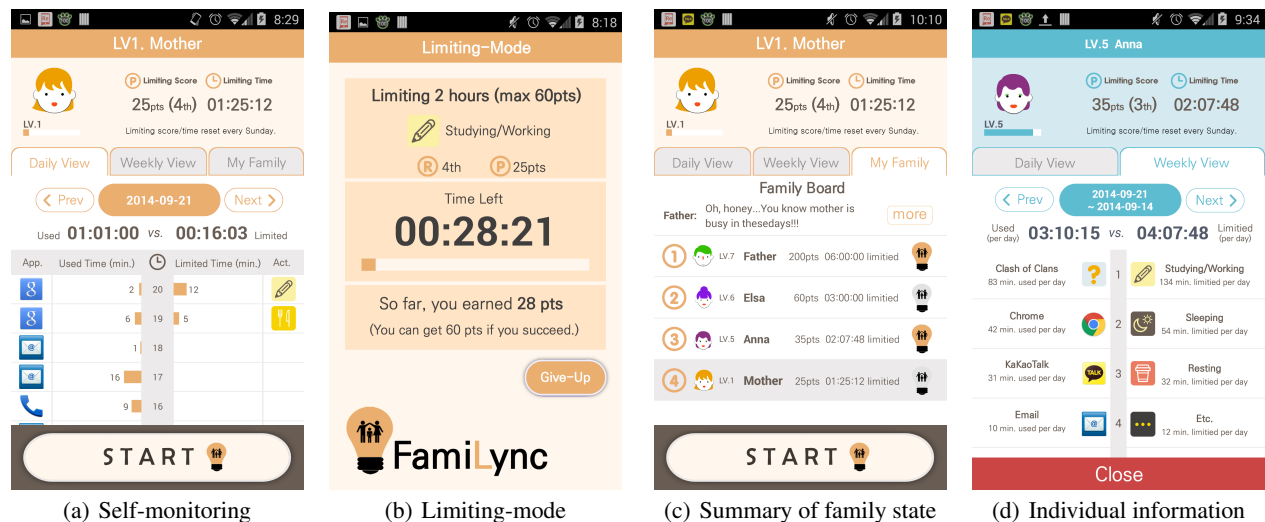


Figure 1. User interfaces of FamiLync.

group interview, we asked them about usage experiences of FamiLync in their parental mediation as well as its usability issues. Each family was compensated with a \$50 gift card. Focus group interview results were analyzed to improve the design of FamiLync. Figure 1 presents the final prototype of FamiLync.

Enabling Family Activities of Use Limiting

We followed the approach of improving self-regulation, as in [24, 27, 32], and mainly considered two design components: self-monitoring of usage/limiting behaviors and goal-based use limiting.

Self-monitoring of usage and limiting behaviors

The first part has a user's profile at the top of screen (screen name, level, weekly points, and weekly limiting time), which allows the user to understand the overall status of their limiting behavior (See Figure 1(a)). Furthermore, two different views are delivered to display usage and limiting information. The interface shows the information of the day through a comparative view of usage data (i.e., hourly usage time and the apps used in that hour) and limiting data (i.e., the amount of usage limiting time and the representative activity that a user performed while limiting the usage). This comparative view helps users to easily compare their usage and recent limiting behavior. We allowed users to navigate to different dates and to check for more detailed information by clicking the hours (in a popup window).

FamiLync also delivers weekly information by showing the top five representative apps (an app icon and usage time of the app) and the kinds of activities users pursued during their use limiting (an activity icon and limiting time of the activity) for the last week. This option was based on the parents' feedback. Initially, we provided only a daily view, but parents commented that weekly views of the usage and limiting behaviors will help them understand children's general usage patterns.

Goal-based use limiting

The goal-based use limiting part is designed to help users to deal with habitual or externally cued usage (e.g., notifications) which often causes less regulated smartphone use [30], particularly when users decided to limit use. Users are allowed to set a limiting goal (called a *limiting mission*) using the start button shown at the bottom of Figure 1(a).

For the goal setting, a user is first asked to set a time duration of use-limiting (ranging from ten minutes to two hours). In order to motivate users to select a longer time duration, we used point systems in which the user can earn points proportional to the use-limiting duration. With such a point system, we expect that their intrinsic and social motivation can be increased [40]—even though the points itself do not have any actual material value, earning the points acts as their gratifications and provides opportunities to boast their limiting effort to others.

The goal setting is finished after the user chooses the activity to perform while limiting smartphone usage (e.g., study). We mandated users to input the current activity because specifying the context can help users to concentrate on their goals (in our case, it is the specified activity). Furthermore, this information can be used for self-monitoring, which helps users to track their activities associated with use-limiting. FamiLync offers five activities, i.e., studying, working, eating, chatting, and sleeping, and additionally, one miscellaneous activity option. Our prior work [24] inspired us to use these options, and this design choice was confirmed in our pilot study.

When goal setting is finished, the app switches to the limiting mode, shown in Figure 1(b), that forbids execution of any apps (except receiving incoming calls). The limiting-mode screen displays the current progress of the mission (e.g., remaining time, the user's points/rank). The limiting mode always overrides any apps, except checking a notification drawer (to allow users to make an informed decision about giving up). The user can give up on a mission if smartphone usage is necessary (by clicking a give-up button); however, points are earned in proportion to the duration of use limiting. Whenever a mission

is accomplished, FamiLync praises the user for the accomplishment and awards special bonus points as a behavioral reinforcement.

Enabling Family Awareness of Usage and Limiting

Another component involves the support of sharing usage and limiting information to provide family awareness. Our design was inspired by the concept of a family window that shares information about social interaction with family members [48]. We significantly extended the concept to fit our design context (i.e., participatory learning of smartphone usage). The sharing component consists of two screens: i.e., a family dashboard and a screen with detailed information for an individual.

Family dashboard

This screen is designed to help users to learn the overall limiting states of the family at a glance (See Figure 1(c)). Basically, a family has a scoreboard on which family members are ranked based on each member's weekly points; the rank is reset when a new week begins. Furthermore, we provide a social indicator that enables family members to check each other's current limiting status. This indicator icon is located at the right side of the scoreboard. It is highlighted whenever a member starts the limiting mode. This real-time update helps family members to know each other's limiting behavior and facilitates their collaborative effort: e.g., a father recognizes that a son set a one-hour limit to allow him to study, or the son notices that his mother set a two-hour limit for family time.

Furthermore, there is a family chat board that allows members to communicate with each other in a textual form. This board was considered to meet the needs of the participants after the pilot study: our participants commented that the chat feature will help them to set common limiting rules or goals among family members, and also allows parents to encourage children. The screen shows the most recent message on the chat board; all the messages posted before can be accessed if the area of the recent message is clicked.

Detailed information about an individual

We designed another screen to display detailed information about each individual, such as daily/weekly usage and limiting information that cannot be covered in the summary screen. For the design of this screen, the most important issue is to determine the level of personal information disclosure. We adapted the guideline of social translucence to a family setting [15, 48] by making significant information visible, but hiding personal details. Research showed that, although sharing fine-grained information can be helpful for parental surveillance, it could negatively affect the development of autonomy in the adolescents [13, 48]. Thus, it is important to strike a balance. We initially hypothesized that app-level usage sharing (e.g., when a user used which app, and for how long) would be more appropriate than content-level usage sharing (e.g., URL and media contents) or sharing only total usage amounts. We confirmed this hypothesis in our pilot study. All the participants were satisfied with this level of sharing. One parent said, *"I think this level of information needs to be shared in order to understand each other and to make efforts together."*

Figure 1(d) shows a user interface that is used to display detailed information about an individual. Family members can

check others' detailed information by clicking on a person's user ID on the summary screen. The screen provides two comparative views for one day and one week, similar to the screen for self-monitoring. However, unlike the case of self-monitoring, when examining others' app usage, it would be difficult to quickly understand their usage patterns only by looking at their icons. There may be apps with which users are unfamiliar. The parents and their children have different usage patterns (e.g., game apps that the parents do not know); more descriptions of apps need to be provided for better understanding. To address this problem, our design highlights unknown apps (i.e., those not installed on one's own smartphone) by using a question icon with the app name; clicking this icon allows users to see a more detailed description of the app from the app market place.

EVALUATION

We performed a within-subject experiment to evaluate the effectiveness of FamiLync. We recruited twelve families from a high school in Korea (17 parents and 18 teenagers who use Android OS). Initially, we were introduced to eleven families by teachers in a high school (advertised via a school newsletter). After one week of the pre-intervention period (during which usage data was logged), we introduced FamiLync to the families. At that time, one new family (one parent and one child) and five additional family members from the existing families wanted to join the experiment; we accepted their requests. The parents were 11 mothers and six fathers; their ages ranged from 40 to 60 ($M = 47.65$, $SD = 4.55$). The children were 14 boys and four girls whose average age was 16.39 ($SD = 1.50$).

By refereeing to the experiment design guidelines [17], we designed a quasi-experiment that was conducted for three weeks: one week for the pre-intervention period and two weeks for the intervention period. At the start of the pre-intervention period, all the participants were remotely instructed to install a usage-logging app in Android (via KakaoTalk, a mobile instant messenger). The usage-logging app runs in the background and collects the usage data regarding when a user executed an app, which app was executed, and how long it was used. The usage-data collection continued for the entire experiment. The pre-intervention period finished by asking participants to complete two surveys about parenting styles and parent-child interaction on their children's smartphone use (see below). Note that the priming effect of our pre-survey is minimal in our in-the-wild experiment, because prior studies confirmed that priming is short-lived, generally disappearing soon after exposure to the stimulus [42, 44].

Next, the intervention period began with a face-to-face orientation in which the participants learned how to install and use the intervention apps. After the orientation, the participants used FamiLync for two weeks at their own discretion and no further usage mediation was conducted. We synchronized the intervention period such that participants wait up to a few days. After the intervention, we asked the participants to complete the same surveys and conducted an exit interview for each participant. The interviews were semi-structured: we prepared questions about how and why they used FamiLync (e.g., self-monitoring, sharing usage, use limiting, and parent-child

interactions) and what features were effective (or not). Each family was compensated with a gift voucher worth 100 USD.

Metrics

First, we used a logger to objectively measure smartphone usage. The measures included the total usage time and the number of app executions. Our usage-data analysis was conducted on the 27 participants whose usage data were successfully collected during the pre-intervention and intervention period. Note that we excluded the seven participants who joined the experiment later in the intervention period and the one participant whose usage data was lost due to a technical problem with his smartphone.

Second, we measured the domain-specific parenting styles regarding smartphone usage by customizing the Parental Authority Questionnaire for Koreans (K-PAQ) [28] (original version [9]). We modified the original questions by specifying our context of parental mediation of smartphone use. The customized K-PAQ consisted of 24 items rated on four-point Likert scales, labeled from “Strongly Disagree” to “Strongly Agree.” The K-PAQ defines three parenting styles based on responsiveness and demandingness: 1) permissive (undemanding): e.g., “*I seldom gave my child expectations and guidelines for my child’s smartphone use.*”; 2) authoritarian (unresponsive, but demanding): e.g., “*I let my children know what behavior I expected of them regarding smartphone use and if those expectations were not met they were punished.*” and 3) authoritative (responsive and demanding): “*I consistently gave my child direction and guidance in rational and objective ways regarding smartphone use.*” The family literature shows that authoritative parenting is generally regarded as the most-recommended parenting style [8], but researchers showed that effective styles vary across different cultures, values, and approaches to families [21]. The responses to the items were averaged for each style; the highest score represented the preferred parental style of the parent. Note that we customized the scales, and thus, our measurement should be interpreted as domain-specific parenting styles regarding smartphone usage.

Third, we measured the quality of the parent-child interaction regarding smartphone use. It has been reported that parent-child interaction patterns are associated with parenting style [25]. Thus, we wanted to check whether the use of FamiLync improved parent-child interaction on intervening smartphone use; again, the scale is framed to be domain-specific. In order to measure the quality of the interaction, we used the Parent-Adolescent Communication Scale for Koreans (K-PACS) [11] (original version [5]). K-PACS consists of 20 items using a five-point Likert scale labeled from “Strongly Disagree” to “Strongly Agree.” The scale has two subscales: Openness (10 items) and Problems (10 items). The openness scale includes items such as “*It is easy for me to express all my true feelings to my mother/father/child.*”; the problems scale includes items such as “*I don’t think I can tell my (mother/father/child) how I really feel about some things.*”

Quantitative Results

First, our usage log analyses revealed significant reductions in the participants’ usage amounts. Table 1 shows our two-tailed paired t-tests for the usage time/frequency per day between the

		Mean (SD)		df	Cohen’s d	P-value
		Pre	post			
Usage Time Amount per Day (m: minutes)	Total	176.34 m (91.64)	142.19 m (66.15)	26	0.79	.000
	Parent	164.76 m (67.95)	135.08 m (51.83)	13	0.79	.013
	Child	188.89 m (149.84)	149.84 m (80.29)	12	0.81	.015
Usage Frequency per Day	Total	96.27 (68.42)	80.30 (59.15)	26	0.57	.007
	Parent	75.38 (30.32)	66.20 (34.34)	13	0.62	.042
	Child	118.78 (89.93)	95.48 (76.30)	12	0.64	.046

Table 1. Two-tailed paired t-tests results for usage amount ($\alpha = 0.05$).

pre-intervention period (denoted as Pre) and the intervention period (denoted as Post). The children’s usage time decreased by about 40 minutes owing to the use of FamiLync. Their number of app executions also decreased significantly. Likewise, we were able to observe changes in parents’ usage behavior. The parents also showed significant decreases of usage time and frequency after the intervention. Interestingly, parents’ usage amounts did not considerably differ from their children’s (by less than about 30 minutes, on average). Overall, our log data showed that daily usage of FamiLync did not significantly change over two weeks (mean number of app launches per day: 3.3 times, and mean use limiting time per day: 90.8 minutes).

We also observed changes in the participants perceived parenting styles on smartphone use. Overall, the scores of the authoritarian style decreased, but those of the authoritative style increased. The proportion of the parents and children who gave the highest score for the authoritative style increased from 54.3% to 80.0%; the proportion of the participants who the most preferred the authoritarian style decreased from 25.7% to 14.3%. This indicates that the parents’ preferences for the authoritative style became stronger after the intervention period and that the children perceived that their parents’ styles became more authoritative rather than authoritarian.

Table 2 presents our two-tailed paired t-tests, which describe detailed changes in the parents and children’s scores for each style. Both parents’ and children’s scores for the authoritative style are significantly increased, whereas only the children’s score significantly decreased for the authoritarian style. In addition, we could not find any significant difference in their scores for the permissive style. More than a half of the parents (10 out of 17) showed decreased scores for authoritarian and permissive style. However, contrary to expectations, other seven parents perceived that their preferred parenting style became more authoritarian or permissive. Further investigation with the exit interviews aided in interpretation; such results were possibly due to improved understanding of usage behavior via FamiLync. These parents had previously tended to allow their children to use the smartphone freely. However, they perceived the need for mediation because they newly identified the details of their children’s problematic usage patterns through FamiLync.

		Mean (SD)*		df	Cohen's d	P-value
		Pre	post			
Permissive Style (range: 1-5)	Total	2.75 (0.62)	2.74 (0.78)	34	0.02	.916
	Parent	2.81 (0.71)	2.63 (0.70)	16	0.28	.287
	Teen	2.64 (0.51)	2.88 (0.84)	17	0.31	.213
Authoritarian Style (range: 1-5)	Total	2.78 (0.75)	2.48 (0.62)	34	0.52	.004
	Parent	2.76 (0.83)	2.51 (0.71)	16	0.37	.155
	Teen	2.80 (0.69)	2.44 (0.55)	17	0.73	.008
Authoritative Style (range: 1-5)	Total	3.35 (0.58)	3.78 (0.48)	34	0.78	.000
	Parent	3.25 (0.72)	3.78 (0.49)	16	0.78	.005
	Teen	3.46 (0.37)	3.78 (0.48)	17	0.99	.001

*: The figures indicate the average score for each style.

Table 2. Two-tailed paired t-tests results for PAQ ($\alpha = 0.05$).

		Mean (SD)		df	Cohen's d	P-value
		Pre	Post			
K-PACS (range: 10-80)	Total	46.46 (8.25)	54.23 (8.17)	34	0.98	.000
	Parent	47.24 (8.49)	53.76 (8.66)	16	0.74	.009
	Teen	45.72 (8.19)	54.67 (7.90)	17	1.31	.000

Table 3. Two-tailed paired t-tests results for K-PACS ($\alpha = 0.05$).

Finally, we compared K-PACS scores before and after FamiLync use. Our two-tailed paired t-test analysis results showed that the total K-PACS scores significantly increased after FamiLync use (See Table 3). Such results can be similarly observed in the responses of both parents and children. This shows that FamiLync facilitates bilateral social interactions between parents and children; it helps them to exchange their feelings/thoughts on smartphone use.

Qualitative Results

Our interview results showed the effectiveness of our approach in parental regulation of child smartphone use. First, self-monitoring and sharing usage information aroused the need to limit usage and facilitated understanding of each other's usage behaviors, which caused positive changes in parental mediation. Second, family-wide use limiting provided unique experiences that helped the parents to understand their children, and similarly, let the children know about their parents' limiting efforts. Finally, we were able to uncover emergent parent-child interactions through FamiLync, such as effective techniques for monitoring and long-distance parenting.

Improved self-awareness on smartphone usage

Overall, both parents and children were satisfied with the self-monitoring feature of FamiLync. Most of the children reported that they could newly identify details of their problematic usage, such as overuse and usage late at night; they strongly

felt the need to independently limit their own usage. One girl among the participants mentioned, "I was surprised when I saw my usage on the first page. I decided to delete KaKao Story [a mobile SNS] because I thought it was something I tended to overuse." (C4). Similarly, many of the parents commented that they also felt the necessity of limiting their usage. One of the parents commented "I thought my usage was good. However, when I launched the app at first, I realized I was wrong." (P2). Interestingly, there was one parent who reconsidered her parenting style, mentioning that "I have used the phone for a very long time. I thought that the current regulation of my son's use was nonsense." (P6).

Less restrictive and enjoyable parenting

Most of the participants were new to the experience of limiting usage in collaboration with their family members, except the two families who had had a rule of putting all the family members' phones in one place at night (however, they admitted that it was difficult to maintain such a rule for a long time). Some of the parents mentioned that it was not that hard to limit their usage to one or two hours because their usage amount was not too large. However, there were also reports of difficulties in self-regulating usage. One parent said, "During the limiting mode, I habitually turned on the screen. I struggled with the phone until the mission was complete." (P3).

The parents' experiences of limiting usage tended to help them to regulate their children's use. First of all, they agreed that they could deeply understand their children's feelings. One parent said, "Now, I knew why my son was stressed out whenever I asked him to stop using his phone. I think I should consider the context of my son's usage when I try to regulate it." (P12). Additionally, they shared information on the advantages of limiting usage by explaining detailed experiences; they recommended that their children follow their behavior. One parent mentioned, "I limited use in diverse contexts such as working, sleeping, and commuting. I felt that it was very good for concentrating on the activity. I recommended that my daughter limit usage for diverse activities because she usually used it only for studying." (P16).

The children also positively responded to limiting use in collaboration with their family members. First of all, many of the participating teens commented that limiting the usage with the parent and comparing the outcomes were enjoyable. Particularly, compared to the previous restrictive parenting methods (e.g., confiscating, nagging), children felt much more respected by their parents when their parents also limited their use. Also, as we expected, the parents' limiting behaviors motivated the children to limit use. One participant said, "I was shocked about my father's limiting scores because I did not expect him to be able to do that. So, I felt I also had to limit my use." (C4). Interestingly, one girl who enjoyed competition with her father was a little disappointed with the current ranking system. She said, "It is not fair because I cannot use my phone at all when I am at school, so I cannot score limiting points. However, my father can do it all the time." (C14).

Understanding each other

We found that sharing usage information helped the parents and children to understand each other. First of all, many of the parents commented that their concerns about the children's use

have been decreased by sharing of usage information. One parent said, “*I found that my child did not use the phone as much as I thought he/she did.*” (P3). Another parent commended the checking feature for unknown apps, “*There were many apps I didn’t know, so I was worried at first. However, after reading the descriptions of the apps in the checking link in FamiLync, my concern was alleviated. The apps were mostly games.*” (P7). One parent, who originally preferred to be permissive, decided to involve herself more in regulating her child’s use instead of allowing him to do whatever he wanted, because he seemed to use his phone too much.

Shared usage information also helped children to understand their parents. Most of the children said that their parents used their phone less than they had expected, while some of the children complained about the problems with their parents’ usage, such as excessive playing of mobile games. Such understanding often brought about conversations between the parents and children. One child mentioned, “*My parent and I had a discussion about each other’s app usage. We had a conversation about which apps were useful or harmful.*” (C1). One child also understood his parents’ daily activities through the usage information. He said, “*One day, I saw my mother used the phone a lot, so I asked my mother to find out what happened on that day. She explained her story, and I was able to understand that she had to work hard on that day.*” (C11).

Facilitated parent-child interactions

Additionally, we found several interesting interactions between parents and children. First, FamiLync’s limiting status indicator helped parents to monitor their children’s behavior while fostering their children’s autonomy (e.g., location of use). A child in one of the families usually stayed in his room at home, causing his mother to often wonder what he was doing in his room and have vague concerns. The mother mentioned the helpfulness of the social indicator of use-limiting that shows whether the child was in the limiting mode for some activity (e.g., studying). From this social indicator, she was able to know that her son was studying without opening the door of his room, which earlier often caused conflicts with him. Later, she praised her son when he was out of his room; he was surprised that she knew that he had been studying. After this, his mother felt that her son liked to use the limiting mode more, to show his good behavior.

Second, we observed online interaction between parents and children. Some of the parents liked the family chat board. Their families actively used this chat board to encourage each other to limit use and exchanging feelings. One of the parents said, “*Of course, KaKaoTalk [a popular mobile instant messenger] exists I think that the family chat board is a little different from that. Because we have a common topic for conversation, I think we can talk more.*” (P2). Another parent wished to strengthen functions for social interaction such as exchanging emoticons or photos.

Finally, we found that our app was helpful for facilitating long-distance parenting. Among the parents, there were three parents who were unable to meet their children during the week because they had to work in different cities. Those parents were very interested in their children’s behavior, such as what the children were doing during the day. FamiLync

helped them to understand the daily lives of their children by delivering usage and limiting information. With the shared information, they were able to know when their child studied and when they played what games. Because those parents were far away from their families, they previously had difficulties in supervision and communication for parental mediation. They liked having the chance to parent their children and share extraordinary experiences. The children of the parents also liked the experience. One of the children said, “*I think our family atmosphere has become better with this app My father really limits his use strongly. I believe that it is his effort to show his love for me.*” (C5).

DISCUSSION

The main goal of our work is to demonstrate the feasibility of enabling participatory parental mediation of teens smartphone use via computer-mediated application services. Given that use-limiting is the most widely used rule for parental mediation, we chose use-limiting as a family activity such that family members could monitor their usage, and actively participate in use-limiting activities. FamiLync provides a family with a virtual public space, in which social awareness of smartphone use is maintained, and a use-limiting tool through which use-limiting activities can be effectively performed. Our user study results showed that FamiLync helped parents to maintain a positive parent-child relationship through *conversations*. Parents typically allowed their children increased smartphone usage independence (e.g., use location and content type), and they actively participated in use-limiting with their children, which significantly motivated their children’s continued participation. Thus, interactions between adults and children have become more two-way, child-centered, and less defined by hierarchical authority arrangements.

Our work contributes to the body of recent work geared toward understanding parental mediation in the digital era [12, 19, 38, 48] and to investigate support tools for effective parental mediation [18, 36, 38, 43]. Unlike existing tools that are based on intrusive approaches (e.g., remote monitoring and locking), FamiLync is the first work to experiment with participatory parental mediation of smartphone usage by facilitating shared understanding and encouraging active use-limiting participation. Because information sharing influences the agency and autonomy of teenagers, we demonstrated that the system design should carefully consider the social translucence guidelines [15] that make user activities visible to support social awareness and encourage accountable behavior according to the rules of the parents. Our design builds upon the prior studies of persuasive system design as we leveraged key features such as self-monitoring and social support [40]. Further, our work provides foundations for further experimental studies exploring the design space of computer-mediated services and ethnographic studies on various aspects of parental mediation on smartphone use (e.g., socio-economic status, mother’s role) as in earlier work [12, 38].

In the following, we discuss several practical design implications based on our findings. For participatory parenting, FamiLync, as a social translucence system, made the smartphone usage of family members visible; however, as shown earlier, there is a vital tension between visibility and privacy.

Family members can benefit from intelligent and effective visualization techniques, which are useful for realizing *abstract representation of usage behavior*. In the experiment, the participants asked us to further improve visualization of the information that summarizes usage behavior. For example, many parents wanted to have usage data specific to content categories such as games, messengers, and web browsing. Furthermore, some parents wished to examine the actual content accessed by the children, although they also worried about privacy issues. As suggested by earlier work [15, 48], designing techniques that support more abstract representation of the content and yet hide private details would assist in participatory parenting. One approach to abstracting content usage is to extract topical interests by text-mining usage data, or to visualize social interactions in graphs. Although our design mainly provides symmetric awareness, family members may want asymmetric awareness [47]; systematically exploring this issue in the participatory parental mediation would be an interesting avenue for future research.

FamiLync leverages social support within a family, by providing social comparison and competition features. It helps family members to share usage and limiting information, which not only help them to understand each other's usage behaviors, but also motivates them to actively participate in use-limiting activities. As shown earlier, however, the children complained about the fairness issue owing to asymmetry in usage conditions (e.g., no usage at school). In the design, heterogeneous life patterns should be properly addressed; for example, we can allow family members to collaboratively set the time span of the day for competition. Furthermore, social support can be extended to include other families. Our participants also wanted to see the usage and limiting statistics of other families, hoping to determine how other families manage this issue. Again, we believe that different life patterns will make direct social comparison and competition difficult. In this case, it would be useful to search for groups of families with similar lifestyle patterns, as is the case in community sensing techniques [26]. In addition to sharing simple statistics, we can help those families to form online communities for information and emotional support as in ParentNet [43]. According to Clark [13], conflicts often arise from lack of experience and knowledge of parental mediation of smartphones; e.g., when and whether to assert parental authority, and how to deal with unfamiliar situations.

Any system designed for parental control should carefully consider the different levels of physical capability and technology competence of its users. The age difference between parents and children continues to increase because the mean age of mothers at first birth is on the rise [34]. In our user study, although the teenagers did not have any problems with reading, a few parents reported discomfort and wanted to adjust font and icon sizes. One parent (who is 60 years old) wanted to actively participate, but he rarely used the smartphone except for voice calls. This asymmetry in usage gave him fewer chances for usage-limiting. In addition, he commented that he has been slow in learning smartphone use. Therefore, the system design should also deal with asymmetry in physical capability and technology competence to elicit more participation; e.g., supporting flexible user interface configurations, enabling

other types of interaction opportunities such as ambient displays at home [29], and offering other types of participatory activities such as guiding children to teach their parents about smartphone use.

LIMITATIONS

The generalizability of our work is limited because it was carried out at a single site. Hence, additional research in different schools and cultural environments comprising students and parents from various socio-economic backgrounds is required. Our results need to be construed in the context of Korean culture. In particular, parents in Korea mostly preferred restrictive methods for parental intervention on media use [2, 49], and Korean teens tend to live in stressful and competitive educational environments centered around the college entrance exams [22]. Despite this cultural bias, we find that restrictive methods on children's social/smart media use have been similarly observed in other cultural contexts [48], and our results provide useful grounds on studying restrictive mediation. Furthermore, longitudinal, randomized, controlled trials must be conducted for thorough evaluation of intervention mechanisms. Our user study results showed the feasibility of a longitudinal study because consistent usage patterns were observed over the intervention period, and most of the participants wanted to continue using the app. Our qualitative results partly affirm that similar results will be observed in a long-term study. As suggested in HCI research guidelines for designing behavioral change technologies [23], we reported qualitative results to illustrate how and why participants used our software and draw practical design implications. As the first work to explore participatory parental mediation of adolescents' smartphone use, our study carefully demonstrates the feasibility of system design, and our user study encourages further research in this direction.

CONCLUSION

In this paper, we showed that effective parenting strategies of regulating smartphone usage require the active participation of parents. However, the distinctive characteristics of smartphones, such as mobility, ubiquity, and individual ownership, present challenges for active parental participation. Furthermore, we reported that the effectiveness of existing software tools that provide various kinds of restrictive functions (e.g., remote monitoring, filtering, and blocking) was limited because of their intrusiveness. To address these issues, we proposed FamiLync, a participatory parental mediation tool that allows family members to share their usage-related information to increase social awareness and facilitate participation in family activities involving the limiting of smartphone use. Our experimental results show that FamiLync significantly increases shared understanding of smartphone use, fosters a positive parent-child relationship, and encourages active participation in use-limiting activities, which significantly reduces overall smartphone usage.

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