Unplug from Your Distractions: The Effects of Smartphone Screen Time Interventions on Self-Regulation and Procrastination

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Abstract

Based on prior research on the role of self-regulation on problematic smartphone usage, this study aimed to investigate the potential effects of smartphone interventions with an extra barrier on self-regulation. A 2 x 2 mixed factorial design experiment (N = 50), with intervention type as a between-subjects factor (psychological vs. psychological + physical) and time of measurement as a within-subject factor (before and after intervention), was conducted to examine the effects of smartphone intervention on self-regulation, the effects of self-regulation on procrastination, and the mediating effect of self-regulation on the relationship between intervention type and procrastination. In addition, the moderating effects of habit strength on the relationship between intervention type and self-regulation were explored. Results showed that the enhancement of self-regulation, induced by the use of a smartphone intervention with a psychological + physical barrier, effectively reduced procrastination. Additionally, the moderating role of habit strength was found to enhance the relationship between intervention type and self-regulation. Together, these results indicate that an extra physical barrier is an effective addition, and that habit strength is an important factor to consider when examining the effectiveness of interventions on problematic smartphone usage.

Keywords: self-regulation, smartphone intervention, habit, procrastination, problematic smartphone usage, psychological barrier, psychological + physical barrier

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Mobile communication technology such as smartphones have been used to communicate with people, services, and gadgets for the past decade, to the point where connection has become entrenched in everyday life (Vanden Abeele et al., 2018). In some cases, it results in unintended screen time (Vanden Abeele, 2020). One example of such unintended smartphone usage is procrastination of other planned tasks, as smartphones provide fast access to temptations (Aalbers et al., 2021). Given that the risk of excessive screen time can lead to smartphone addiction (Gökçearslan et al., 2016), which in turn leads to procrastination (Yang et al., 2018), it is essential to provide smartphone users with interventions that could prevent them from excessively using their smartphone.

Existing literature reveals that smartphone interventions are not always successful, and further investigation to improve the effectiveness of intervention tools is required (Dunican et al., 2017; Eide et al., 2018; Turel et al., 2018; Wilcockson et al., 2019). A possible solution to reduce problematic smartphone use might be to impose a higher level of restriction for breaking habits and enhancing self-regulation. When it comes to explaining the underlying mechanism of the relationship between the use of intervention tools and procrastination, several studies suggest that self-regulation − i.e., the human behaviour that enables a person to postpone gratification to obtain desired outcomes and facilitates goal-directed behaviour (Carey et al., 2004) − might mediate the relationship. For example, previous studies demonstrate that self-regulation can influence smartphone addiction (Gökçearslan et al., 2016; van Deursen et al., 2015). Additionally, it has been discovered that problematic smartphone usage predicts academic procrastination

(Yang et al., 2015). Another study even revealed that self-regulation directly affects procrastination (Zhang and Wu, 2020).

Moreover, Agrawal et al. (2017) revealed that smartphone users are more likely to be distracted by smartphone notifications when they have low levels of self-regulation. Once distracted, it takes some time to get the mind back to its previous, productive state. Such findings imply that enhanced self-regulation via screen time intervention tools may mediate the effects of screen time intervention on excessive procrastination. Imposing a physical barrier might be the solution as it requires users to take another physical step to use their smartphone, which may be effective for breaking habits and enhancing self-regulation. The enhancement of self-regulation via the imposing of a physical barrier intervention may consequently reduce procrastination.

Another thing that merits notice is the potential moderating role of user habits on the relationship between screen time intervention and self-regulation. Conceptually, habit refers to "learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states" (Verplanken & Aarts, 1999, p. 104). The habit of often checking the smartphone for short periods to access information and connect to people is supported by the constant ongoing connectivity between users. An earlier study provided evidence that notifications are more likely to disrupt users with a strong smartphone checking habit (Meier, 2021). This implies that the habit of checking one's smartphone may moderate the relationship between intervention type and self-regulation.

Investigating ways to improve the effectiveness of intervention tools is critically important for preventing the negative consequences of problematic smartphone use (i.e., procrastination). Therefore, this study will use the recently created screen time intervention tool Unpluq (Smits et al., 2021), which was created to assist problematic smartphone users with digital detoxification

(i.e., the act of reorganizing or removing oneself from digital technology for some time; Syvertsen & Enli, 2019). Unpluq provides smartphone users with two types of services: 1) the Unpluq software application accompanied by a USB key that must be put in the smartphone to enable the usage of self-restricted applications (physical device) and 2) the Unpluq Premium software application in which users may activate self-restricted applications by shaking their smartphones for three seconds. Based on the theoretical reasoning, it can be implied that the Unpluq software application with a physical device has a greater degree of screen time intervention than the Unpluq Premium software application. With this understanding, this study examines a) if the screen time intervention tool defined as psychological + physical barriers will differ from psychological barriers in influencing procrastination; b) whether perceived self-regulation will mediate the differential effects; and c) whether habit strength will moderate the relationship between intervention type and perceived self-regulation.

Literature Review

Smartphone Use

Mobile communication has become entrenched in everyday life over the past decade. Currently, there are 6.378 billion smartphone users in the world, which indicates that 80.76 per cent of the world's population possesses a smartphone. This is a significant increase from 2016, when there were just 3.668 billion users, accounting for 49.40 per cent of the global population at the time (Turner, 2021). Smartphones are becoming more than just a method of communication. They impact people's lives in various ways, mainly because they are the devices that come into closest physical touch with people regularly (Lee et al., 2014). Existing research investigating the average daily screen time among Americans older than 18 revealed that almost 50% spent

between 5 to 6 hours a day on their smartphone (Statista, 2021b). The actual time spent on a smartphone will be even higher, considering that work-related smartphone use is not considered. These are disturbing numbers as the average adult in America spends almost an entire workweek on their smartphone.

The pervasive presence of connectivity allows users access to their smartphones at any place and time they want (Vanden Abeele et al., 2018). As a result, technological unconsciousness may have arisen, meaning that communication technology has effortlessly integrated into the activities of everyday life. This leads to most people being unaware of the presence of media (Deuze, 2011) because they take the connectedness at every place and moment for granted (Ling, 2012). Unlimited accessibility to connectivity devices may equip people with greater autonomy over their daily lives. Autonomy is the freedom to make self-conscious choices that are not imposed from the outside, which can be considered someone's authentic self (Stanford Encyclopedia of Philosophy, 2020). "The root idea of autonomy is that in making a voluntary choice a person takes on responsibility for all the foreseeable consequences to himself that flow from this voluntary choice." (Arneson, 1980).

This autonomy provides smartphone users with several advantages, such as staying in touch with friends, an endless amount of information, and sharing knowledge (Lepp et al., 2013; Omar et al., 2016; Radtke et al., 2021). Smartphones have also taken over various computer tasks, like sending and receiving emails, browsing and shopping, paying for products, and opening and editing documents (Alfawareh & Jusoh, 2014; Brown & Kuss, 2020). As the revenue model of the most used applications on a smartphone is the attention of its users, they will benefit from users spending much time and keeping their attention on their smartphone (Williams, 2018). This results in users spending unintended time on their smartphones, which provides short term

gratification, and in some cases, might feel intemperate, unsuitable, or even problematic (Vanden Abeele, 2020). When someone cannot control their behaviour and screen time is too much for a more extended period, this can be seen as smartphone addiction (Ting & Chen, 2020). This is further substantiated by the study of Gökçearslan et al. (2016), which revealed that the risk of smartphone addiction increases when smartphone usage rises.

Existing research has proven that the lack of self-regulation contributes to smartphone addiction (LaRose et al., 2003; Mahapatra, 2019). It is important to understand the underlying mechanism of smartphone addiction, as the consequences are anxiety, procrastination, and stress (Li et al., 2020; Mahapatra, 2019; Yang et al., 2018). Breaking habits (i.e., reinstating self-regulation) through increasing the level of intervention might be the key to resolving the issue of procrastination.

Types of Intervention: Psychological and Physical Intervention

There is ample research showing that ‘automaticity in use’ is a big problem. This automaticity results from initially goal-directed behaviour, but then habituation kicks in (Oulasvirta et al. 2011). Given this automaticity, effective change needs to be change that really ‘breaks the habit’; this is done preferably by discontinuing exposure to cues (Gardner, 2012; Orbell & Verplanken, 2010). Major context changes, such as going back home or beginning a new profession, have been recommended by habit theorists to alter habitual patterns of behaviour by ending exposure to stimuli. Such shifts provide "windows of opportunity" for behaviour to align with underlying intentions and new habits to emerge (Lally & Gardner, 2013). However, instead of dismantling or overwriting cue-response associations, it might offer long-term behaviour change because associated cues are no longer encountered (Gardner, 2012).

Big technology companies such as Apple and Google have integrated applications into their operating systems to provide daily and weekly usage data. These applications track how long users spend on applications and predefined categories of applications, how many notifications they get, and how frequently they unlock their smartphones. Based on this data, users can independently set daily application limits (Apple, 2021; *Digital Wellbeing through Technology | Google*, 2021). Hiniker et al. (2016) has proven that a screen time management application has several benefits. It allows users to limit certain features on their smartphone while still being able to use other features, can effectively bring users closer to their goals, and, at least temporarily, can be an effective tool to limit screen time. This implies that when participants can set time restrictions themselves, they will spend less time on their smartphones.

Even though the use of screen time applications has been proven to be beneficial, several studies have revealed that smartphone interventions are not always successful, as the absence of electronic devices for several days does not lead to increased cognitive performance (Dunican et al., 2017; Turel et al., 2018). Not using a smartphone could even have counteracting forces, as abstinence from a smartphone leads to more symptoms of craving and withdrawal (Eide et al., 2018; Wilcockson et al., 2019). These studies reveal the need for further investigation to improve the effectiveness of intervention tools. A possible reason might be because screen time applications do not really discontinue exposure to cues – they just set a window within which one is exposed but within that window, automaticity is just further endorsed. In line with this idea, several studies have revealed that smartphone interventions may not always be effective (Dunican et al., 2017; Turel et al., 2018). This implies that a new approach to screen time interventions is necessary. With more substantial barriers, the exposure to cues could be disrupted more explicitly. Consequently, automatic behaviour may be prevented, which will break habits and

enhance self-regulation. Potentially, the imposing of a physical barrier to using smartphones may contribute to reinstating the idea of "goal-directed" use of smartphones.

Within smartphone intervention applications, we can make a distinction between applications with a psychological barrier and between applications with a physical barrier. Most of the applications on the current market could be defined as tools that impose a *psychological barrier*. The psychological barrier relates to the software-based screen time intervention type that imposes weaker restrictions in a sense that it allows users to cancel the restrictions easily. While screen time intervention through software apps could add a barrier to self-regulation, it should be only psychological and weak insofar as restrictions are imposed based on psychological decisions. Besides interventions that only provide a psychological barrier, interventions with a *psychological and physical barrier* are being developed. A physical barrier, defined as a hardware (device)-based screen time intervention, differs from the psychological barrier in that it works to impose stronger restrictions to using smartphones by adding another layer (i.e., physical actions). Given that a physical barrier may make users take another physical step to use smartphones (e.g., unplugging the Unpluq USB key to use self-restricted applications), the addition of a physical barrier to a psychological barrier may work more effectively in breaking users' habitual use of smartphones. Therefore, it can be argued that using an intervention with a psychological and physical barrier can be beneficial for increasing users' self-regulation.

Screen Time Intervention and Self-Regulation

A critical component of self-regulation is attention control, which refers to the extent to which a person can focus their attention on a particular task, manage internal and external distractions, and achieve goals (Diehl et al., 2006). While checking smartphones may not steal

much time from users, it could break their concentration. This hinders productivity because the entire focus must be regained before optimal productivity can occur again (Agrawal et al., 2017). To decrease these adverse effects of smartphone usage, smartphone users have tried standard management tactics for controlling usage such as physical isolation, deleting/turning off programs, and restricting services. However, due to a lack of self-regulation, users typically struggled to sustain their selected management tactics (Ko et al., 2015). This seems to imply that for an application to become successful, it needs to improve self-regulation.

Several anti-distraction interventions have emerged to assist users in self-regulation, which often work by reducing or limiting distractions from user interfaces, tracking and visualising device usage, and rewarding or penalising intended - or unintentional - device usage (Lyngs, 2018). Parry et al. (2020) revealed that a behaviour modification intervention based on self-regulation theory is a viable strategy for increasing single-tasking and maybe allowing for the occurrence of smaller attentional states in the short term. Another study by Hiniker et al. (2016) established "MyTime," a program to help individuals achieve their aims of not using their smartphones. They discovered that individuals reduced their time spent on applications they consider to be a bad use of time by 21%, while their time spent on apps they consider to be a good use of time remained unaltered. These studies reveal that interventions that discourage distractions can increase self-regulation, leading to less time spent on smartphones.

Other studies have proven that there are more effective ways to promote self-regulation. A study by Kim et al. (2019) revealed that a lockout task, an extra mandatory interaction, has great potential for discouraging smartphone usage. Their results revealed that behavioural inhibitors such as lockout tasks aided users in analyses to self-regulate frequent app use. Another approach was examined by Ko et al. (2015) by investigating an application called NUGU that uses social

support (which adds another layer to using smartphones) to improve self-regulation in limiting smartphone usage. Their study revealed that NUGU-Group members' smartphone use reduced dramatically compared to their non-social counterparts, and their perceived degree of interruption management improved significantly. These studies imply that adding another layer to using smartphones via the imposing of a physical barrier may improve users' self-regulation. Therefore, I assume that smartphone interventions with a psychological + physical barrier might positively influence perceived self-regulation. As the psychological + physical intervention has one more barrier that prevents users from smartphone overuse compared to the psychological intervention, I formulated the following hypothesis:

> H1. The use of a software app with a physical device (psychological + physical barrier) for screen time intervention will improve the level of self-regulation as compared to the use of a software app (psychological barrier).

Potential Moderating Role of Habitual Use of Smartphone

A study by Verplanken and Wood (2006) revealed that more than 40% of daily performed activities are habits. A critical reason that habits are formed is the brain's continual search for methods to save time and effort. The problem is that the brain does not know whether a habit is a good or a bad one. We are often unaware of our ability to regulate habit loops because we do not identify them as they develop. It becomes possible to modify the routines by learning to notice the cues and rewards (Duhigg, 2014). Therefore, we might argue that using a smartphone multiple times a day might become automatic, resulting in a habit. For a behaviour to become automatic, satisfactory repetition needs to occur in which a particular cue must spontaneously activate a certain response to its surroundings (Verplanken & Orbell, 2003).

Bad smartphone habits have been demonstrated by the study of Oulasvirta et al. (2011) in which the constantly working connectivity is found to result in checking habits among smartphone users. They refer to checking habits as the use of a smartphone for a short period to access information or people. However, the habit of checking often leads to other actions and applications. This has been further investigated with a revisitation analysis of smartphone use by Jones et al. (2015). They revealed that the habit of checking a smartphone occurred not due to technology but more likely by the information or service the user receives. Most of the time these checking habits are triggered by notifications such as social media, instant messages, and social games (Ko et al., 2015). Interestingly, users who have a strong mobile checking habit are more likely to experience such interruptions from notifications (Meier, 2021).

As smartphone interventions with a psychological + physical barrier adds another layer to the exposure to cues, it is more likely to prevent automatic behaviour. This might positively affect perceived self-regulation when the habit loop is interrupted, as people will not act automatically. As previously stated, a habit is a type of automaticity, specifically, the automatic elicitation of action in response to certain stimuli in the context of an engaged purpose. The more we repeat that behaviour, the more likely it will become habitual. Habitual use of a smartphone is an individual trait that could possibly moderate the effects of screen time intervention on self-regulation such that the effects of psychological + physical intervention on self-regulation will be strengthened when it is used by users with a greater level of habitual use. As a result, the following hypothesis was formed:

> H2. The degree to which users habitually use smartphones will moderate the effects of screen time interventions on perceived self-regulation such that the effects will be stronger for users who tend to habitually use smartphones.

Self-Regulation and Procrastination

Previous studies defined *procrastination* primarily as an unreasonable, intentional delay in beginning or finishing a planned task (Steel, 2007) while knowing that the delay would be damaging (Wessel et al., 2020). Procrastination appears to be harmless at first but can develop into a habit of wilfully deferring critical activities (Rozental & Carlbring, 2013). In most cases, procrastination refers to people succumbing to environmental temptations. Examples of such environmental temptations are the satisfaction of social and entertainment demands and choosing short-term satisfaction over the long-term advantages of activities that are less pleasurable but must be completed (Duckworth et al., 2016).

Chronic procrastination has been more common in recent decades, and it is expected to continue to rise in the following decades (Steel, 2007). One possible reason for this tendency is the exponential surge in smartphone availability. Smartphones aid procrastination because people are more prone to procrastinate when temptations are close at hand (Aalbers et al., 2021). The wireless internet connection provides users with constant informational and social incentives. As people keep their smartphones close by, they are more likely to succumb to the numerous temptations a smartphone provides rather than the work at hand (Oulasvirta et al., 2011). Additionally, a study by Sahin (2014) revealed that high levels of Facebook use were associated with greater levels of academic procrastination.

Several studies have suggested that self-regulation is a significant contributory factor to the development of procrastination as low levels of self-regulation have been linked to increased internet/smartphone use, as well as adverse outcomes including anxiety (LaRose & Eastin, 2004; LaRose et al., 2003; Soror et al., 2012). Furthermore, in European populations, inadequate self-

regulation was found to be a significant predictor of problematic smartphone usage (Gökçearslan et al., 2016; van Deursen et al., 2015). In turn, problematic smartphone usage has been found to predict academic procrastination (Yang et al., 2018). This leads to the assumption that self-regulation and procrastination are related. This assumption has been proven in a study by Zhang and Wu (2020), who identified that poor self-regulation could directly lead to procrastination. Therefore, it might be argued that a high perceived level of self-regulation is essential to prevent procrastination. This led to the following hypothesis (see figure 1):

> H3. Increased level of self-regulation, resulted from the use of a software app with a physical device (psychological + physical barrier), will reduce procrastination.

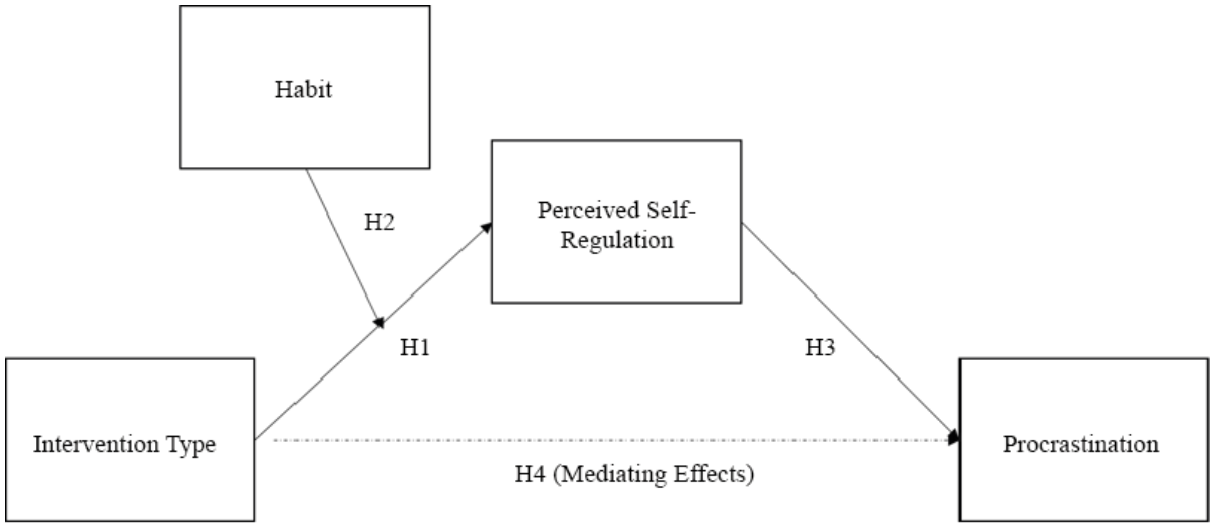
Mediating Effects of Self-Regulation

As discussed earlier, previous literature revealed that smartphone interventions could effectively increase users' self-regulation (Hiniker et al., 2016; Kim et al., 2019; Ko et al., 2015; Parry et al., 2020). This is important as low levels of self-regulation can cause unpleasant consequences (LaRose & Eastin, 2004; LaRose et al., 2003; Soror et al., 2012), and poor self-regulation has been shown to increase procrastination (Gökçearslan et al., 2016; van Deursen et al., 2015; Yang et al., 2018; Zhang and Wu 2020). Overall, these findings suggest that self-regulation may mediate the effects of intervention types on procrastination. Given the idea, this study examines the mediating role of self-regulation on the relationship between intervention types and procrastination:

> H4. Self-regulation will mediate the relationship between intervention type and procrastination.

Figure 1

Research model



Note. Hypothesised relationships among the independent variable (Intervention Type), the dependent variable (Procrastination), the moderator (Habitual use of smartphones), and the mediator (Perceived Self-Regulation).

Method

Experimental design

A 2-week micro-longitudinal field experiment based on a 2 x 2 factorial mixed ANOVA design with a between-subject factor (intervention type: psychological vs. psychological + physical) and a within-subject factor (Time of measurement: before and after intervention) was conducted to examine whether the intervention methods of psychological barriers differ with psychological + physical barriers in influencing smartphone usage.

Participants

(N=50) participants were recruited to participate in the experiment. The participants consisted of 25 males (50%), 23 females (46%) and two that identified differently (4%), which were approached via the Tilburg University Participant Pool. The participants had to meet several requirements to participate in this study. They had to be older than 18 years, own an Android smartphone (as the Unpluq application is only available on Android OS), not yet invested in any application aimed at restricting their smartphone usage and willing to limit their screen time for two weeks. These criteria were checked in advance and later re-checked at the intake session. Participants were randomly assigned to one of the two between-subject conditions.

Materials

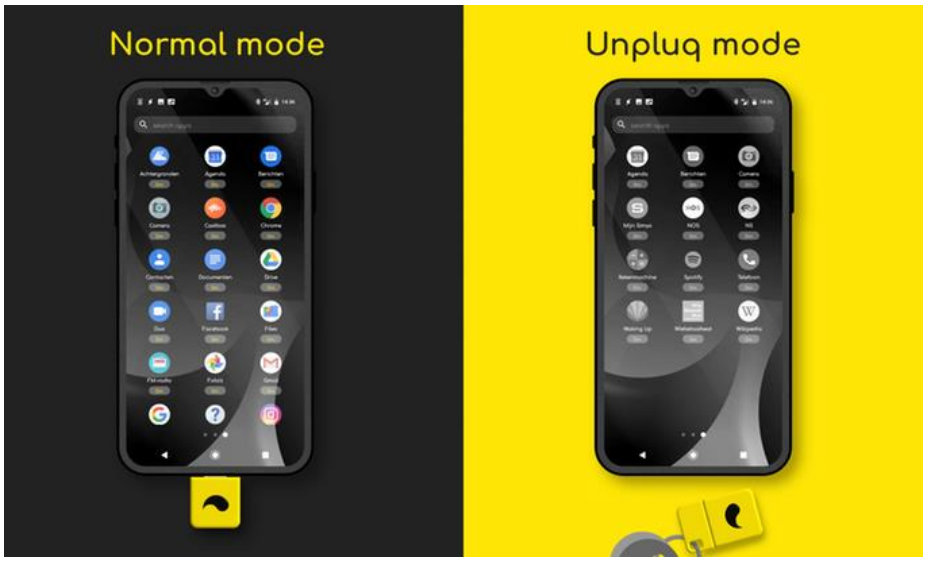
As the stimuli of the current study's experiment, Unpluq (Smits et al., 2021) was used. Unpluq provides two types of services: 1) Normal service that requires users to use hardware (the Unpluq USB key) and software (the Unpluq launcher) for activating self-restricted apps and 2) the Unpluq Premium service that only requires users to use software for activating self-restricted apps. Both types of services allow users to track their smartphone usage and impose restrictions on the use of pre-assigned applications.

The experimental group with a psychological + physical barrier used the Unpluq launcher and the USB key. For this experimental group, the Unpluq launcher switched between the 'Focus mode' when the USB key was not inserted and between the 'Normal mode' when the USB key was inserted into the smartphone. When the USB key was not inserted into the smartphone, the participants could not use the applications they put restrictions on, and their notifications were blocked. When the USB key was inserted, the users could use all the applications available on their smartphone and receive all their missed notifications. The users in the experimental group

with only a psychological barrier will use the Unpluq premium service, which allows users to activate the restricted applications via shaking their smartphones for three seconds.

Figure 2

Illustration of Unpluq software application with physical device



Note. The stimuli used for the experiment (normal mode and Unpluq mode) which was used for the experimental group with a psychological + physical intervention.

Procedure

After signing up for the study, participants received an email that double-checks their eligibility and invites them to an intake session on campus. During the intake session, participants were asked to fill out a pre-survey questionnaire through which demographic information, tendency to habitually use their smartphone, self-regulation, and procrastination before intervention was measured. This was to acquire the baseline information regarding participants' smartphone use patterns that could be compared with the data collected after the intervention.

Additionally, the experimental group with a psychological + physical intervention received instructions about the Unpluq services and the experimental group with a psychological intervention received instructions about the Unpluq application. The experimental groups used the allocated intervention for about two weeks. All participants completed an online survey before the two-week intervention period.

Participants in the ‘psychological’ barrier condition were asked to choose three applications that they think are the most distracting and put restrictions on the apps via the Unpluq service. Participants in the ‘psychological + physical’ barrier condition were also asked to download and install the ‘Unpluq’ application in the app store. They also had to put restrictions on three applications that they thought were most distracting. They were also able to choose their restrictions. However, this experimental group used the Unpluq USB key. The three picked applications were only available when the Unpluq USB key was inserted into their smartphone. After using the Unpluq application for two weeks, both experimental groups filled out an online survey and reported their data collected by the Unpluq application.

Measures

Perceived Self-regulation

The participants' perceived self-regulation was measured by ten 4-point Likert Scale items (see appendix A) extracted from the study of Diehl et al. (2006). The perceived self-regulation was measured twice, once at the intake before the intervention and once after the experiment. Examples of items are "For past two weeks, I was able to concentrate on one activity for a long time, if necessary" and "For past two weeks, if I was distracted from an activity, I didn't have any problem coming back to the topic quickly" (pre: $\alpha = .76$; post: $\alpha = .80$; Overall: $\alpha = .78$).

Habit

The degree to which participants habitually use smartphones was measured using twelve 7-point Likert scale items (see appendix B) adapted from the study of Verplanken and Orbell (2003). Habitual smartphone usage was measured once at the intake before the intervention. The measure consisted of the items such as "Using a smartphone is something I do frequently" and "Using a smartphone is something I do automatically" ($\alpha = .88$).

Procrastination

The participants' procrastination was measured using 5 5-point Likert scale items (see appendix C) adapted from the study of Yockey (2016). The participants' procrastination was measured twice, once at the intake before the intervention and once after the experiment. The measure consisted of the items such as "I put off projects until the last minute" and "I know I should work on schoolwork, but I just don't do it" (pre: $\alpha = .91$; post: $\alpha = .95$; Overall: $\alpha = .93$).

Data analysis

To analyse the data, a partial least squared structural equation modelling (PLS-SEM) via WarpPLS 7.0 (Kock, 2021) was used to answer the hypotheses (H1 - H3). WarpPLS 7.0 was used because the normality assumption, sample size, and complicated structures of a model are known to have little effect on WarpPLS (Chan et al., 2015). Difference scores are recommended as a method for assessing route models with a two-condition within-subject design in general (Montoya & Hayes, 2017). Therefore, difference scores (i,e., post-interventions minus pre-interventions) for self-regulation and screen time were obtained. A repeated-measures ANOVA was used to examine the variability in the difference of the variables before looking at the connection between them. To test the mediating effect of perceived self-regulation (H4), the

MEMORE Macro (Montoya & Hayes, 2017) was used in IBM SPSS 27. In a repeated measures design, MEMORE facilitates the execution of a mediation analysis.

Results

Measurement Validity

The validity of the measurement model was tested using the PLS-SEM method. In the measurement model, intervention type was the only binary variable ([1] = Unpluq APP (premium software); [2] = Unpluq USB key group). The rest of the variables used in the measurement model were reflective indicators. The item loadings of the reflective indices were examined to confirm the validity of the measurement model. According to Kock (2021), the item loadings of reflective indicators with a significance level below .05 can ensure the suitable reliability of a measurement model. The results of PLS-SEM showed that two of the items in the self-regulation measure did not have significant loadings (i.e., “0,16” and “-,05”). Therefore, two items were dropped for the hypotheses testing. Other than the two items, the item loadings for all the measures were found to be significant (for more details, see Table 1).

Table 1

Item loadings for reflective indicators

SR	Item loading	PROC	Item loading	HAB	Item loading
SR1	.83***	PROC1	.87***	HAB1	.66***
SR2	.64***	PROC2	.84***	HAB2	.67***
SR5	.41***	PROC3	.81***	HAB3	.74***
SR6	.45***	PROC4	.81***	HAB4	.58***
SR7	.38**	PROC5	.87***	HAB5	.83***

SR8	.70***			HAB6	.72***
SR9	.50***			HAB7	.67***
SR10	.67***			HAB8	.69***
				HAB9	.75***
				HAB10	.44***
				HAB11	.61***
				HAB12	.49***

Note. SR = Self-regulation, PROC = Procrastination, HAB = Habitual smartphone use.

**$p < .01$, ***$p < .001$.

Hypotheses testing

Before testing the main hypotheses, a repeated-measures ANOVA was conducted to ascertain if self-regulation and procrastination significantly changed after two weeks of intervention. Results from a repeated measures ANOVA indicated that participants had a greater level of self-regulation after having the two weeks of intervention ($M = 2.66$, $SD = .32$) than before having the intervention ($M = 2.48$, $SD = .44$), $F\ (1, 48) = 7.94$, $p = .007$, $\eta_p^2 = .14$. In addition, results showed that participants had a lower level of procrastination after having the two weeks of intervention ($M = 2.90$, $SD = 1.26$) than before having the intervention ($M = 3.49$, $SD = 1.17$), $F(1, 48) = 11.44$, $p = .001$, $\eta_p^2 = .19$. Overall, these results suggest that the two weeks of intervention was effective.

Next, the significance of the causal paths posited in the structural model was tested using PLS-SEM (H1- H3). H1 hypothesised that using a software app with a physical device (psychological + physical barrier) for screen time intervention will improve the level of self-regulation compared to using a software app (psychological barrier). Inconsistent with the

prediction of this research, results from PLS-SEM showed that the intervention type did not have significant effects on self-regulation (β = .17, *n.s.*). Therefore, H1 was not supported.

H2 predicted that the degree to which users habitually use smartphones (i.e., habit strength) will moderate the effects of screen time interventions on perceived self-regulation such that the effects will be stronger for users who tend to use smartphones habitually. In support of the prediction, PLS-SEM results indicated that habit strength significantly moderated the relationship between intervention type and self-regulation (β = .27, p = .02). The positive moderation effects (i.e., positive beta coefficient) suggest that the use of Unpluq USB key (psychological + physical barrier) was more effective for participants who have been more habitually using smartphones. Therefore, H2 was supported.

H3 predicted that the increased level of self-regulation, influenced by the use of a software app with a physical device (psychological + physical barrier), will reduce participants' level of procrastination. Consistent with the prediction, results from PLS-SEM indicated that the increase in self-regulation significantly reduced participants' procrastination (β = .39, p < .01, R^2 = .15). Therefore, H3 was supported.

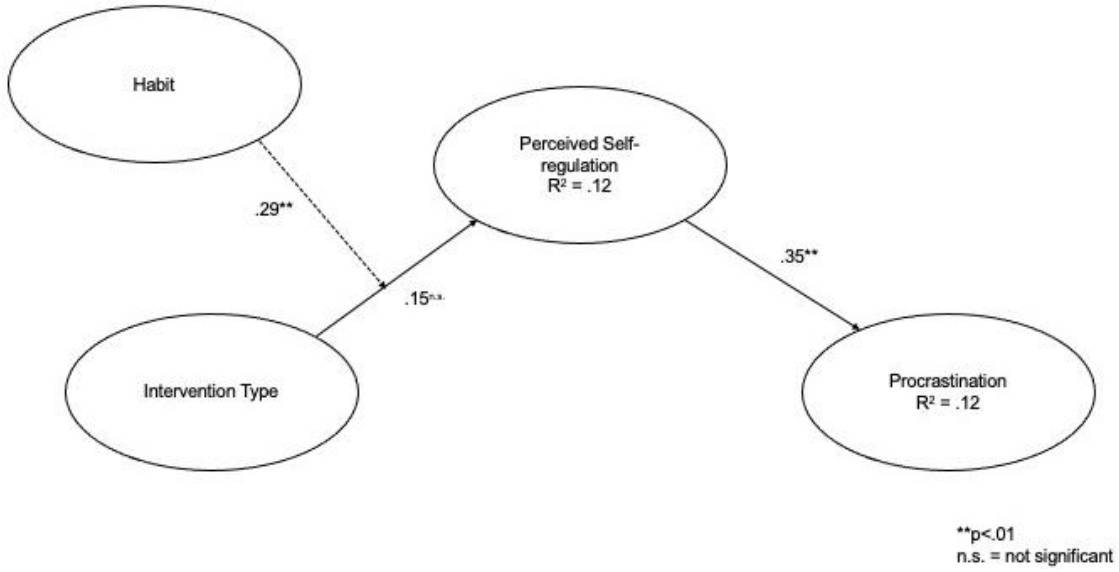
H4 was tested using the MEMORE Macro (Montoya & Hayes, 2017). With 5,000 replicates, the bias-corrected bootstrap approach was used. Inconsistent with the prediction of this study, results from a mediation analysis indicated that the effects of intervention type on procrastination was not significantly mediated by self-regulation: B = -.02, SE = .09, 95% CI [-.2280, .1471]. Thus, H4 was not supported. The holistic view of PLS-SEM results is presented in Figure 3.

Model fit

The average path coefficient (APC), average R-squared (ARS), average variance inflation factor (AVIF), and average full collinearity VIF (AFVIF) were examined to test the validity of the research model. Kock (2021) demonstrates that AVIF and AVFIF values below 3.3 and significant APC and ARS can ensure that a research model has a good model fit. Other than the ARS index (= .121, p = .08), all indices indicated that the current study's research model has a good model: APC = .28, p < .01; AVIF = 1.01; and AFVIF = 1.07.

Figure 3

PLS-SEM results



Note. Solid lines indicate direct paths and dashed lines indicate a moderation path.

Discussion

In order to confirm the general research question, this study began to construct particular hypotheses based on past research. To begin with, the current research predicted that using a software app with a physical device (psychological + physical barrier) for screen time intervention will improve the level of self-regulation compared to using a software app

(psychological barrier). Next, this research progressed to predict that the degree to which users habitually use smartphones (i.e., habit strength) will moderate the effects of screen time interventions on perceived self-regulation such that the effects will be stronger for users who tend to use smartphones habitually. This assumption was largely based on the research conducted by Meier (2021), which revealed that habit strength has a significant relationship with procrastination. Also, it was predicted that the increased level of self-regulation, influenced by the use of a software app with a physical device (psychological + physical barrier), will reduce participants' level of procrastination. Lastly, it was expected that self-regulation would mediate the relationship between intervention type and procrastination.

In contrast to the prediction of this research, the results of this study revealed that self-regulation improved after two weeks with a small difference between the two intervention types (Unpluq app and Unpluq USB key), which indicate that both intervention types can be effective. The findings were consistent with earlier studies (e.g., Kim et al., 2019; Ko et al., 2015), which revealed that interventions that add an extra mandatory interaction to using smartphones can be more effective for improving users' self-regulation. A possible reason for the small difference between the two intervention types might be that shaking a smartphone to use restricted applications (which was the case in the psychological condition) might have affected the results by making the participants also perceive shaking phones as an extra physical layer. This may imply that even a weak physical barrier might be sufficient to restrain screen time.

Although the results revealed that the difference between intervention type (Unpluq app and Unpluq USB key) was not significant, the moderating effect of habitual smartphone usage was found to be significant. More specifically, habitual smartphone usage was found to enhance the relationship between intervention type and perceived self-regulation. This is in line with

previous research that indicated that habit strength has a significant relationship with procrastination (Meier, 2021). The positive moderation effects suggest that the relationship between intervention type and self-regulation was more successful for the Unpluq USB key condition when used by habitual smartphone users. This was in accordance with the findings proposed by Kim et al. (2019), wherein they revealed that an extra mandatory interaction has great potential for discouraging smartphone usage.

The results further revealed that increased self-regulation leads to reduced procrastination. In alignment with the hypothesis, the increased level of self-regulation, influenced by the use of a software app with a physical device (psychological + physical barrier), reduced participants' level of procrastination. This corresponds to prior findings, in which self-regulation is found to be a crucial contributory component for interventions to decrease procrastination (LaRose & Eastin, 2004; LaRose et al., 2003; Soror et al., 2012).

Finally, the perceived self-regulation did not significantly mediate the effects of intervention type on procrastination. This is in contrast with previous literature, in which smartphone interventions were found to effectively increase users' self-regulation (Hiniker et al., 2016; Kim et al., 2019; Ko et al., 2015; Parry et al., 2020), and in which increased self-regulation was found to decrease procrastination (Gökçearslan et al., 2016; van Deursen et al., 2015; Yang et al., 2018; Zhang and Wu 2020). This contradicting finding might be caused by the insignificant difference of intervention type on self-regulation in this study. However, as the moderation effect of habitual smartphone usage was significant on the relation between intervention type and self-regulation, we may argue that intervention effectiveness can be determined by habit strength. This brings about the importance of taking into account the role of individual traits when understanding the effectiveness of smartphone interventions.

Implications

Theoretically, this study appears to improve current literature on the impact of smartphone treatments on procrastination by offering another approach. Although there has been a significant amount of research into the effects of smartphone interventions on self-regulation, it is worth noting that only a few studies (e.g., Kim et al., 2019) have looked into whether and how the effects of an extra mandatory interaction will increase self-regulation. Considering this fact, even though the results revealed that there was no significant difference between the two intervention types on self-regulation, this study contributes to advancing current scholarship by revealing that self-regulation, influenced by a smartphone intervention with a psychological + physical barrier, significantly reduces procrastination. Therefore, this study contributes to recent scholarship by providing a new approach to the role of smartphone interventions on procrastination.

In addition, this study seems to provide implications to the effectiveness of smartphone interventions on habitual smartphone users. It was discovered that using a smartphone on a regular basis improved the relationship between intervention type and perceived self-regulation. This is consistent with prior research that has found a link between habit strength and procrastination (Meier, 2021). For the Unpluq USB key condition, the association between intervention type and self-regulation was more successful for habitual smartphone users. This seems to imply that smartphone interventions with a psychological + physical barrier can be an effective tool for habitual smartphone users to limit the negative consequences of problematic smartphone usage. Notably, this may potentially provide habitual smartphone users with the benefits of using smartphones without the negative consequences. Moreover, smartphone interventions with a psychological + physical barrier may also prevent non-habitual smartphone users from developing problematic smartphone usage in the future. This study indicates that the

use of smartphone interventions can attract smartphone users who want more control over their smartphone usage.

In summary, the current study adds to the theoretical knowledge of how intervention types may help increase self-regulation and prevent negative consequences of problematic smartphone usage (i.e., procrastination).

Limitations and future directions

This study has a few limitations. First, because the current study used only students as a stimulus, the findings' generalisability in terms of the role of intervention types on problematic smartphone use is limited. The mean age among the participants in this study (M = 22.8) is in line with the findings by Csibi et al. (2019), which revealed that problematic smartphone usage occurs the most between the ages 20 - 34. However, Csibi et al. (2019) also reported that the second and third most vulnerable groups were between the ages 3 -11 and 35 - 50 years. Therefore, future research should further investigate whether the findings of this study are applicable for other age ranges as well.

Second, another limitation of this study is that it only includes Android smartphone users. In other words, I did not consider that different operating systems might influence the usage of smartphones. However, this study is in line with the fact that Android is the leading mobile operating system worldwide. Future studies may consider examining whether the results of this study are also applicable to iOS users, as Android and iOS possess over 99 per cent of the global market (Statista, 2021a).

The third limitation of this study pertains to the lack of certainty that all participants thoroughly used the interventions over the two weeks. As this study used an uncontrolled experiment with self-report scales, participants may have bent the truth about using the

intervention to receive their course credits. Future studies may consider using an interview after the experiment to ask several questions in order to obtain honest and open responses.

Last, even though the results reported no mediating effect of self-regulation on the relation between intervention type and procrastination, there was a moderating effect of habitual smartphone usage. Given that this study included participants that experience habitual smartphone usage and participants that don't, future studies with only habitual smartphone users might be beneficial to see if the results will turn out differently. In other words, the insignificant results in this study might become significant after running an experiment only with participants who habitually use smartphones.

Conclusion

The results of this study revealed that the effectiveness of smartphone interventions may depend on the habit of using a smartphone. As a result, researchers should focus their attention on the habituation of smartphone usage in order to avoid the efficacy of smartphone interventions from deteriorating. Additionally, the use of an intervention with a psychological + physical barrier was more successful when it comes to increasing self-regulation and decreasing procrastination. Therefore, this research should help to solve the issue of problematic smartphone usage and act as a foundation for the design of future smartphone interventions.

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Appendix A

Self-regulation scale described by Diehl et al. (2006)

Statement	not at all true	barely true	somewhat true	completely true
I can concentrate on one activity for a long time, if necessary.	( )	( )	( )	( )
If I am distracted from an activity, I don't have any problem coming back to the topic quickly.	( )	( )	( )	( )
If an activity arouses my feelings too much, I can calm myself down so that I can continue with the activity soon.	( )	( )	( )	( )
If an activity requires a problem-oriented attitude, I can control my feelings.	( )	( )	( )	( )
It is difficult for me to suppress thoughts that interfere with what I need to do	( )	( )	( )	( )
I can control my thoughts from distracting me from the task at hand.	( )	( )	( )	( )

When I worry about something, I cannot concentrate on an activity.	( )	( )	( )	( )
After an interruption, I don't have any problem resuming my concentrated style of working.	( )	( )	( )	( )
I have a whole bunch of thoughts and feelings that interfere with my ability to work in a focused way.	( )	( )	( )	( )
I stay focused on my goal and don't allow anything to distract me from my plan of action	( )	( )	( )	( )

Appendix B

Self-reported habit index described by Verplanken and Orbell (2003)

Statement: Using a smartphone is something...	Strongly disagree	Disagree	Somewhat agree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I do frequently.	( )	( )	( )	( )	( )	( )	( )
I do automatically.	( )	( )	( )	( )	( )	( )	( )
I do without having to consciously remember.	( )	( )	( )	( )	( )	( )	( )
that makes me feel weird if I do not do it.	( )	( )	( )	( )	( )	( )	( )
I do without thinking.	( )	( )	( )	( )	( )	( )	( )
that would require effort not to do it.	( )	( )	( )	( )	( )	( )	( )
that belongs to my	( )	( )	( )	( )	( )	( )	( )

(daily, weekly, monthly) routine.							
I start doing before I realize I'm doing it.	( )	( )	( )	( )	( )	( )	( )
I would find hard not to do it.	( )	( )	( )	( )	( )	( )	( )
I have no need to think about doing.	( )	( )	( )	( )	( )	( )	( )
That's typically "me."	( )	( )	( )	( )	( )	( )	( )
I have been doing for a long time.	( )	( )	( )	( )	( )	( )	( )

Appendix C

Self-reported procrastination index described by Yockey (2016)

Statement:	Strongly disagree	Slightly Disagree	Neither agree nor disagree	Slightly Agree	Strongly agree
I put off projects until the last minute.	( )	( )	( )	( )	( )
I know I should work on schoolwork, but I just don't do it.	( )	( )	( )	( )	( )
I get distracted by other, more fun, things when I am supposed to work on schoolwork.	( )	( )	( )	( )	( )
When given an assignment, I usually put it away and forget about it until it is almost due.	( )	( )	( )	( )	( )
I frequently find myself putting important deadlines off.	( )	( )	( )	( )	( )