Nudging Problematic Smartphone Use to a Lower Level

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Abstract

Smartphone usage has evolved in people's lives from necessity to habit and in some cases leading to compulsive use and addiction. However, only a little research has been performed on the prevention of Problematic Smartphone Usage (PSU). Behavioral economics has been applied to investigate how smartphone users respond to nudges that try to lower their smartphone usage. Findings revealed that the Total Screen On Time (SOT) decreased when nudging smartphone users with information on their usage behaviors. Intermittent glancing, as well as the median session time increased, and the reduction in SOT was no longer statistically significant in the observation period after the nudges were no longer applied, suggesting relapse in smartphone usage behavior.

Keywords: addiction; behavioral insights; nudge; smartphone

Introduction

Behavioral economics researchers (Kahneman, 2003) have identified a large number of systematic biases in people's decision-making and judgements. These biases have been regarded as evidence that people do not follow principles of the rationality suggested in neoclassical theory (Samuelson, 1937). Instead, people use a series of heuristics that often lead to systematic errors (Tversky and Kahneman, 1973). Thus, the results of the mainstream views in behavioral economics have a generally low opinion about human rationality.

A new positive approach – nudge – for peoples' decision-making have emerged (Thaler and Sunstein, 2008). According to this approach, people could be helped by a nudge to make optimal decisions (Thaler and Sunstein, 2008). By planning the environment based on so-called "choice architects" in order to make people change behavior to make decision makers better off as judged by themselves (Thaler & Sunstein 2008). One example of the benefit of the nudge and choice architecture is to prompt vaccination receivers to write down the date and time of the appointment to increase vaccination rate (Milkman et al., 2011).

According to the dualistic model people engage two systems of thinking. System 1 is an automatic, effortless and often influenced by habits that cannot be influenced easily, whereas System 2 is effortful, deliberately controlled and associated with conscious thinking operations (Kahneman, 2003). The limited capacity of mental effort results to people preferring the System 1 thinking by applying heuristics. As an outcome, many decisions are based on beliefs of probabilities of possible outcomes (Tversky & Kahneman, 1973). Nudges build on the proposition of dualistic system. By preferring the effortless processing, "choice architects" can for instance design routinization of medication, thus creating a habit that is easier to maintain than a medication that is not based on a routine (Ryan & Wagner, 2003).

Problematic Smartphone Use

The heuristics suggested from the dualistic system can be theorized to be present in a person's smartphone usage habits. The high daily usage of a smartphone in people's lives have become significant (Montag et al., 2015b; Kim, 2013; Oulasvirta et al., 2012; Lin et al., 2015). Even if 82% of the respondents say that using their phone during the conversation hurts the setting, 89% of the people have used a phone themselves during their most recent social gathering (Rainie & Zickuhr, 2015). People have been shown to frequently return to their uncompelled behavior even if they were willing to change their behavior for better (O'Connell, 1996). Smartphone usage can be seen to have evolved into a habit which can lead to compulsive use and addiction (Lee, Chang, Lin & Cheng 2014, 373).

Frequent phone use has been connected to the indicators of certain types of addiction. Some studies (Lin et al., 2015; Hong et al., 2012; Lin et al., 2014; Leung, 2008) indicate that the compulsive use of smartphones share the characteristics of drug and alcohol addiction, and internet dependency. Moreover, pathological gambling analyses has been used to classify this type of smartphone addiction (Leung & Liang, 2016).

Using a mobile device frequently and at excess durations has been shown to lead to various types of symptoms. Using phones in excessive quantities in personal business situations has been shown to lower quality outcomes in negotiations and to give a less trustworthy and less professional impression (Krishnan et al., 2014). In addition, the increased use of smartphones has been shown to lead to reduced concentration levels during school classes and unsafe driving habits (Hong, Chiu & Huang, 2012). Furthermore, by taking a wireless device even for a short time can increase anxiety (Cheever, Rosen, Carrier & Chavez, 2014).

Whereas most of studies have focused frequent phone use from addiction point of view, it is hard to find studies that have focused on the prevention of Problematic Smartphone Use (PSU) on healthy test subjects. In order to help lower the smartphone use without coercion or policies, it is important to investigate how PSU can be influenced by using behavior change interventions.

Behavioral economics can be applied to investigate how smartphone users respond to nudges (Thaler and Sunstein, 2008) that try to lower their smartphone usage. A concept of 'nudge' has been introduced in contrast to policies enforcing a desired behavior or to introducing significant economic

incentives. Nudges can be used to design an environment that "alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler et al., 2008). Although the nudge has been applied in many studies and projects (Johnson & Goldstein, 2003; Shu et al., 2012), it is hard to find research reports that have focused on applying behavior change interventions to influence smartphone usage.

The nudges used in this research to influence smartphone use were designed based on Michie, van Stralen and West's (2011) Capability, Opportunity-Motivation-Behaviour (COM-B) framework. According to this framework, behavior change involves changing one or more of the capability, opportunity and motivations that relate to the behavior (Michie, Atkins & West, 2014). Capability refers to knowledge and skills that influence engaging in the activity, opportunity refers to everything outside the test subject that prompts for behavior or makes it possible, and motivation refers to processes that energize and direct behavior (Michie et al., 2014). The first nudge used in this study was designed to influence to the capability component, whereas Motivational and Goal-Attainment nudges were designed to influence to the motivational component in the COM-B framework.

Goal setting combined with a commitment, and feedback concerning the behavior has been shown to lead to behavior change. Where providing information has improved knowledge about the issue, the behavior change has resulted from tailored information, goal setting and feedback. Whether the goal has been set by an external party or the subject themselves, it has not been shown to have influence. (Abrahamse, Steg, Vlek & Rothengatter, 2007).

The Capability-nudge provided information regarding the phone use. The nudge was designed to be compatible with Hansen & Jespersen's (2013) definition of Transparent type 1 nudge. In this category, the reflective thinking of a subject is a by-product of the nudge.

Both Motivational-nudge and the Goal-attainment-nudges added influence to the motivational component by providing an optional valentic emoticon based on the progress of the smartphone use. The appearance of the valentic emoticon in a Goal-attainment nudge was shown if the test subject attained a self-defined personal goal in reducing smartphone usage. The valentic emoticon was designed to influence behavior through reflective thinking and to indicate an attainment of a desired behavior. These nudges built on Hansen & Jespersen's (2013) definition of Transparent type 2 nudge: the emoticon provided feedback to reinforce the commitment mechanism while the test subject maintained a complete freedom of choice, both before engaging with the phone, or after opening the phone and thus becoming subject to the nudge.

Even though excessive smartphone usage can lead to compulsive use and addiction (Lee, Chang, Lin & Cheng, 2014), little is known how people can voluntarily lower smartphone use. Here we use the COM-B behavioral change framework to study how smartphone usage can be influenced by nudges.

Method

Participants

Total of 201 users were recruited from social media (Twitter, Facebook and LinkedIn) to participate in the research using the following recruitment message: "Are you hooked to your phone? Do you use it way too much? Find it out. Participate in a research. Install Deglancer." The participants were not assessed or selected based on their attitudes towards smartphone usage. The participants were incognito to the researchers throughout the study. The study was initiated by a test subject when installing the application onto their Android smartphone from Google Play store. The users were presented information about the research both before installing the research application, and when the research information sheet was made available to them in the application.

Following the research practices of an earlier research project (Montag et al., 2015b) the data was filtered to include only the participants that completed the full five weeks of research without stopping their phone usage for more than three consecutive days during the research. After discarding corrupted research data and ineligible users, 78 users were included to the data analysis.

Earlier research results (Mueller, van der Heijden, Klein & Potters, 2011; Altmann & Traxler, 2014) had shown that the effect of nudges do not significantly correlate with economic or socio-demographic variables. Therefore, sociodemographic background variables are not reported. The ethics committee of the Federation of Universities of Applied Sciences approved the study.

Procedure

A smartphone application was developed to conduct an intervention study using three different type of nudges. The study was constructed for consecutive five stages, each lasting for 7 days. As soon as the users started the application for the first time, the study initiated. The application registered itself to the service hosted in Google cloud computing infrastructure. In the beginning of the research, the test subjects responded to the Smartphone Addiction Inventory (SPAI) questionnaire in the research application, measuring their attitudes and effects towards smartphone usage (Lin et al., 2014), however, the SPAI data has not been analyzed for this paper. The participants used their personal smartphone for the duration of five weeks during which the interventions were performed and the research data was collected.

The first Baseline stage created a personal baseline of smartphone usage of a participant. During the second, Capability stage, at every unlock of the smartphone, the user was presented a nudge including the following information: the number of minutes that the phone was locked before the unlock event, the number of unlock events so far during the

ongoing day and the total duration that the screen has been turned on during the ongoing day. The purpose of this stage was to test the effect of information to the smartphone use.

During the third, Motivational stage, a user was presented with a similar nudge to the second stage. Information in the nudge was preceded with a positively valenced injunctive emoticon if the smartphone user had lowered the smartphone usage and therefore the indicator value had improved: if smartphone was locked for longer than the average sleep time one week earlier, if the number of unlocks up to the current hour of the day was less than the number of unlocks up to the current hour of the day one week earlier, or if the total screen time up to the current hour of the day was less than up to the same hour of the day one week earlier. The purpose of this stage was to test the effect of positively valenced injunctive emoticon judged by an external authority.

In the beginning of the Goal-attainment stage, the user was prompted to select a goal for how much he or she wished to decrease the phone usage this week. If the user did not select a goal, the application used the default goal of 5 % improvement to the previous week. Every time the user unlocked the smartphone, the application calculated if one or more of the indicators had improved more than the target percentage compared to the previous week's information. If the sleep time was at least 5 % longer than the average sleep time in the previous week, if the number of unlocks was at least 5 % less than the number of unlocks up to the same hour of the day in the previous week, or if the total duration of the screen time was at least 5 % less than up to the current hour of the day in the previous week, the indicator was preceded with the same injunctive emoticon that was used in the Motivational stage.

As in the Motivational stage, the nudge in the Goal-attainment stage built on the motivation component of the COM-B. However, as the stage included a task to define the percentage of the desired reduction in smartphone use, the goal-setting intended to direct attention and effort to reach the goal defined by the test subject. In order for the test subjects to easily maintain their state of goal attainment, the test subjects would have to reflect their phone usage before engaging with the phone, thus reducing phone usage. The purpose of this stage was to test the effect of goal-attainment, and the effect of injunctive emoticon based on a personally set goal. By prompting the test subject with active decision-making regarding the amount to reduce their smartphone use, it was expected that the test subjects would make effort to attain the goal that they had specified themselves.

As the study progressed to the fifth week, all notifications stopped, and application only recorded the user behavior for one week. In the same way with the first stage of the study, the fifth stage did not involve a nudge. The purpose of this stage was to investigate if users relapse to their prior behavior after the nudges are no longer present.

After full five weeks, the application notified the user that the study had been completed. However, the user could continue to use the application, and choose the type of nudge to present at every unlock. The test subjects had a choice to continue to use the application, or uninstall the application from their smartphone.

Data Analysis

A total of 606062 events were collected over the 5-week study period were tested. These events were converted to 2304 observations, each of them representing one day of one test subject, equivalent to the definition of per day per user (pdpu) used in an earlier similar research (Oulasvirta et al. 2012). Five key indicators of smartphone usage were calculated from the research data: Total Screen On Time per day (SOT), Median Screen On Time of each session (Session Time), Total number of phone usage sessions per day (Unlocks), Number of phone usage sessions equal or shorter than 30 seconds in duration, over 10 minutes apart from the previous session (Glances) and Median Screen Off Time between two sessions (Median SFT). Of the 78 participants who completed the research, 58 chose to set their own goal in the goal-setting phase, whereas 20 participants got the default as a goal.

Time series of each key indicator was processed with Hilbert-Huang Transform (HHT). In this so-called sifting process, the time series of each key indicators were broken into intrinsic mode functions (i.e. IMFs) and by sequentially de-composing these intrinsic modes from the original signal, the remaining data represented the trend of the data over the study period. This analysis was compatible with the method used by Lin et al. (2015). Inferential statistics were performed to measure the effect of nudges in Capability, Motivational and Goal-attainment stages compared to the Baseline and to the Observation stages. The differences in key indicators were tested between the stages of the study for each test subject. The inferential statistic tests were done by performing independent-samples t-test using different stages of the study as a grouping variable, and each key indicator as test variable. Finally, a regression equation was calculated to predict a key indicator from another key indicator. The processing of the data was performed with the MatLab software package and the inferential analysis was performed with an SPSS statistical software.

Results

There was a significant effect of intervention for SOT between Baseline and Capability stages. Between these stages, mean SOT lowered from 3 hours and 40 minutes pdpu to 3 hours and 14 minutes pdpu. The effect of intervention for SOT was also significant between the Baseline stage and the Motivational stage, as well as and between the Baseline and Goal-attainment stages. In the Motivational stage, SOT lowered to approximately 3 hours and 10 minutes, and to 3 hours and 13 minutes in the Goal-attainment stage. The decrease in SOT was not statistically significant when comparing the first stage to the last week, Observation stage, of the study. Table 1 below illustrates differences and statistical significance of SOT by stage.

Table 1: SOT by stage (N=78).

Stages	Difference	Significance and effect size
1 vs. 2	-26 minutes	t(922) = 2,888, p < .01, d = 0,19
1 vs. 3	-30 minutes	t(925) = 3,356, p < .01, d = 0,22
1 vs. 4	-27 minutes	t(916) = 2,871, p < .01, d = 0,19

The difference in Session Time was significant between the Baseline stage and Observation stage. The mean duration of individual session increased from 51 seconds pdpu to 92 seconds pdpu. The difference was also significant between Capability and Goal-attainment stages, as well as between Capability and Observation stages. This difference was also significant between Motivational and Observation stages. The mean duration increased from 44 seconds in the Capability stage to 49 seconds in Motivational, to 63 seconds in Goal-attainment and finally to 92 seconds in Observation stage. The changes were not significant between adjacent stages. Table 2 below illustrates the changes in Session Time by stage.

Table 2: Session Time by stage (N=78).

Stages	Difference	Significance and effect size
1 vs. 5	41 seconds	t(913) = -2,466, p < .05, d = -0,16
2 vs. 4	5 seconds	t(920) = -2,298, p < .05, d = -0,15
2 vs. 5	19 seconds	t(917) = -2,945, p < .01, d = -0,19
3 vs. 5	33 seconds	t(920) = -2,674, p < .01, d = -0,18

The difference in Glances was only significant between Capability and Observation stages, t(917) = -2,006, p < .05. Mean Glances pdpu increased from 41,24 times in Capability to 45,55 times in Observation stage.

Simple linear regression was calculated to predict SOT based on Glances. Poor regression equation was found (F(1,2274) = 142,124, p < .000) with an R2 of .059. Also, simple linear regression was calculated to predict Unlocks based on Glances. A significant regression equation was found (F(1, 2274) = 10188,592, p < .000) with an R2 of .818.

Median SFT was significantly different between the last two stages when compared to the first three stages. However, due to the HHT being used in the pre-processing stage to address the non-linearity and non-stationarity of the research data, the comparison of the key indicator values using original units of measure might not be accurately depicted. Median SFT values after HHT pre-processing smoothed the data to a negative range without equivalent real world phenomenon. The changes in Median SFT can be characterized so that the difference in Median SFT is not significantly different between stages 1, 2 and 3, but Median SFT is markedly higher in stages 1, 2 and 3 compared to stages 4 and 5. The below Table 3 illustrates the trend of change in Median SFT by stage.

Table 3: Median SFT by stage (N=78).

Stages	Significance and effect size
1 vs. 4	t(916) = 3,194, p < .01, d = 0,21
1 vs. 5	t(913) = 2,815, p < .01, d = 0,19
2 vs. 4	t(920) = 3,194, p < .01, d = 0,21
2 vs. 5	t(917) = 2,801, p < .01, d = 0,18
3 vs. 4	t(923) = 2,299, p < .05, d = 0,15
3 vs. 5	t(920) = 2,491, p < .05, d = 0,16

Discussion

There was a significant main effect for SOT between the Baseline stage and all of the three stages with the nudges. Consistent with COM-B framework (Michie et al., 2011) this change in SOT could be associated to an individual's aptitude to change their phone usage. Especially in the Capability stage the information pertaining to the user's phone usage was planned to be consistent with the definition of the type 1 transparent nudge (Hansen & Jespersen, 2013). It can therefore be suggested that the effect of the nudge was significant enough to trigger an automatic reflection of smartphone use.

It is not possible to conclude that one type of nudge has higher significance to smartphone behavior than the other. Statistically significant decrease of SOT between the Baseline stage and both the Capability stage and the Motivational stage suggests that by using nudges that increase capability or motivational components can result to behavior change. However, there was no significant change in any of the key indicators between the different types of interventions.

Locke and Latham (2002) have earlier suggested that "the effects of goal setting are very reliable". Michie, Atkins and West (2014) have also reported that the interventions with "explicit targets and actions plans to feedback" had a higher impact compared to interventions without targets. According to Locke and Latham (2002), failures to replicate the effects of goal settings can be due to many reasons, including for example the lack of feedback, lack of commitment or failure to match the goal to the performance measure. It is possible that the key indicators used in this research do not mediate smartphone usage behavior. Also, by only providing positively valenced feedback about the goal attainment but inhibiting negatively valenced feedback about the failure to attain a goal could explain why this research could not successfully replicate the effects of goal setting.

The level of SOT per day (162 minutes) is in line with what Oulasvirta et al. (2012) reports, but it is only 62,3 percent of what Lin et al. (2015) reports as a median daily use time. Lin et al. (2015) report that the recruitment strategy in their study was "based on the potential higher penetration rate of smartphone use". Montag et al. (2015a) have written that substantial part of the sample in Lin et al.'s (2014) study was characterized as being smartphone addicted. The difference in the level of usage compared to Lin et al.'s research results

may suggest that the sample in this research did not include substantial amount of problematic smartphone users or smartphone addicts.

There was a significant difference in Session Time between number of stages as indicated in Table 2. In these comparisons with Observation stage, the Session Time increased from the stage under comparison.

The difference in Glances was only significant between the Capability stage and the Observation stage. Oulasvirta et al. (2012) define intermittent smartphone use as SIRB, short duration isolated, reward-based usage sessions. This definition includes a notion about the type of application: "at least 50% of the usage session duration is spent interacting with applications that provide the reward values". The definition of Glances is not therefore fully compatible with the definition of SIRBS.

There was no evidence that nudges can reduce the number of Glances. Oulasvirta et al. (2012) have suggested earlier that "checking habits may lead to more use overall". Poor regression equation to predict SOT based on Glances did not support Oulasvirta et al.'s previous findings, however, significant regression equation to predict Unlocks based on Glances would suggest that even though changes in Unlocks were not statistically significant during the research, Unlocks can be expected to increase after the nudges are no longer in effect. Oulasvirta et al. (2012) have earlier concluded that the increased "checking habit" is associated with higher phone usage overall. Oulasvirta et al. (2012) suggest that short sessions act as a "gateway" for other content on the device, and that they can be seen as a proxy for habitual usage.

Median SFT was significantly lower from Motivational stage onwards compared to the baseline. It was not possible to find a report that would have included at least descriptive statistics about the Session Time or Median SFT. In this research, Session Time was 23 seconds, and Median SFT was 198,50 seconds. Due to the lack of prior reported research evidence, these numbers provide little basis for inferential or comparative analysis. Davis (2001) has suggested that procrastination has a role in both the development and maintenance of generalized PIU. However, based on the data from this research it is not evident if a more frequent engagement with the phone is due to the test subjects putting off their responsibilities – as Davis suggests - or due to other reasons.

It can be theorized that the changes in SOT and Median SFT is due to the test subjects reducing their screen time overall even if they engaged with their phone more frequently. In the Goal-attainment stage the nudge was built on Motivational component in COM-B framework, proposing that the explicit goal is associated with lower phone usage. Evidence referred by Klasnja (2009) have proposed that the automatic goal activation can be triggered with presentation of salient information. It is possible that the nudge in the Capability stage had already triggered automatic goal activation, and the differences in nudges between the stages were not significant enough to trigger additional ways of behavior change beyond what was already active from the Capability stage onwards. This could support an unchanged amount of glances throughout the experiment, although it remains unclear what triggered an increase in the mean Glances in the Observation stage.

Neither Session Time nor the number of unlocks lowered significantly between the Baseline and Capability stage. One possibility is that there was a mere-measurement effect from the beginning of the study and the users made an effort to generally lower the amount of engagement with the phone throughout the study by spending less time with the phone at each unlock. Another possibility is that the users generally reflected their phone usage and did not unlock the phone as often as before. In this case, as soon as they would engage with their phones, they would approximately spend the same amount of time with their phone, but that would happen less often. The changes can, however, be so small that it is not statistically significant for Unlocks or Median SFT. If the latter assumption was true, it would suggest that automatic goal may have triggered users to reflect their phone usage before they engage with their phone. As SOT was significantly or highly significantly lower in all stages of the study compared to the Baseline stage, the observation could be a sign of learning the phone usage behavior resulted by the interventions.

According to these results, a systematic relapse in behavior was seen after the interventions were no longer in effect. Block (2008) has earlier reported that the individuals with internet addiction are resistant to treatment and tend to relapse at a high rate. The findings from this research are compliant with Block's suggestion, although it is not possible to associate the findings from this research to a relapse based on psychiatric reasons.

Even though this research supports both Klasnja et al.'s (2009) as well as Oulasvirta et al.'s (2012) conclusion that interventions can help trigger behavior change, this research does not support the proposition that interventions can help maintain a behavior change.

This research does not provide evidence that the type of nudge explains differences in the number of unlocks or glances per day. It is possible that this is due to the path dependence between the stages of the research and the lack of a control group. Even though there was statistically significant different in the mean Glances between the Capability and the Observation stage, this finding is not supported by current literature. More evidence would be required to prove relapse in smartphone use resulting from the absence of a nudge, by randomizing the order of stages in the research and by introducing a control group.

It can be concluded that nudges can help lower key indicators of smartphone use, however, this might increase intermittent glancing and result to overall increased usage of the phone when the interventions are no longer present.

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