ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Master Thesis Behavioral Economics

To Inhibit or Not To Inhibit?

An Ego Depletion Study

How inhibiting smartphone usage affects our cognitive performance in a subsequent task, in a workplace replication environment

Student name: George Verros

Student ID number: 475772gv

Supervisor: Tong Wang

Second assessor: Merel van Hulsen

Final version date:

Table of contents

Abstract

Along with the smartphone breakthrough, numerous restriction policies also came within a lot of companies, trying to restrain employees from using their smartphones while working, in the name of productivity. But do smartphones indeed have such a negative impact on the workplace? Can inhibiting smartphone usage be more detrimental, based on the ego depletion theory, than the smartphones themselves? This experiment focuses on replicating a workplace environment while discovering the subsequent effects on productivity of exerting self-control to not use smart phones, making a direct comparison with individuals that were allowed to indulge their smartphone-related impulses. To accomplish that, subjects were assigned in a control and treatment group, with the former instructed to use their smartphones as they like and the latter to perform inhibition before a subsequent Go/No-Go task assessing their cognitive performance. By measuring participants' reaction times and errors on this task, this study's main objective was to explore if ego depletion was present for individuals that inhibited using their smartphones in the first place. Secondly, the study investigated gender differences in reaction times and errors for the participants in both the control and treatment group. It was hypothesized that women's social orientation would have a stronger negative impact on the subsequent task's performance in comparison with the men in the same group. The experiment also investigated how participants' haptic processing is correlated with their performance on the Go/No-go task, by using the autotelic Need for Touch scale. Analyzing the participants' performance on the Go/No-Go task, no differences were found between individuals that inhibited their smartphone use and the ones that were instructed otherwise. Gender differences were non-existent in both groups, as also subjects' haptic processing did not play a role in predicting their performance on the subsequent task. Despite the lack of significant results, this research raises the question of whether inhibiting using our smartphones in the workplace in the first place is more harmful for our cognition than using them, providing an experimental blueprint for future research. Exploring the possibility that inhibition in the first place can interfere with one's working performance is essential and valuable for establishing policies within companies.

1 Introduction

The radical revolution of technology and social media have made smartphones an integral part of people's everyday lives. People use smartphones not only for communication purposes but also to entertain themselves, replacing the more traditional means of entertainment and socialization. However, extensive usage of smartphones led to habitual checking behaviors and even more severe psychological disorders, as people usually check their smartphones and social media throughout the day (Thomée et al., 2007; Oulasvirta et al., 2012). Studies showed that, on average, a person checks his phone around every 10 minutes (SWNS, 2017). This lack of self-regulation is believed to hurt people's productivity, especially in the workplace ("More Firms Ban Smartphones at Work for Safety Reasons",, 2018). Having employees being distracted and not focused on their job tasks have drawn attention to companies' management, and a few companies established stricter cell-phone policies to overcome this (Jeff Griffin, 2018). Only a few companies (Simons J., 2018) banned the use of smartphones in the workplace, but the majority have restricted smartphone policies instead, which can lead to employees trying to self-regulate their phone usage at work.

Yet, exerting self-control in the first place can lead to a deteriorated cognitive performance in a subsequent task, according to the ego depletion theory. Exerting self-control, inhibiting impulses and urges in the first place can have a spillover effect in a following task, adversely affecting one's performance on it (Baumeister et al., 1998). So understanding how employees' productivity is affected, by restraining their smartphone usage, is crucial before having companies establishing policies that would lead to the opposite direction they aim. This research focuses on replicating a workplace to compare environments where smartphone usage needs to be inhibited and where it is allowed. It is vital to know how these two aspects are measured against each other in a direct comparison, identifying which take is less detrimental for individuals' cognition, and therefore productivity.

This leads to the following research question:

How does inhibiting smartphone usage affect our cognitive performance in a subsequent task?

To answer this question, an experiment was conducted, randomly assigning 100 participants in two groups, a control and a treatment group. The essential differences between the two groups were on the first task, allowing subjects in the control group to use their smartphones before they move on to the second part of the experiment, while subjects in the treatment group had to inhibit using or even touching their phones. The second part of the experiment was to measure the cognitive capacity of the participants by instructing them to take part in a Go/No-Go task. A Go/No-Go task is a well-known psychology test designed to assess the inhibition and selective attention of individuals by presenting predominant stimulus in high frequency (Go sign), forcing subjects to perform inhibition when No-Go sign is displayed (Verbruggen & Logan, 2008). Based on ego depletion theory (Baumeister et al., 1998), this experiment expects that participants that completed inhibition in the first place will have higher reaction times and errors than participants that were allowed to use their phones. That is because a deteriorated performance originated from ego depletion is attributed on a decline on cognitive (Davis & Leo, 2012) and may energy resources (Gailliot et al., 2007) rather than shifts in attention caused by being distracted from using your phone (Jeff Griffin, 2018). As both states are expected to hurt employees' performance and, therefore, productivity, it is expected that the effects of inhibition will be worse for the over mentioned reasons.

Additionally, do men and women take a similar approach to inhibition or smartphone use? Are there any distinct differences between genders that can predict their performance on a subsequent unrelated task? Studies showed that differences in smartphone usage are mainly goal-oriented, meaning that men tend to use their phones for process oriented tasks as video games and women for socializing (Frangos et al., 2010). This study tested if women's social proneness and likelihood to display social anxiety disorders (Van Deursen et al. 2015) would have an adverse effect on the secondary task, either after performing inhibition or while using their smartphones.

But previous research illustrated that not only gender differences could alter the performance in a successive task but also individual traits, like the need for touch. Studies showed that women's higher haptic processing (Schifferstein, 2006) can also play a vital role in predicting their performance after inhibition, as most of smartphones' sessions include touching behaviors. Oulasvirta and colleagues (2012) found that an average person unconsciously checks his phone 34 times a day without signaling. Either when an individual using his phone or trying to restrict its usage, their unique haptic orientation can tweak his subsequent performance, by making it easier to be distracted or harder to inhibit using it. This study used the Autotelic dimension of the Need for Touch scale to evaluate the unconsciousness arousal-seeking sensory stimulation of the participants in this experiment (Peck & Childers, 2003) and examined if individuals' haptic processing would predict a participants' cognitive performance

The next two chapters will elaborate more on explaining the strength model of self-control and how ego depletion is activated but also the reasons that lead to its deficiency effects. Furthermore, an extended elaboration is presented on the psychological effects of excessive smartphone usage, how it is related to the lack of self-control, as well as the gender and individual traits that can act as ego depletion predictors.

2 Literature review

2.1 The strength model of self-control & Ego depletion

2.1.1 What does the strength model of self-control refer to & how is it related to ego-depletion?

People every day perform small acts of self-control, trying to avoid engagement in harmful actions and emotions and trying to resist their conscious impulses. For most people exerting self-control has to do with overriding habits and temptations as eating unhealthy foods or postponing duties. But why humans engage in these actions in the first place? Because acts of self-control have a positive effect in the long term in peoples' lives (Mischel, 1996). Altering one's initial response and modifying it to an appropriate one is a difficult task which requires mental strength. Baumeister et al. (1994) were the first that theorized that self-regulation failures are attributed to the exertion of a limited energy resource, portraying a muscle. The same way a person can train a muscle to achieve better endurance, he can also improve his self-control if he performs regular exertions (Baumeister et al., 2006) but also conserve his strength and initiate a last exertion act when is needed most (Muraven, 2006). But the most exciting and tested aspect of the strength model is what is known of as ego depletion. This state refers to the deteriorated self-regulation on a subsequent task after an individual consumed most of this limited resource while trying to regulate himself in a first task (Baumeister et al., 1998).

A plethora of experiments have been conducted supporting the idea of ego depletion. Even if the nature of the depleted resource has not been directly identified, the types of control that can lead to worsening performance in a second unrelated task have. Control over one's thoughts, emotions, and impulses are the most common types of self-control that have been proven that draw from this limited inner resource (Baumeister et al., 1998). Baumeister and colleagues in a series of experiments showed that subjects that were assigned to eat radish inhibiting eating chocolate were prone to give up easier in a problem-solving task, compared to participants that were allowed to give up on their urges and consumed chocolate. In the same experimental series, they illustrated that participants that suppressed their beliefs and thoughts by reading an incongruent statement with their personal views showed a deteriorated performance in a persistence task, pointing up that both types of self-control draw the same energy resource.

Despite that most research focus on the internal states of inhibition, one of the earliest studies from Glass et al. (1969) found that an external factor or event, as an unexpected noise, can initiate a self-regulation stage. In that study, the sound acted as a stressor, and the individuals exposed showed a decrease in tolerance on an unsolvable task, highlighting that coping with stress was at an expense of a "psychic cost." In the same sphere of thinking, an external factor as a noise, the sight of a drink, cake, or smartphone, can act as an inhibitor.

The majority of the studies emphasize the effects of self-control on impulses, urges, and temptations, because of the adverse effects the lack of self-regulation on behaviors like drinking, overeating, and smoking, etc. have. That is because these kinds of behaviors not only impact people's everyday lives but they are also crucial for policymakers, who have made it a necessity to understand eating disorders and especially obesity. Self-regulation of obese individuals and especially youngsters, can be established at school and by their parents over time (Golan & Bachner-Melman, 2011). Practicing self-control over time can increase one's limited energy capacity, and therefore his overall energy stockpile (Muraven & Baumeister, 2000). But even people that practice inhibition for years can be vulnerable to self-control failures after being depleted. Life-long dieters that strengthen their inhibition system throughout their lives have shown that they are equally exposed to inhibition failures on subsequent tasks. Dieters that had restrained their emotional reactions while watching a joyless video proceeded in higher ice cream consumption in a taste test, compared to dieters that were instructed to act as they like (Vohs & Heartheton, 2000). As this study did not have the time and resources to identify participants' self-control capacity, it is vital to highlight that even individuals with strengthened self-regulation are prone to inhibition failures.

But being aware of these failures alone can act as a reminder for individuals. Yet, even when people know and are aware of the consequences of their behaviors, such as driving unsafe back home, they still tend to illustrate a lack of self-regulation. Muraven et al. (2002) demonstrated that social drinkers, after stifling their thoughts in a first task, were vulnerable to ego-depletion compared to the ones that did not, reaching higher Blood Alcohol Content (BAC), even when they were informed for a successive driving test. That is because self-control is also associated with individual personality traits. Failures in self-control related to drinking behaviors have shown to be also attributed to personality traits, like temptation that are correlated with drinking behavior; the higher the trait temptation is, the more likely to display higher alcohol consumption (Muraven et al., 2002). That is because drinkers tend to drink more when having higher urges for alcohol consumption (Bensley, 1991). which will be elaborated more in the next chapter.

These are numerous examples of self-control failures in predominant everyday behaviors, but not all studies have shown this spillover effect from task at time 1 to the task at time 2. Following a different approach Tuk et al. (2011) while exploring the impact of exerting self-control during a visceral state, as urination, they found improved performance on a second task contrary to the ego-depletion model. After manipulating the urination urgency by instructing subjects to participate in a water taste trial and an additional 45 minutes unrelated task, participants with higher urination urgency demonstrated decreased future discounting, compared to participants with low. This implies that the former inhibited the present and more tempting monetary options and choose the long-term beneficial ones. Exempting the manipulation stage in the same series of experiments, improved performance was also found (for subjects that stated high urination urgency) on a Stroop task while participants had to control their bladder at the same time. The result of the last set-up is quite different for the traditional ego depletion one, as both of the tasks were performed at the same time and not subsequently as ego depletion theory states.

2.1.2 The self-control task matters

While illustrating how ego depletion works, it is essential to highlight that the task of self-regulation at time 1 matters and is vital in showcasing the effect of ego depletion at time 2. Numerous experiments assigned their subjects to high and low inhibition groups depending on the self-control task the participants had to take. Muraven et al. (2002) found out that participants that inhibited thinking of a white bear while doing a thought-provoking task at time 1 did not manage to restrain their alcohol consumption at time 2 compared to participants that had to solve arithmetic problems. Despite that subjects can find very irritating solving arithmetic problems (Muraven et al., 1998), it does not require high self-control acts as it is not related to suppressing urges that are goal-oriented as suppressing the thought of a white bear, which is in line with previous studies.

As it is already mentioned, Baumeister and colleagues (1998) found out that subjects who made an incongruent statement contrary to their beliefs showed a subsequent task failure. But they also showcased that the high inhibition group, participants that intentionally decided to read the given statement, were more depleted at time 2 compared to the ones that were given no choice. That is because the deliberate involvement of the self and accountability of action is an exertion act (Scher & Cooper, 1989), resulting in a deteriorated performance on a second task.

In like manner, Vohs & Heatherton (2000) demonstrated that different formats of situational cues could act as high and low inhibitors between long-duration dieters. More specific, varying the distance of the available food, they found out differences in performance on a persistence task. Dieters that were assigned to the high inhibition group, close to food, had a deteriorated self-control ability on the persistence task compared to the ones to the low inhibition group, where the food was on the other side of the room.

2.1.3 Self-control as a physical limited energy resource: Linking glucose to ego depletion

Freud was the first one who theorized that the self is a system that uses energy as fuel to carry through all the cognitive tasks it needs to function (Freud, 1961a). Trying to validate this view and to see if this also applies to self-regulation processes, modern psychologists started exploring the origin of this energy resource. Because glucose is well-established as the fuel the brain uses for its functions, the majority of the studies focused on the role of glycose on ego depletion and how it affects it. Gailliot et al. (2007), with a series of experiments, illustrated that exertions of self-control produce a significant drop of glucose, which is responsible for ego depletion at time 2. But more importantly, their research found out that providing glucose to participants could reverse ego depletion. More specifically, by giving subjects drinks that contained sugar, the effects were eliminated during a word-solving quiz at time 2, unlike with people who were given placebo drinks.

Lack of self-control suggests that people indulge their impulses and urges, showing an underestimation of the long term benefits from this exertion. Reducing the glucose levels and, therefore, the individuals' ability to process the value of these benefits can also expand in different areas of interest. Wang & Dvorak (2010) explored how varying one's glucose level can affect his future discounting. By giving participants sugar-free drinks, they observed that people undervalue options that can give them more money in the future, where the ones that consumed sugar-contained drinks were more willing to wait for higher future rewards. Supplying the brain with fuel can interfere not only on one's self-control functions but also in his decision making, proving additional evidence to the view that glucose is the limited self-regulatory resource.

But glucose is not the only way to counteract the ego depletion effects. On agreement of the limited energy capacity model but not solely on that, many authors explored effective antidotes for these self-regulatory deficiencies. Motivation is something that has been shown that can overcome ego depletion and moderate its pre and post effects. Motivating and giving people the perception that even after being depleted their performance at time 2 can have a positive impact on others, can eliminate self-control failures (Muraven & Slessareva, 2003). High incentives, which is a form of motivation, can also stamp out the aftermath of self-regulating (Muraven & Slessareva, 2003). In the same sphere of thinking, Martijn et al. (2002) illustrated that altering one's expectation by letting him know that his performance will worsen after the first task led to superior performance in a second task.

2.1.4 Self-control from a mechanism and dual-system perspective: Revisiting the original strength model

Most of the literature on the strength model is focusing on self-control, relying on glucose as an energy resource; when it is consumed, it can lead to the so-called ego depletion (Baumeister & Heatherton, 1996). This theory has been evidentially challenged by numerous studies that did not support glucose's counter effects on ego depletion (Lange et al., 2014; Vadillo et al., 2016). Inzlicht and Schmeichel (2012) argued that the relation between glucose and self-control might be very simplistic and that reduction of glucose in the bloodstream might not be the only reason behind ego depletion. The authors argued that a mechanical point of view on self-control could account for the ego-depletion effects, highlighting that shifts in motivation and attention can better explain why self-control is limited.

Exerting self-control is a hard task, which needs agility and attention, attributes that can exhaust one's self (Muraven & Baumeister, 2000). For that reason, the authors argue that after participants in experiments exert self-control at time 1 they may not be motivated to put further effort at time 2, especially when, in most of the experiments, no incentive was given for the first task. Instead of having a deficit on an energy resource, they have a motivational one, as they are unmotivated to self-control themselves (Inzlicht & Schmeichel, 2012). Based on their model, experimental subjects' deteriorating performance in the following task can be explained by the participants' need to gratify themselves by not regulating their impulses on a subsequent task, highlighting the importance of motivation on ego depletion studies.

The second reason responsible for ego depletion is, as it is already mentioned, shifts in attention. The authors claim that ego depletion may occur not because people cannot exert self-control but because their attention is shifted, and they are unable to notice when control is required. Relying on the dual-system logic and acknowledging that humans' cognitive performance is attributed to a regulatory system and conflict-monitoring system

(Botvinick et al., 2001), Inzlicht and Schmeichel (2012) believe that peoples' inability to monitor their attention and capture these changes is related to deficits on their monitoring system. The monitoring system is responsible for detecting the deviation between impulsive and actionable responses (e.g. smell a chocolate cake while you are on a diet), and the regulatory one for implementing the appropriate response and suppressing the impulsive one. In an attempt to find the physiological reason behind ego depletion, Inzlicht and Gutsell (2007) found that the error-related negativity (ERN) – which is a brain waveform that mirrors subconscious error detection (Nieuwenhuis et al., 2001) - was reduced for subjects that exerted self-control in an emotional task but performed worse in a subsequent cognitive test. Their study showed that the decrease in ERN was originated from the monitoring system, meaning that after individuals' self-control resources are depleted, these individuals have difficulty to exert control because their conflict-monitoring system has decreased their executive control ability. In simpler words, the attentional system is dulled when a person exerts self-control, resulting in the monitoring process not getting started.

To conclude, the origin of the self's limited inner capacity may not have been identified yet, but it was essential to present the most predominant theories and consider them while forming the experimental set-up of this study.

2.2 The negative effects of excessive smartphone usage, and how are they related to self-control

2.2.1 How do smartphones affect our lives?

Imagine you are sitting on your desktop, working on a project that you have to present tomorrow in your work, or watching your favorite series. Then try to think what is the common denominator in both of these environments, distracting you from completing your task. For most of the people, it is their smartphone that is always "laying" there "distracting" them. Now think about how many times you touch your smartphone daily even without having a notification flashing. An average person checks his/her smartphone 34 times a day, without a signal or a trigger simply because he is used to (Oulasvirta et al., 2012). Phones are not only part of people's lives, but they are necessities as most people use their smartphone to socialize, finding this habit not only rewarding but also as a way to escape from their everyday life and routine (Chou, & Hsiao, 2000). Humans came from using the exponential advancements in technology for their own benefits to form smartphone-related compulsive and automatic behaviors.

These behaviors seem to be getting worse through the years, affecting mostly the Millennial generation. The Millennial study showed that almost 80% of millennials sleep with their phones, and more than half wake up during the night to check them (Brandon, 2017), highlighting this way how the younger generation is affected the most. These behaviors not only have negative results in everyday life, but they are also associated with psychological disorders like compulsive habits, depression, and technostress (Thomée et al., 2007). Adverse effects on college students such as sleep deprivation and stress because of excessive texting (Murdock, 2013) and dangerous driving behavior from young drivers (Cazzulino et al., 2014) are just a few examples that drew the attention of various academic fields.

Behaviors that are related to extensive usage of social media (e.g., Instagram, Facebook, etc.) are associated with loss of self-control (LaRose et al., 2003). This lack of self-regulation can lead media related behaviors to become automatic (Stone & Stone, 1990). One type of automatic behavior that is related to this research is the checking habits, which can be described by "automated behaviors where the device is quickly opened to check the standby screen or information content in a specific application" (Oulasvirta et al., 2012). Oulasvirta and colleagues found that 35% of the automated behaviors were brief touching sessions, where participants just unlocked their lock screen and that these sessions mostly take place during the morning hours. This type of session is even more common in the younger generation, as Millennials projected this behavior over 150 times per day (Brandon, 2017). And because smartphones can act as a means to connect with other people but also providing a wide variety of entertainment options, checking habits play an even more routine role, as they act as a gateway for these options.

2.2.2 Why do we nurture these habitual behaviors?

A fascinating take on why we form these habitual behaviors is the fear of missing out (FoMo), which is a form of social anxiety describing the tendency of people to check what their social environment is doing, primarily through social media. People with high scores in FoMo scale are more likely to report excessive smartphone usage (Elhai et al., 2016). This habit is attributed first and foremost because people perceive social interaction via social media and peer communication as a reward (Oulasvirta et al., 2012). This form of social anxiety is most prevalent in the younger generations as people tend to check their smartphone while doing other tasks. Studies, investigating how smartphones changed consumer behavior, found out that more than 50% of people check their smartphones when watching TV (Our Mobile Planet, 2013), exposing this way peoples' need to feel included.

Another reason for this compulsive smartphone behavior is related to our haptic system and our tendency to gain information by touching objects, which is described as the Need for touch. The informational cues individuals receive from this haptic interaction, either is taking place in a store or the workplace, are hedonic (Peck & Childers, 2003). Peck and Childers conceptualize the Need for Touch scale in two dimensions, the autotelic and the instrumental. The autotelic dimension refers to a haptic sensory stimulation that is not goal-oriented, with the only objective being to explore and scour for arousal. On the other end, the instrumental one applies to outcome-oriented haptic exploration aiming to retrieve information from, e.g., a product, evaluating it this way with an end goal to buy it (Holbrook & Hirschman, 1982). The main difference, despite the goal of both dimensions, is that the instrumental factor is a controllable conscious act, while the autotelic is described by its lack of self-control (Peck & Childers, 2003). The Need for Touch was first introduced in marketing research, but as smartphones were becoming an irreplaceable part of peoples' lives, social psychologists started to explore the association between Need for Touch and compulsivity. Lee and colleagues (2014) investigated this relationship finding a positive correlation, meaning that people with higher Need for Touch score were found with reduced self-control and displayed smartphone compulsive behavior.

2.2.3 Gender differences on excessive smartphone usage

It seems that there are distinct gender differences not only in smartphone usage and behaviors related to it but also on psychological traits. Even before the smartphone breakthrough, research shows that females were more social-oriented than man and tended to use their houses' landline phones for communication purposes, externalizing a need to connect with their environment and friends (Claisse & Rowe, 1987). It seems that it is also the case for the younger generations as females are more likely to experience habitual and compulsive behaviors, as they mostly use their smartphones for social interactions via social media but can also suffer from stress originated from this, compared to men (Van Deursen et al. 2015).

It is essential to mention that the gender differences in habitual smartphones' tendencies largely depends on the reason why both genders are using their smartphones. Women may be more social-oriented than men, and for that reason they can experience media habits, but men tend to express more compulsive behavior in process-related task, as playing video games and online gambling (Frangos et al., 2010). Understanding the process orientation of each gender is necessary to establish this research's hypotheses correctly.

In addition to this, psychological traits as the Need for Touch are different between genders. Women tend to initiate more haptic evaluation of products than men, e.g., clothing, household items, etc. (Schifferstein, 2006). Following the same approach, Lee et al. (2014) found out that females display a higher relation between Need for Touch (both in the autotelic and instrumental dimensions) and smartphone compulsive usage, compared to men. This way, the idea that females are more likely to exhibit a stronger need for haptic sensory information is supported in both marketing and psychology fields.

2.2.4 How are these behaviors activated?

But why people develop these tendencies in the first place? Research has shown that one underestimated reason for habitual smartphone usage is boredom. Boredom is associated with the lack of self-regulation (Dahlen et al., 2005), but studies have also shown that it is correlated with substance addictions. Borrayo (2007) found that boredom is a situational cue that can predict smoking behavior, making the case that it is an essential predictor for lack of self-control. Combining these findings with the fact that most people use their smartphone to kill their "free" time (Oulasvirta et al., 2012), it is safe to conclude that boredom is one of the cues that can form and activate habitual smartphone usage.

Boredom is an internal and emotional state that most people try to avoid, but habits can also be triggered by external cues, like calls, messages, and applications' notifications.

Oulasvirta et al. (2012) experimented on an intervention stage, meaning that the subjects in the treatment group were exposed to external cues. They found that the average number of short scrolling sessions per user was increased by 800% and the touching one by more than 100%, compared to the control group that was not exposed to the same cues. These findings are also supported by Lee et al. (2014), who investigated how students that self-reported excessive smartphone usage spent on average more time on their phones when they were triggered with notifications. The conclusion of both papers concluded that notifications, either from messaging apps (Facebook, Instagram, etc.), newsfeed, or e-mail, act as an external cue that can trigger habits.

Last but not least, Oulasvirta and colleagues theorized that the sight of a lying smartphone on a desk could act as a cue by itself. This experimental research highly relies on this view, as it is believed that the mere view of a smartphone can act as a triggering instrument but also as a reminder of the rewards and escapism that social media and instant communication can provide.

2.2.5 The relation between compulsivity, habits and self-regulation

In the process of reviewing the necessary literature for this research, numerous concepts and theories were mentioned, but it is essential to clarify the connections of some of these concepts with the self-control theory. Habitual and compulsive behaviors are different but yet conjunctive, and it is vital to distinguish them. Compulsivity is defined as the tendency to enact a specific behavior over and over again, knowing its consequences and effects but lacking the self-control to restrain this repeated action (English and English, 1958). This failure to consciously override and inhibit an impulse is pathological (Lance Dodes, 2016). On the other hand, habits start as repetitive actions that are established over time, and people are aware of them but end up becoming or even acting subconsciously (Robert Longley, 2018).

The common aspect these two concepts share is the lack of impulse control. Because of the time limitation in this research, it was not possible to explore if the subjects in this experiment were displaying habitual or even compulsive behaviors towards smartphone usage. But as most of the participants were between 18 and 31 years old, it was assumed that their relationship with their phones is similar, as previous research has shown. In an attempt to overcome this limitation, a habituation phase was introduced to the treatment group identical to the one Baumeister and Vohs (2016) used, which will be explained furthermore in the next chapter.

But not only takes like the habituation phase were taken into account while forming the design of this experiment. In this chapter, studies related to ego depletion and smartphone usage were introduced to the reader to understand the theoretical and experimental thinking behind this research. Therefore, it is critical to revisit some of the aforementioned aspects that are essential for the set-up of this experiment. As it is already mentioned, the distance and placement of things that can act as inhibitors (e.g. food, smartphones, etc.) can vary the degree of inhibition that participants are asked to exert (Vohs & Heatherton, 2000). Making sure that the smartphones in the inhibition group were placed in front of them was priority while constructing the experimental design. Likewise, tasks that force emotional and thought inhibition are proven to worsen the ego depletion effect, either is by restricting the smartphone usage or restrain thinking of a white bear while doing a thought-provoking task (Muraven et al., 2002). Inhibiting the urge and the impulse to use the smartphone can be considered an emotional state, and it is anticipated to have a higher degree of self-control difficulty.

In conclusion, modifying the set-up of the self-regulation task and the experimental layout can instantly affect the ego-depletion effects, and because of that, all the above were taken into account on the construction of the experimental design of this research.

3 Methodology & Experimental design

3.1 Place & Control Process

The experiment took place in the study/common area of Xior student housing. As the goal of the experiment is to replicate an ordinary day in a workplace, this place was considered ideal as it is a quiet area but at the same time surrounded by students studying. The replication of a workplace was essential for this experiment to provide insights to companies of how smartphone usage may or may not interfere with their employees' work.

This experimental set-up transfuses more external validity, as more and more companies are adopting a flat organization structure with other colleagues surrounding an employee during the day.

To control the environment, a similar set-up was followed by other self-control experiments (Baumeister et al., 1998). The experimenter or a second hidden experimenter was observing the subjects by being in the study area, usually doing something else and not being in subjects' sight and communicating with the participants only when the participants had to move to the next phase of the experiment. Moving to the following stage, subjects were being instructed only by the experimenter to avoid confounding effects that could alter the results and could interfere with the experimental process.

3.2 Incentives

To incentivize subjects to participate in the experiment, free ice creams were promised for each of the 100 participants. The ice creams were given after the end of the experiment because they contain sugar and, therefore, glucose. Previous research on self-control indicated that feeble performance in a subsequent task could be reversed after consuming a glucose drink (Gailliot et al., 2007). To motivate participants to perform better, they were informed that they could win a 25€ Zara gift card. The gift cards were in plain view in the experimental area to overcome any uncertainty that participants may have about the prize. Because the two groups had different instructions that could affect their performance without their knowledge, two cards were given to the participants with the best scores of each group. A total amount of 85€ was spent for the conduction of this experiment, 35€ for the 100 ice creams and 50€ for the two gift cards.

3.3 Timetable & Randomization

Following the same approach, Saturday and Sunday were excluded from the experimental timetable as our optimal goal is to test the participants in working days and inside the usual working hours. The experiment took place from 12 pm to 6 pm, and the reasoning behind was that specific touching behaviors relative to smartphones like scrolling and touching frequently take place in the afternoon and waking hours, respectively (Oulasvirta et al., 2012). To complete the experiment and gather the 100 participants needed, seven working days were spent in the common area, accumulating on average 15 participants per day. To control for selection bias and confounding effects, the timetable below (Table 1) was used. In this way, it was easier to achieve proper randomization as every hour represents different treatment. The 100 subjects, of which 50 were men and 50 women, were randomly assigned to 2 groups (Control & Treatment). Every participant that was approached in and outside Xior student housing was randomly assigned to the corresponding group depending only by the time they were approached and agreed to participate in the experiment.

	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday
12-1 pm	C	T	C	T	C	T	C
1-2 pm	T	C	T	C	T	C	T
2-3 pm	C	T	C	T	C	T	C
3-4 pm	T	C	T	C	T	C	T
4-5 pm	C	T	C	T	C	T	C
5-6 pm	T	C	T	C	T	C	T

Table 1. Subjects' randomization table

For the participants needed to be gathered the next following days of the first week, the order of the hours of the above timetable was also reversed to test the opposite treatments to the first week.

3.4 Experimental Structure & Overall Time

Every subject spent approximately **9 minutes** for each session. Every session was composed of two phases, the first phase was the completion of the given instructions for each group, and the second phase included the Go/No Go task and a questionnaire. For both the Control and Treatment group, the overall time of the first phase was **5.5 minutes**. Before any detailed instructions were given, subjects were asked to put their smartphones to silence mode, to achieve control and apply the desirable and optimal conditions to all participants and across all groups, as habits are easier to be triggered by external cues such as ringtones and messages' sounds (Gökçearslan et al., 2016). In the Control group, the participants were instructed to use their smartphones as they like, but for the Treatment group, an additional two-phase process was used:

- **Habituation Phase**: Participants were asked to use their smartphones for **90 seconds** (1.5 minutes) because "… participants first establish a habit and then must override these habitual responses when more complex rules are introduced "(Baumeister & Vohs, 2016).
- **Inhibition Phase**: Participants then had to put their phones on the back and placed them in front of them for **240 seconds** (4 minutes), inhibiting using and touching them. The placement of the phone was used to enhance participants' urge and temptation to use their smartphones, as the device itself laying in front of them can be used as a cue and trigger a usage behavior (Oulasvirta et al., 2012) and can lead to a high self-regulation state (Vohs & Heatherton, 2000). This timespan was decided after meta-analysis in self-control literature set the minimum duration time in self-control tasks was 3 minutes (Hagger et al., 2010).

3.5 Subject's Briefing

No detailed information was given to participants, only that this experiment is about measuring cognitive performance in different states. General instructions about the following procedure were given to both the control and treatment group:

Before the experiment starts, you must put your phone in silence mode. The experiment consists of two phases. First, you have to follow the given instructions for a few minutes and after you must play a short game on my laptop and answer a small questionnaire. After the first phase, I will enter the room, and I will guide you to the second phase. The overall time of this will not exceed the 9 minutes.

More detailed the control group received the following additional instructions:

After you put your phone in silence mode, you must sit here, and feel free to use your phone for a few minutes. You can watch Youtube videos, listen to music, messaging etc. Feel relaxed and enjoy.

The Treatment group was instructed the following:

For the Habituation phase,

After you put your phone in silence mode, you must sit here, and feel free to use your phone for a few minutes. After this stint, I will enter the room, and I will give you further instructions.

For the Inhibition phase,

Now that you finished with this part, you must put your phone in front of you facing the back. Now you must not use or even touch your smartphone for a few minutes, and after that, I will enter the room, and I will put you to play a short game and answer a small questionnaire.

Both groups were given this final instruction, with the only difference between the number of groups (1 for Control & 2 for Treatment):

Now you will play the demo of the game to be familiar with it, and after you will play a longer version of the same game and answer a short questionnaire. The goal of the game is to respond as fast as possible and try not to make any mistakes. When you see the green sign with the Go message, you have to press the SPACE bar, and when you see the red sign with the No Go message, you have to inhibit responding. Do not forget you are in group _.

At the end of both phases, subjects were thanked for their participation in the experiment, an ice cream was given to them as was promised, and they were told to wait for an e-mail informing them if they won the prize.

3.6 Go/No-Go task

The Go/No-Go task, and also the questionnaire, was created using the Psytoolkit platform (Stoet, 2017), which is established in the psychology field, allowing more comprehensive research for topics that involve cognitive psychology's tasks. This task uses two different stimuli, the Go (green sign) and the No-Go stimuli (red sign), as can be seen from Figure 1 below.

Figure 1. Go/No-Go task overview

The purpose of this cognitive task is to respond as fast as possible when the Go stimuli appear and to restrain responding to the wrong stimuli (No-Go). The mean reaction times for each respondent were recorded and the errors as well, determining participants' performance. Because of the time limit, the participants completed a total of 100 trials but also 20 demo trials to familiarize themselves with the task. From these trials, the Go stimuli randomly appeared on 80% of trials and No-Go stimuli on the remaining 20%, following the most used set-up of this test (Redick et al., 2011). This way, the task is more difficult, as it has more Go trials because a participant may not be able to restrain himself from responding to the wrong stimuli (No-Go sign) as through repetition, one tends to respond faster every time the Go stimuli appear. In this version of this task:

- the **stimulus duration** was 2000ms meaning that one had to respond to Go sign within 2 seconds and inhibit press the SPACE button for 2 seconds,
- followed by a 500ms **feedback** in case of an error,
- the **interstimulus interval** (ISI) was 500ms as well, and the **mean inter-trial interval** (ITI) was 2500ms,

keeping almost identical intervening periods used in other neuroscience research (Donkers & Van Boxtel, 2004).

3.7 Questionnaire & Autotelic Need for Touch scale

For this research, some general information such as gender, age, nationality was asked but also more specific ones. As it is already mentioned, one of the additional goals of this research was to see if differences in individuals' haptic information processing for the Treatment group, can predict their performance in the Go/No-Go task. To assess this, only one dimension of the Need for Touch scale (Peck & Childers, 2003) was used, the Autotelic one. The second part of this scale, the Instrumental, was rejected as it refers to outcome-oriented touch, e.g., when one individual touches a product to obtain information that could help him to final purchase, something that could not be useful to this research. The Autotelic factor, on the other hand, refers to engaging in spontaneous, no goal-oriented touching behavior. The Autotelic touch "…involves a hedonic-oriented response seeking fun, arousal, sensory stimulation, and enjoyment" (Holbrook & Hirschman, 1982). A seven-point Level of Agreement Likert scale (Vagias, 2006) was used to assess participants' processing of haptic information, for this six-item subscale. The subjects had to state the level of agreement with the statements below (Figure 2), ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). The aim is to test if subjects' Autotelic Need for Touch could act as a predictor for their performance in the successive cognitive task.

Need for Touch: NFT

(Peck and Childers 2003)

Instrumental Factor Items

1. I place more trust in products that can be touched before purchase.
2. I feel more comfortable purchasing a product after physically examining it.
3. If I can't touch a product in the store, I am reluctant to purchase the product.
4. I feel more confident making a purchase after touching a product.
5. The only way to make sure a product is worth buying is to actually touch it.
6. There are many products that I would only buy if I could handle them before purchase.

Autotelic Factor Items

1. Walking through stores, I can't help touching all kinds of products.
2. Touching products can be fun.
3. When browsing in stores, it is important for me to handle all kinds of products.
4. I like to touch products even if I have no intention of buying them.
5. When browsing in stores, I like to touch lots of products.
6. I find myself touching all kinds of products in stores.

Figure 2. Items of the Need for Touch Questionnaire

At the end of the questionnaire, one last question was added to determine if the participants' experience for the overall experiment was pleasant, bland, or boring. It was included because previous research indicated that the difficulty and pleasing level could explain success or failure in inhibition-control experiments, as positive mood can counteract ego depletion (Tice et al., 2007).

4 Hypotheses

Before stating the tested hypotheses for this research, it is essential to clarify how performance is constructed and measured in the Go/No-Go task. As this task measures the reaction times and errors for every participant for each trial, subject's overall performance consists of their mean reaction time (in milliseconds) and number of errors they committed in all 100 trials, following an identical approach as other experimental studies with similar cognitive task (Inzlicht & Gutsell, 2007).

Higher reaction times and errors refer to worsen performance in the subsequent Go/No-Go task, and lower reaction times and errors refer to an improved performance.

As we already mentioned, having difficulty to control impulses and automated behaviors is one of the most common reasons for inhibition failures (Metcalfe & Mischel, 1999). We also established that based on the self-control strength model, people perform worse in a subsequent unrelated task after they successfully performed inhibition (Baumeister et al., 1998). As extensive smartphone usage is associated with lack of self-regulation (Van Deursen et al. 2015) and a smartphone by itself can act as an inhibitor, self-regulation on smartphone usage in the first place can negatively affect the performance on a successive task, establishing the first hypothesis:

Hypothesis 1: Subjects that exerted self-control in smartphone usage will perform worse in the subsequent Go/No-Go task compared to participants that were allowed to use them.

Additional, Oulasvirta and colleagues (2012), with their research, already established social media applications as Facebook, e-mails, and newsfeed as the most common patterns that can lead to habitual behaviors. As lack of self-regulation can be driven by impulses but also emotions (Metcalfe & Mischel, 1999), women's emotional perception (Barret et al., 2000) can be the driving force behind the lack of self-regulation. Being more active in social media services help women reduce their social stress, making them rely more on smartphones than men (Gökçearslan et al., 2016). Women relying more on their smartphones than men, act as a distractor either when using their smartphone or when inhibit using them. Combining women's higher tendency in the autotelic dimension which provides instantly sensory gratification (Lee et al., 2014), with their social media orientation, the following hypothesis is tested:

Hypothesis 2: Women will perform worse in the subsequent Go/No-Go task, compared to men in the same treatment.

Furthermore, expressing a higher tendency of using the haptic system to obtain sensory enjoyment is tightly correlated to impulsiveness (Peck & Childers, 2003). Having difficulty to control impulses and reflective behaviors is one of the most common reasons for self-control failures (Metcalfe & Mischel, 1999). Lee and colleagues (2014) found that people with higher Need for Touch score displayed reduced self-control and excessive smartphone behavior. As smartphones touchscreen can act as a reward cue by itself and can trigger habits (Oulasvirta, 2012), having employees trying to restrict their usage in the workplace can increase their inhibition state and, therefore, negatively affect their performance in a successive task (Baumeister et al., 1998). At the same time an average person unconsciously checks his phone 34 times a day without signaling (Oulasvirta et al., 2012), and most users perceive these touching sessions satisfying (Power, 2010), which highlights the autotelic dimension of smartphones. Employees with high haptic processing it is more likely to use their smartphone because of this autotelic dimension, and therefore being distracted. For that reason, it is expected that participants' haptic sensory processing can act as a predictor of their subsequent performance in the Go/No-Go task, establishing the last hypothesis:

Hypothesis 3: Subjects' autotelic haptic processing will be negatively correlated with the performance on the Go/No-Go task.

5 Results

The main variables in our dataset consists of six different variables of interest. *Group* and *gender* are two dummy variables we used in our analysis which consists of:

- *Group*, indicator of the group participants, was assigned: control group (1) and treatment group (2)
- *Gender*, indicator of whether the participant is man (1) and woman (2)

But our dataset also has a categorical variable, *ANFT* which consists of:

- *ANFT*, indicator of the participants' autotelic need for touch which consists of seven level of agreement with the statements in Figure 2: strongly disagree (1), disagree (2), more or less disagree (3), undecided (4), more or less agree (5), agree (6), strongly agree (7)

We also have two continuous dependent variables; mean RT and errors:

- Mean RT, indicator of mean reaction time (in millisecond) of every participant
- Errors, indicator of how many errors every participant did

Last but not least, our dataset contains the continuous variable *age* (in years).

The average age of the participants in this research is 24 years old, the age of the youngest, and the oldest participant is 18 and 31 years old, respectively. Seeing the frequencies of the dummy variable gender we see that 50% of the sample are women and 50% men. The same applies to the dummy variable group, where the 100 subjects are equally splitted between control and treatment groups. For the dependent variable Mean RT and errors, we see that the average reaction time is 671.218 milliseconds while the average number of errors the subjects committed is 2, with the lowest and highest number to be 0 and 9, respectively.

A one-way analysis of variance (ANOVA) planned to be used for the analysis, but the main dependent variables, mean reaction times and errors, were not normally distributed, violating one of the main assumptions the use of parametric tests need. The normality of the dependent variables was tested by conducting a Shapiro Wilk test (Figure 3) and their asymmetry by observing their histograms (Figure 4 & 5). High kurtosis is seen to the histogram of the dependent variable "Mean RT" and a positive skewness on the dependent variable "Errors". Combining with the findings of the Shapiro Wilk test ($p<0.05$), the normality assumption is violated. To overcome this restriction, a logarithm transformation was performed to overdo the skewness of the data. But the dependent variable Errors was not near to a normal distributed dataset. For the easiness of this research's analysis, the use of non-parametric tests was decided and, more specific, the use of the Mann-Whitney U test, which does not require a normal distribution assumption. The non-parametric assumptions in this research hold, as all of the independent variables were categorical, with the main dependent variables being continuous. The independency assumption non-parametric tests require is also satisfied as every subject participated only once and alone.

In general, the Mann-Whitney U test compares two different groups and it uses a ranking method, ranking and listing all the values of the dependent variable on increasing order. First, the lower number of the dependent variable is ranked as 1 and the highest as 100 (the total number of observations) and then it reports the average of the ranks for each group (McKnight & Najab, 2010). The null hypothesis on a Mann-Whitney U test, tests if the distribution of the control and treatment group is identical.

5.1 Ego depletion

As the majority of the studies above already established it, it was expected that participants in the treatment group that proceed in inhibiting using their smartphones at time 1 would have higher reaction times and more errors at time 2 than participants in the control group.

However, while performing two Mann-Whitney U tests to see what effect the group has on both the mean reaction times ($z=-0.007$, $p=0.9945$) and errors ($z= -0.712$, $p= 0.4767$), no statistically significant effect was found for either of the dependent variables (Figure 6 & 7), rejecting this way the first hypothesis. On average, the overall errors in the control group and the treatment group were 1.74 and 2.22 errors, respectively (Figure 9). The differences in mean reaction times and between the control and treatment group can also be seen on the bar graph below (Figure 8) but also from the following histograms (Figure 10).

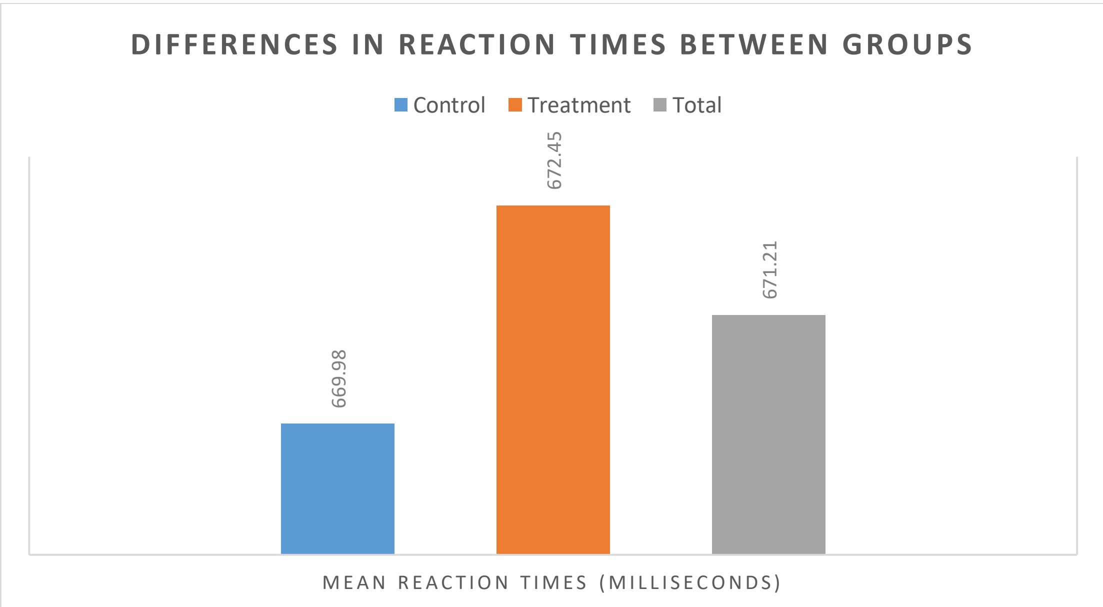

Figure 8. Differences in mean reaction times between control and treatment group

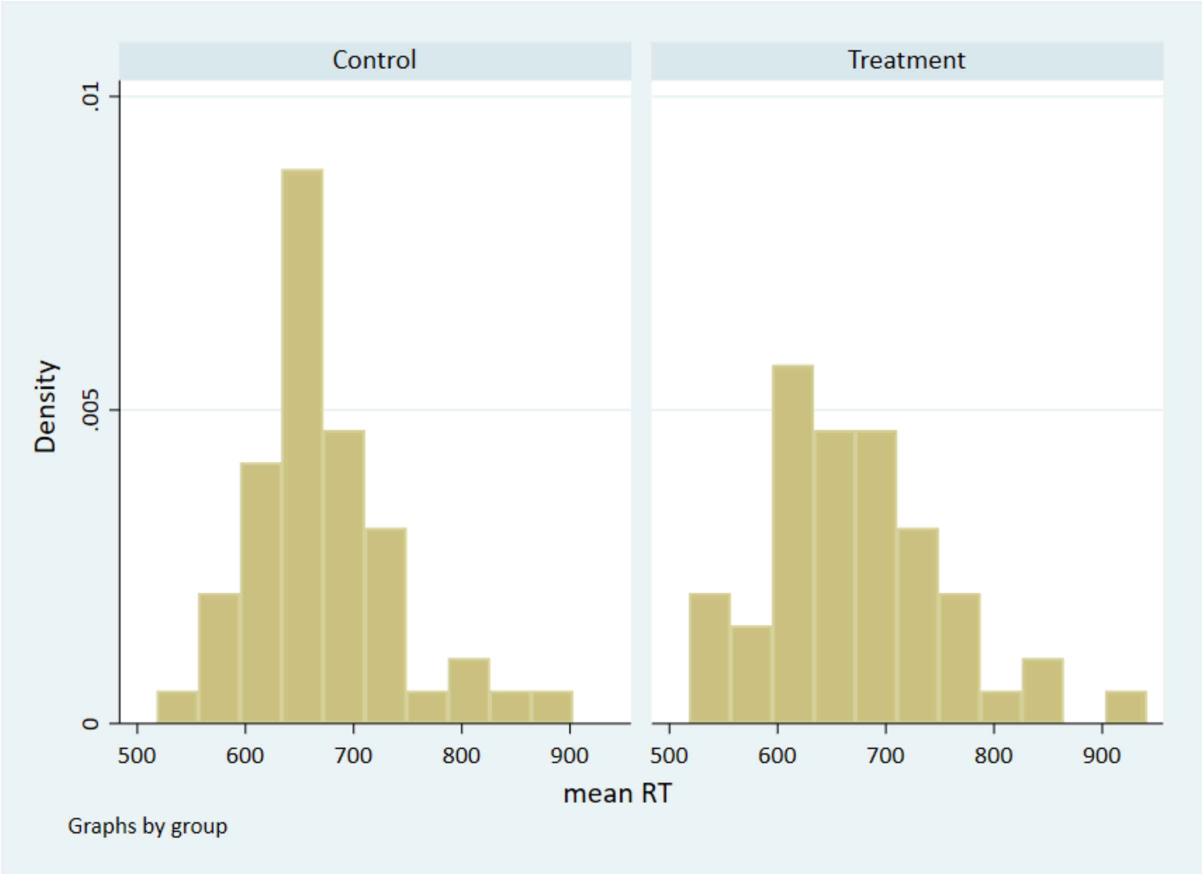

Figure 10. Histogram of the dependent variable, mean reaction times, for both groups

5.2 Gender differences

The second hypothesis supported that women in both groups will have a deteriorated performance on the Go/ No-Go task compared to men, with higher reaction times and errors.

To identify gender differences for participants, that either exerted self-control or used their smartphones, , two independent Mann-Whitney U test were run. As it is shown in Figure 11, the first Mann-Whitney U test showed no statistically significant differences in reaction times between men and women (z=-0.800, p=0.4239). The same result also applies for the second test, in regards to gender differences on errors (z=0.197, p=0.8436) (Figure 12). The differences between men and women can also be captured by the cumulative distribution plots below (Figure 13 & 14), with women less prone to errors than men but at the same time slower, without having any statistical significance.

Additionally, two regressions with an interaction term between the dummy variables *gender* and *group*, was used to further investigate the effect of gender on reaction times and errors for the control and the treatment group. In Figure 15, we see that there is a negative effect of the interaction term on mean reaction times but is not statistically significant (F(5,93)=1.96, p=0.283). On the other hand when investigating the same effect on the dependent variable errors (Figure 16) we observe a positive effect that is not statistically significant (F(5,93)=1.10, p=-0.304).

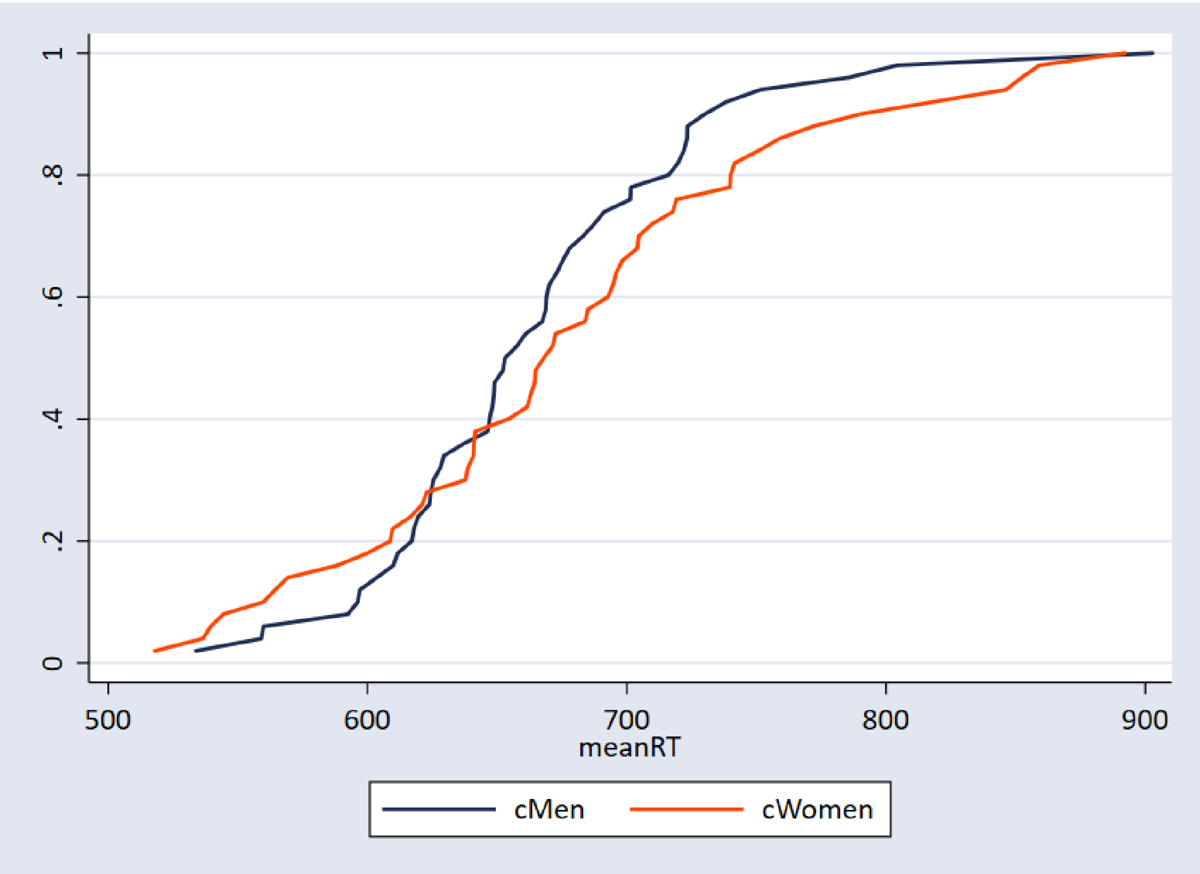

Figure 13. Cumulative distribution plot for the dependent variable reaction times by gender.

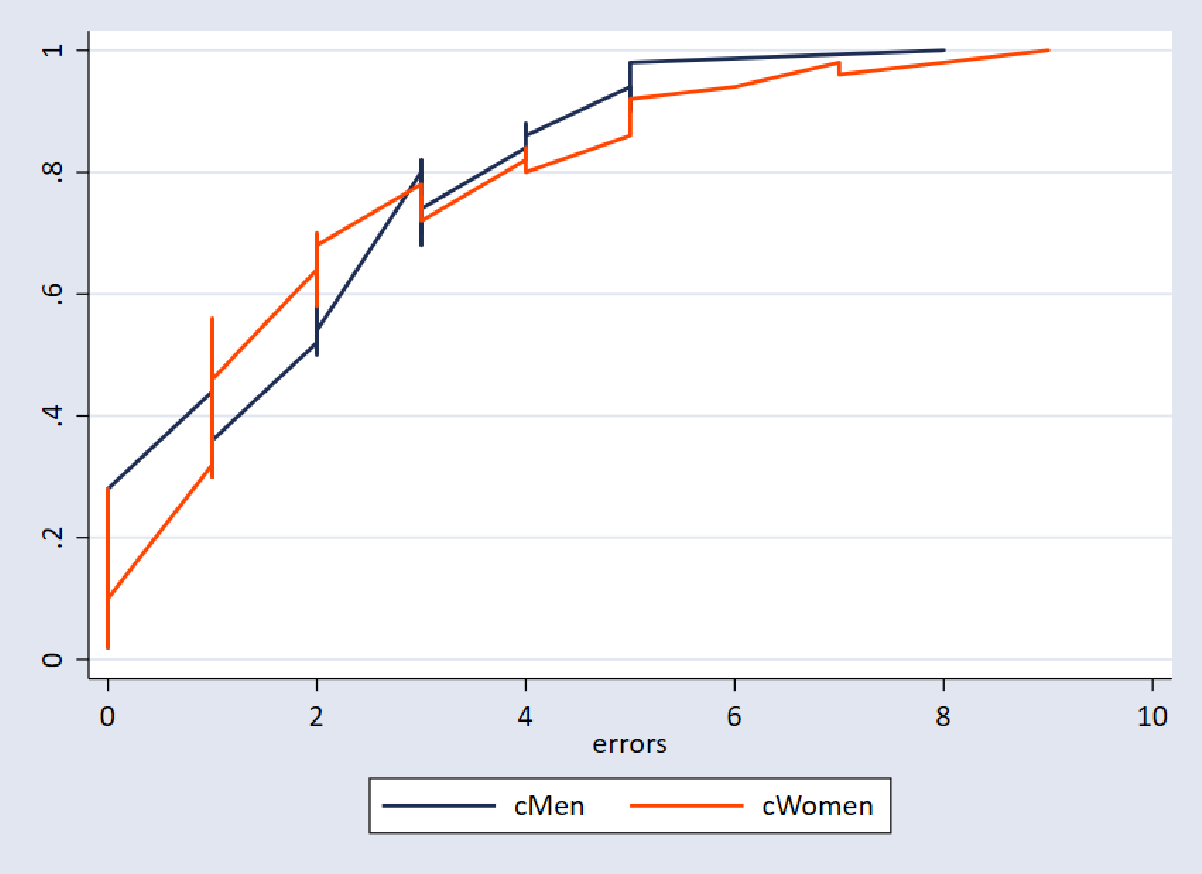

Figure 14. Cumulative distribution plot for the dependent variable, errors by gender.

5.3 Autotelic need for touch

On the third and last hypothesis, it was theorized that the Autotelic Need for Touch score could predict participant's performance on the Go/No-Go task. Participants' haptic processing was evaluated, as it is already mentioned, by six questions that were constructed by a seven-point Likert scale. To identify if a correlation between the two dependent variables, mean reaction time and errors, and the Autotelic Need for Touch scale existed, one index variable was generated, named "anft". This index variable was the mean score of each participant's overall statement score (with the highest index value being 7, as there were six overall questions with a 7-point agreement scale), and it was used as one's haptic processing index. Before testing for correlation, Cronbach's Alpha test was performed as a measure of internal reliability for the autotelic need for touch scale. With a scale reliability coefficient (α) equal to 0.7979, autotelic need for touch is a consistent and reliable instrument (Figure 17).

Two multiple regressions were used to see if a positive correlation between the dependent variables and the generated variable “anft” existed. As it is shown in Figures 18 and 19, no significant correlation was found for mean reaction times (F(3,95)= 2.55; p= 0.367) and errors F(3,95)= 1.39; p= 0.441), and autotelic need for touch index.

	Coefficient	Standard deviation	t	p-value
(constant)	504.5836	2.591436	2.38	0.019
Age	6.164472	16.26588	1.79	0.077
gender	29.05891	6.316376	-0.91	0.367
anft	-5.725016	66.19593	7.62	0.000
Dependent Variable: Mean RT				

Figure 18. Multiple regression’s output for Hypothesis 3 – Summary table

	Coefficient	Standard deviation	t	p-value
(constant)	5.426202	2.180329	2.49	0.015
Age	-.1498949	.0792091	-1.89	0.061
gender	-.3158448	.4211475	-0.75	0.455
anft	.1429991	.173095	0.83	0.411
Dependent Variable: Errors				

Figure 19. Multiple regression’s output for Hypothesis 3 – Summary table

6 Discussion

As we already mentioned it is believed that employees using their smartphones hurt their productivity by being distracted (Jeff Griffin, 2018). With this experiment, this research wanted to test if inhibiting smartphone usage, in a workplace replication environment, could lead to a deteriorated performance in a successive task and how it is directly compared with a smartphone allowed environment. However, we found no significant effects on reaction times and errors between the groups, in contrast to previous research on ego depletion (Baumeister et al., 1998; Muraven et al., 2002). The subjects that performed inhibition in smartphone usage do not differ on reaction times and accuracy with subjects that were allowed to use their smartphones. But this could be seen as a first indication that shows the negative side-effect of inhibition, as this experiment was a direct comparison of the negative effect of smartphone usage and that of inhibition in a workplace environment. Instructing participants to put their phones in front of them, acting as a triggering cue, and a high inhibitor as previous research indicated (Vohs & Heatherton, 2000; Oulasvirta et al., 2012), may was the reason why the deteriorated performance in the inhibition group was around the same size as the one in the control group.

In our research, we also wanted to test if gender differences were present after the exertion of self-control or after using smartphones. Based on previous research, men are mostly process-oriented and can display compulsive and addictive behaviors in online gambling and gaming. On the other hand, women all more social-oriented than men, using social media for communication purposes, displaying media habits (Frangos et al., 2010). Combining with findings on social anxiety, like fear of missing out that manifests through social media, women's media-bearing behaviors makes them more likely to perform worse in the following task. However, when tested for performance differences on the Go/ No-Go task, no differences were found between men and women. An explanation for the lack of gender differences can lie on the experimental conditions of this research. We already mentioned that habits could be triggered by external cues such as ringtones and notifications (Gökçearslan et al., 2016), and allowing them could trigger higher inhibition to women. But to control for confounding effects and keep the same conditions of the experiment for all participants, subjects were instructed to put their smartphones on silence mode. This instruction could interfere with the results, but it was necessary to have the same experimental conditions for every participant in both groups.

To identify whether the performance on the Go/No-Go task was correlated with the individuals' haptic information evaluation, we used the Autotelic Need for Touch scale (Peck & Childers, 2003). We considered that the Instrumental dimension of the Need for Touch scale was not necessary in this research as it is goal-oriented (Holbrook & Hirschman, 1982) and because the experimental set-up controlled for external situational cues (e.g., messages and notifications), no goal-triggering action needed to be taken from the subjects. On the other hand, the Autotelic dimension, which is associated with impulsive haptic exploration and therefore, lack of self-regulation (Peck & Childers, 2003), was viewed as ideal for this research. An index for the autotelic need for touch scale was created to investigate the relation between haptic processing and performance on the Go/No-Go task. The results showed that the autotelic dimension of need for touch did not affect reaction times and accuracy. These results were opposed to previous research that indicated that touching behaviors related to smartphones are considered hedonic (Power, 2010), highlighting the hedonic dimension of the autotelic Need for Touch scale.

The present study aimed to fill a gap in the literature review but also providing psychological insights on how different states can interfere with employees' productivity. Previous research indicated that even employees that illustrate addictive phone behaviors consider smartphones to have a negative effect on their productivity (Duke & Montag, 2017). But contrary to the norm, this study wanted to illustrate that smartphones are not the only mean of distraction in a workplace and that the current gap in cell-phone policies within companies can hinder productivity in other ways. By allowing a direct comparison between a phone allowed environment and a state that employees try to restrict their smartphone usage, we wanted to explore how these states can hinder performance and which one can be proven worse.

Despite the lack of significant results, we consider that this research can trigger the exploration of not only the physiological implications of smartphones in cognition and productivity but also the psychological ones.

7 Limitations and further research

Even if the effects of smartphone usage on cognition are still not fully explored and neuroscience is a field that continually uncovers the origin of these effects, this research has to take into consideration that the adverse effects of smartphones on individuals' cognitive performance could be underestimated. A plethora of studies indicated the negative effects of habitual smartphone use on cognition, from the limited cognitive performance because of sleep deprivation on the previous day (Lanaj et al., 2014) to the deficiency on individuals' mnemonic operation (Wilmer et al., 2017). But the effects of smartphones on attentional functioning are very mixed in the existing literature, with studies that used self-assessing reports indicate a negative correlation of media-related smartphone use and attentional functioning, and studies that used more controlled measures reveal a positive one (Wilmer et al., 2017). More specific, Cardoso-Leite et al. (2015) illustrated that action video games could improve attentional performance, highlighting the mixed results of smartphone use on cognition. As the Go/No-Go task that was used in this research, is a measure of inhibition and selective attention, we cannot draw any straightforward conclusion of a potential smartphone interference on the results of this research. Because the performance of the inhibition group on the Go/No-Go task was almost equal with the already lowered performance in the control one, we believe that ego depletion was present but the degree of its effect may be overestimated by the all reasons above.

For the reasons mentioned above, two more complete experimental design could be advised for future research. On the first design, having the same experimental structure of this research but adding an additional treatment group could show the ego-depletion effects that this experiment tried to replicate. Adding a second treatment group that instead of using their smartphones could use another object to "kill" its' free time, could undo possible negative effects on cognition that smartphone usage may cause. This way, the research can have a third group to compare the subsequent task performance. The second experimental design that is proposed keeps the same structure and groups of the current study but replaces smartphones with another daily object, still managing a workplace replication. The above experimental designs were not taken into consideration because of the limited time and resources and because a real-time replication of a workplace was the objective of this research.

Another reason why no significant results were found in this research was the self-control task by itself. It was expected that inhibition would lead to a deteriorated performance than allowing using smartphones. Even if the results tend to illustrate that ego depletion was indeed present, allowing an almost identical performance between the two groups, the degree of this depletion may be overvalued. As it is already mentioned, the self-regulatory task matters, and it can act as a low or high inhibitor, depending on the emotions it creates to participants. Frustrating tasks can deplete subjects more compare to low inhibition tasks (Muraven et al., 2002). To identify the pleasantness of the experiment and if it's overall structure created emotions of discomfort to the subjects, one question was included on the last part of the experiment. From Figure 20, one can see that 77% of the participants found this self-control experiment pleasant, 19% of them bland, and only 4% boring. One of the goals of the experimental design was to create a state of boredom, as it is correlated with a lack of self-control (Borrayo, 2007), which could further expedite the ego depletion effects.

Have only 4% of the participants finding the overall experiment boring and 19% bland; it is safe to conclude that the limited time did not manage to re-create the needed state to illustrate stronger ego depletion effects

One of the most important limitations of this research, due to the time limit, was the lack of self-evaluation questionnaires. Including questionnaires related to habitual and compulsive smartphone behavior could reveal significant correlations with the reaction times and errors in the Go/ No-Go task.

8 Conclusion

The present study did not show any significant results on either of its objectives. But the lack of substantial results on the inhibition hypothesis is an indication of the existiance of ego depletion on this study, with the degree of its effects to be ready to further be explored by future research. As it is already highlighted numerous limitations could have affected the experimental design, with most important the time limitation of this study.

Nevertheless, this study's main goal was to explore if the effect of ego depletion is present when an individual inhibits using his smartphone in the workplace. As nowadays, smartphones are an irreplaceable thing in peoples' lives and present during work, is it essential for future research to explore if resisting the impulses of using a smartphone during work harms one's cognitive performance. Future research can give new insights and contradict the norm that smartphones can only be a mean of distraction while working and maybe show that inhibiting them can have a much worse effect on one's cognitive processing.

9 References

Barrett, L. F., Lane, R. D., Sechrest, L., & Schwartz, G. E. (2000). Sex differences in emotional awareness. Personality and Social Psychology Bulletin, 26(9), 1027-1035.

Baumeister, R. F., & Vohs, K. D. (2016). Misguided effort with elusive implications. *Perspectives on Psychological Science*, *11*(4), 574-575.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource?. *Journal of personality and social psychology*, *74*(5), 1252.

Baumeister, R. F., Gailliot, M., DeWall, C. N., & Oaten, M. (2006). Self-regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. Journal of personality, 74(6), 1773-1802.

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). Losing control: How and why people fail at self-regulation. San Diego, CA: Academic Press.

Borrayo, E. (2007). Smoking and Boredom: Relationship Between Boredom, Cravings, and Smoking Behaviors. ProQuest.

Brandon J. (2017). The Surprising Reason Millennials Check Their Phones 150 Times a Day. Retrieved from https://www.inc.com/john-brandon/science-says-this-is-the-reason-millennials-check-their-phones-150-times-per-day.html

Cardoso-Leite, P., Kludt, R., Vignola, G., Ma, W. J., Green, C. S., & Bavelier, D. (2016). Technology consumption and cognitive control: Contrasting action video game experience with media multitasking. Attention, Perception, & Psychophysics, 78(1), 218-241.

Cazzulino, F., Burke, R. V., Muller, V., Arbogast, H., & Upperman, J. S. (2014). Cell phones and young drivers: a systematic review regarding the association between psychological factors and prevention. Traffic injury prevention, 15(3), 234-242.

Chou, C., & Hsiao, M. C. (2000). Internet addiction, usage, gratification, and pleasure experience: the Taiwan college students' case. Computers & Education, 35(1), 65-80.

Claisse, G., & Rowe, F. (1987). The telephone in question: Questions on communication. Computer Networks and ISDN systems, 14(2-5), 207-219.

More Firms Ban Smartphones at Work for Safety Reasons. (2018) Retrieved from https://coremarkins.com/more-firms-ban-smartphones-at-work-for-safety-reasons/

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. Accident Analysis & Prevention, 37(2), 341-348.

Davis, D., & Leo, R. A. (2012). Interrogation-related regulatory decline: Ego depletion, failures of self-regulation, and the decision to confess. Psychology, Public Policy, and Law, 18(4), 673.

Donkers, F. C., & Van Boxtel, G. J. (2004). The N2 in go/no-go tasks reflects conflict monitoring not response inhibition. *Brain and cognition*, *56*(2), 165-176.

Duke, É., & Montag, C. (2017). Smartphone addiction, daily interruptions and self-reported productivity. Addictive behaviors reports, 6, 90-95.

Elhai, J. D., Levine, J. C., Dvorak, R. D., & Hall, B. J. (2016). Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. Computers in Human Behavior, 63, 509-516.

English, H. B., & English, A. C. (1958). A comprehensive dictionary of psychological and psychoanalytical terms: A guide to usage.

Frangos, C. C., Fragkos, K. C., & Kiohos, A. (2010). Internet addiction among Greek university students: Demographic associations with the phenomenon, using the Greek version of Young's Internet Addiction Test. International Journal of Economic Sciences and Applied Research, 3(1), 49-74.

Freud, S. (1961a). The ego and the id. In J. Strachey (Ed. and Trans.), The standard edition of the complete psychological works of Sigmund Freud (Vol. 19, pp. 12–66). London: Hogarth Press. (Original work published 1923)

Gailliot, M. T., Baumeister, R. F., DeWall, C. N., Maner, J. K., Plant, E. A., Tice, D. M., ... & Schmeichel, B. J. (2007). Self-control relies on glucose as a limited energy source: willpower is more than a metaphor. Journal of personality and social psychology, 92(2), 325.

Glass, D. C., Singer, J. E., & Friedman, L. N. (1969). Psychic cost of adaptation to an environmental stressor. Journal of personality and social psychology, 12(3), 200.

Gökçearslan, Ş., Mumcu, F. K., Haşlaman, T., & Çevik, Y. D. (2016). Modelling smartphone addiction: The role of smartphone usage, self-regulation, general self-efficacy and cyberloafing in university students. *Computers in Human Behavior*, *63*, 639-649.

Golan, M., & Bachner-Melman, R. (2011). Self-regulation and the management of childhood obesity. J Community Med Health Edu, 1(107), 2.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological bulletin*, *136*(4), 495.

Holbrook, M. B., & Hirschman, E. C. (1982). The experiential aspects of consumption: Consumer fantasies, feelings, and fun. Journal of consumer research, 9(2), 132-140.

Holbrook, M. B., & Hirschman, E. C. (1982). The experiential aspects of consumption: Consumer fantasies, feelings, and fun. *Journal of consumer research*, *9*(2), 132-140.

Inzlicht, M., & Gutsell, J. N. (2007). Running on empty: Neural signals for self-control failure. Psychological science, 18(11), 933-937.

Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. Perspectives on Psychological Science, 7(5), 450-463.

Jeff Grifin (2018). How Cell Phone Use at Work is Shaping Company Policies. Retrieved from https://www.griffinbenefits.com/employeebenefitsblog/how-cell-phone-use-at-work-is-shaping-company-policies

Lanaj, K., Johnson, R. E., & Barnes, C. M. (2014). Beginning the workday yet already depleted? Consequences of late-night smartphone use and sleep. Organizational Behavior and Human Decision Processes, 124(1), 11-23.

Lance Dodes (2016, May 26). Addiction or Compulsion or Habit? Retrieved from https://www.thefix.com/addiction-or-compulsion-or-habit

Lange, F., & Eggert, F. (2014). Sweet delusion. Glucose drinks fail to counteract ego depletion. Appetite, 75, 54-63.

LaRose, R., Lin, C. A., & Eastin, M. S. (2003). Unregulated Internet usage: Addiction, habit, or deficient self-regulation?. Media Psychology, 5(3), 225-253.

Lee, U., Lee, J., Ko, M., Lee, C., Kim, Y., Yang, S., ... & Song, J. (2014, April). Hooked on smartphones: an exploratory study on smartphone overuse among college students. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems (pp. 2327-2336). ACM.

Lee, Y. K., Chang, C. T., Lin, Y., & Cheng, Z. H. (2014). The dark side of smartphone usage: Psychological traits, compulsive behavior and technostress. Computers in human behavior, 31, 373-383.

Longley, Robert. (2018, September 27). The Psychology of Compulsive Behavior. Retrieved from https://www.thoughtco.com/psychology-of-compulsive-behavior-4173631

Martijn, C., Tenbült, P., Merckelbach, H., Dreezens, E., & de Vries, N. K. (2002). Getting a grip on ourselves: Challenging expectancies about loss of energy after self-control. Social Cognition, 20(6), 441-460.

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: dynamics of willpower. Psychological review, 106(1), 3.

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: dynamics of willpower. *Psychological review*, *106*(1), 3.

McKnight, P. E., & Najab, J. (2010). Mann-Whitney U Test. The Corsini encyclopedia of psychology, 1-1.

Mischel, W., Cantor, N., & Feldman, S. (1996). Principles of self-regulation: the nature of willpower and self-control.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle?. Psychological bulletin, 126(2), 247.

Muraven, M., & Slessareva, E. (2003). Mechanisms of self-control failure: Motivation and limited resources. Personality and social psychology bulletin, 29(7), 894-906.

Muraven, M., Collins, R. L., & Neinhaus, K. (2002). Self-control and alcohol restraint: an initial application of the self-control strength model. Psychology of Addictive Behaviors, 16(2), 113.

Muraven, M., Shmueli, D., & Burkley, E. (2006). Conserving self-control strength. Journal of personality and social psychology, 91(3), 524.

Murdock, K. K. (2013). Texting while stressed: Implications for students' burnout, sleep, and well-being. Psychology of Popular Media Culture, 2(4), 207.

Oulasvirta, A., Rattenbury, T., Ma, L., & Raita, E. (2012). Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing*, *16*(1), 105-114.

Our Mobile Planet (2013). Google. Retrieved from https://www.thinkwithgoogle.com/advertising-channels/mobile-marketing/our-mobile-planet-us-infographic/

Peck, J., & Childers, T. L. (2003). Individual differences in haptic information processing: The "need for touch" scale. Journal of Consumer Research, 30(3), 430-442.

Peck, J., & Childers, T. L. (2003). To have and to hold: The influence of haptic information on product judgments. *Journal of Marketing*, *67*(2), 35-48.

Power, J. D. (2011). Social Media Use Drives Higher Satisfaction among Owners of Smartphones and Traditional Mobile Phones. Retrieved from https://www.jdpower.com/business/press-releases/2011-wireless-smartphone-and-traditional-mobile-phone-satisfaction-studies

Redick, T. S., Calvo, A., Gay, C. E., & Engle, R. W. (2011). Working memory capacity and go/no-go task performance: Selective effects of updating, maintenance, and inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(2), 308.

Scher, S. J., & Cooper, J. (1989). Motivational basis of dissonance: The singular role of behavioral consequences. Journal of Personality and Social Psychology, 56(6), 899.

Schifferstein, H. N. (2006). The perceived importance of sensory modalities in product usage: A study of self-reports. Acta psychologica, 121(1), 41-64.

Siesjö, B. K. (1978). Brain energy metabolism. John Wiley & Sons.

Simons J. (2018). "I Lost It": The Boss Who Banned Phones, and What Came Next. Retrieved from https://www.wsj.com/articles/can-you-handle-it-bosses-ban-cellphones-from-meetings-1526470250

Stoet, G. (2017). PsyToolkit: A novel web-based method for running online questionnaires and reaction-time experiments. *Teaching of Psychology*, *44*(1), 24-31.

Stone, G., & Stone, D. (1990). Lurking in the literature: Another look at media use habits. Mass Communications Review, 17(1), 25-33.

SWNS (2017). Americans check their phones 80 times a day: study. Retrieved from https://nypost.com/2017/11/08/americans-check-their-phones-80-times-a-day-study/?utm_source=url_sitebuttons&utm_medium=site%20buttons&utm_campaign=site%20buttons

Thomée, S., Eklöf, M., Gustafsson, E., Nilsson, R., & Hagberg, M. (2007). Prevalence of perceived stress, symptoms of depression and sleep disturbances in relation to information and communication technology (ICT) use among young adults–an explorative prospective study. Computers in Human Behavior, 23(3), 1300-1321.

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of experimental social psychology*, *43*(3), 379-384.

Tuk, M. A., Trampe, D., & Warlop, L. (2011). Inhibitory spillover: Increased urination urgency facilitates impulse control in unrelated domains. Psychological Science, 22(5), 627-633.

Vadillo, M. A., Gold, N., & Osman, M. (2016). The bitter truth about sugar and willpower: The limited evidential value of the glucose model of ego depletion. Psychological Science, 27(9), 1207-1214.

Vagias, W. M. (2006). Likert-type Scale Response Anchors. Clemson International Institute for Tourism. & Research Development, Department of Parks, Recreation and Tourism Management, Clemson University.

Van Deursen, A. J., Bolle, C. L., Hegner, S. M., & Kommers, P. A. (2015). Modeling habitual and addictive smartphone behavior: The role of smartphone usage types, emotional intelligence, social stress, self-regulation, age, and gender. Computers in human behavior, 45, 411-420.

Verbruggen, F., & Logan, G. D. (2008). Automatic and controlled response inhibition: associative learning in the go/no-go and stop-signal paradigms. Journal of Experimental Psychology: General, 137(4), 649

Vohs, K. D., & Heatherton, T. F. (2000). Self-regulatory failure: A resource-depletion approach. Psychological science, 11(3), 249-254.

Wang, X. T., & Dvorak, R. D. (2010). Sweet future: fluctuating blood glucose levels affect future discounting. Psychological Science, 21(2), 183-188.

Wilmer, H. H., Sherman, L. E., & Chein, J. M. (2017). Smartphones and cognition: A review of research exploring the links between mobile technology habits and cognitive functioning. Frontiers in psychology, 8, 605.

10 Appendix

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
Mean	100	0.96393	2.978	2.421	0.00774
Errors	100	0.90365	7.955	4.601	0.00000

Figure 3. Shapiro-Wilk normality test's output

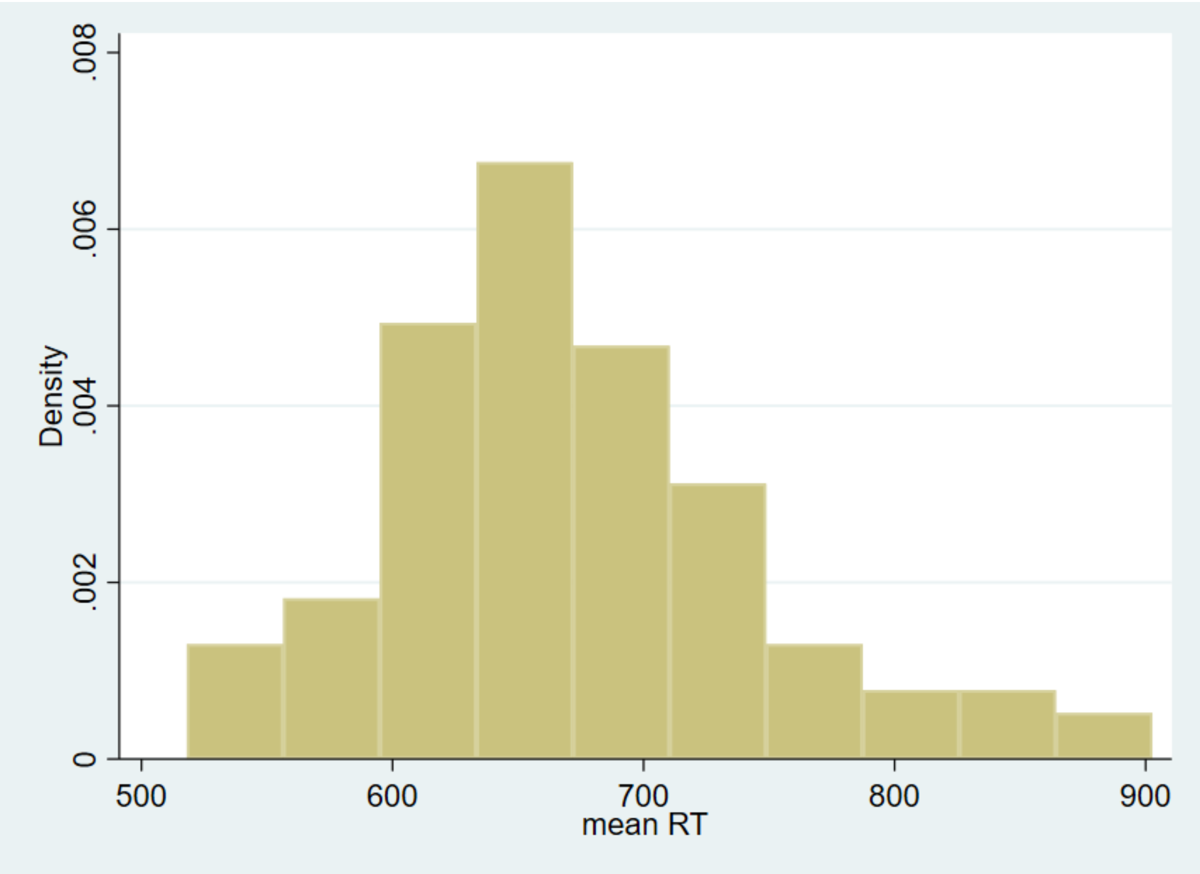

Figure 4. Histogram for the dependent variable, mean reaction times

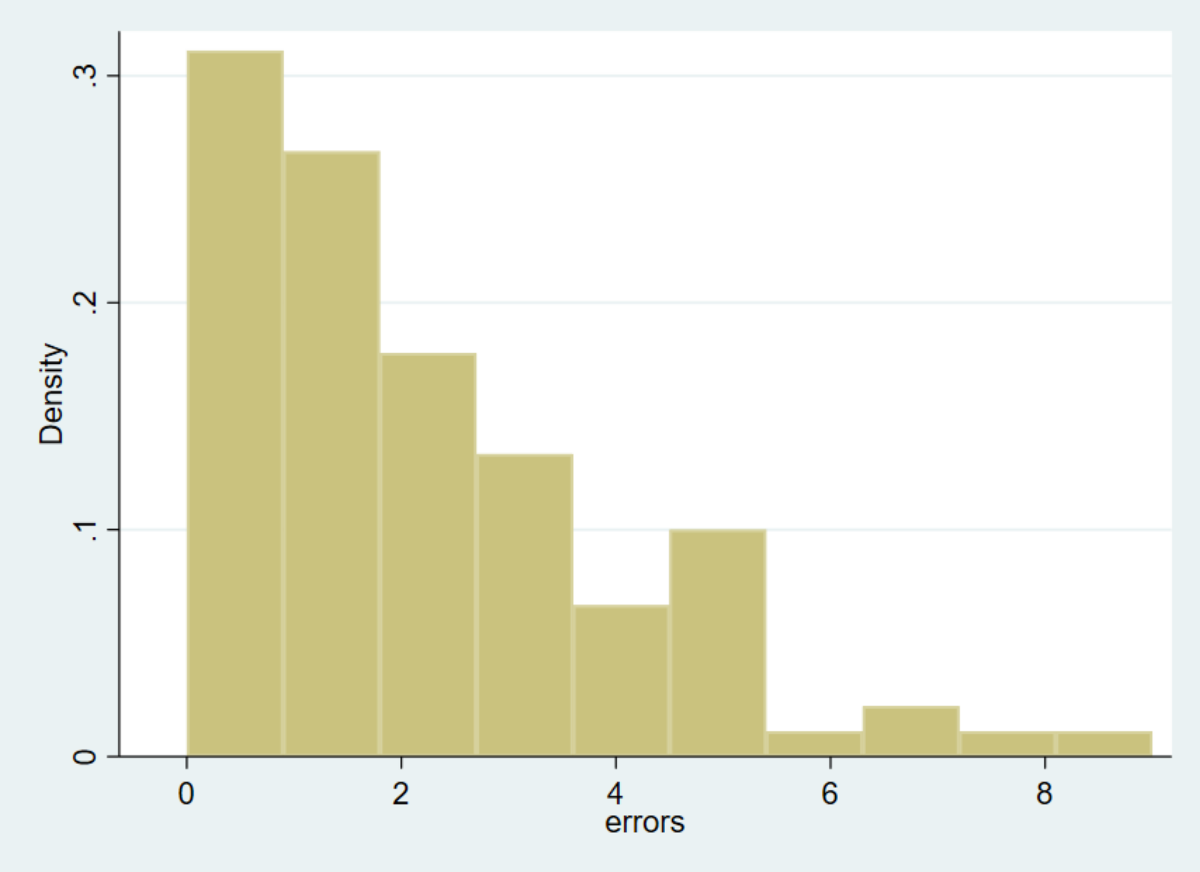

Figure 5. Histogram for the dependent variable, errors

```
. ranksum meanRT, by(group)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

        group |      obs    rank sum    expected
  ------------+---------------------------------
      Control |       50        2524        2525
    Treatment |       50        2526        2525
  ------------+---------------------------------
     combined |      100        5050        5050

unadjusted variance    21041.67
adjustment for ties        0.00
                      ----------
adjusted variance      21041.67

Ho: meanRT(group==Control) = meanRT(group==Treatment)
             z =  -0.007
    Prob > |z| =   0.9945
```

Figure 6. Mann-Whitney U test's output for Hypothesis 1

```
. ranksum errors, by(group)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

        group |      obs    rank sum    expected
--------------+---------------------------------
      Control |       50        2424        2525
    Treatment |       50        2626        2525
--------------+---------------------------------
     combined |      100        5050        5050

unadjusted variance    21041.67
adjustment for ties     -893.43
                     ----------
adjusted variance      20148.23

Ho: errors(group==Control) = errors(group==Treatment)
             z =  -0.712
    Prob > |z| =   0.4767
```

Figure 7. Mann-Whitney U test's output for Hypothesis 1

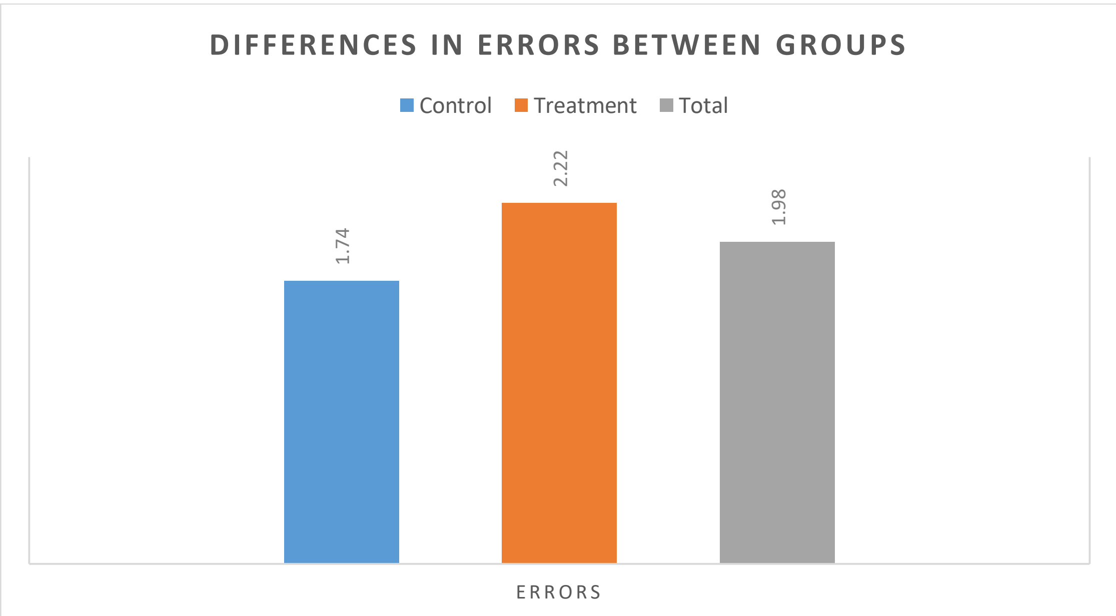

Figure 9. Differences in errors between control and treatment group

```
. ranksum meanRT, by(gender)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

      gender |      obs    rank sum    expected
-------------+---------------------------------
         Men |       50        2409        2525
       Women |       50        2641        2525
-------------+---------------------------------
    combined |      100        5050        5050

unadjusted variance    21041.67
adjustment for ties        0.00
                     ----------
adjusted variance      21041.67

Ho: meanRT(gender==Men) = meanRT(gender==Women)
             z =  -0.800
    Prob > |z| =   0.4239
```

Figure 11. Mann-Whitney U test's output for Hypothesis 2

```
. ranksum errors, by(gender)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

      gender |      obs    rank sum    expected
-------------+---------------------------------
         Men |       50        2553        2525
       Women |       50        2497        2525
-------------+---------------------------------
    combined |      100        5050        5050

unadjusted variance    21041.67
adjustment for ties     -893.43
                     ----------
adjusted variance      20148.23

Ho: errors(gender==Men) = errors(gender==Women)
             z =   0.197
    Prob > |z| =   0.8436
```

Figure 12. Mann-Whitney U test's output for Hypothesis 2

```
. regress meanRT age gender group gender*group anft, robust

Linear regression                               Number of obs     =         99
                                                F(5, 93)          =       1.96
                                                Prob > F          =     0.0919
                                                R-squared         =     0.0679
                                                Root MSE          =     75.818
```

meanRT	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	5.8302	2.598372	2.24	0.027	.6703485	10.99005
gender	77.06876	44.69923	1.72	0.088	-11.69505	165.8326
group	53.78219	43.22602	1.24	0.217	-32.05612	139.6205
gendergroup	-32.55986	30.18225	-1.08	0.283	-92.49582	27.3761
anft	-5.031349	6.258709	-0.80	0.424	-17.4599	7.397206
_cons	430.2038	85.99381	5.00	0.000	259.4371	600.9705

Figure 15. Multiple regression's output for Hypothesis 2

```
. regress errors age gender group gender*group anft, robust

Linear regression                               Number of obs     =         99
                                                F(5, 93)          =       1.10
                                                Prob > F          =     0.3637
                                                R-squared         =     0.0604
                                                Root MSE          =     1.9971
```

errors	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.1265405	.0740403	-1.71	0.091	-.2735699	.0204889
gender	-1.471412	1.138614	-1.29	0.199	-3.732474	.7896506
group	-.7670784	1.183859	-0.65	0.519	-3.117988	1.583831
gendergroup	.8127962	.7866081	1.03	0.304	-.7492516	2.374844
anft	.0826029	.1847338	0.45	0.656	-.2842419	.4494477
_cons	6.182626	2.955616	2.09	0.039	.313359	12.05189

Figure 16. Multiple regression's output for Hypothesis 2

```
. alpha ANFT1 ANFT2 ANFT3 ANFT4 ANFT5 ANFT6

Test scale = mean(unstandardized items)

Average interitem covariance:     1.096303
Number of items in the scale:            6
Scale reliability coefficient:      0.7979
```

Figure 17. Cronbach's alpha reliability test for the Autotelic Need for Touch scale

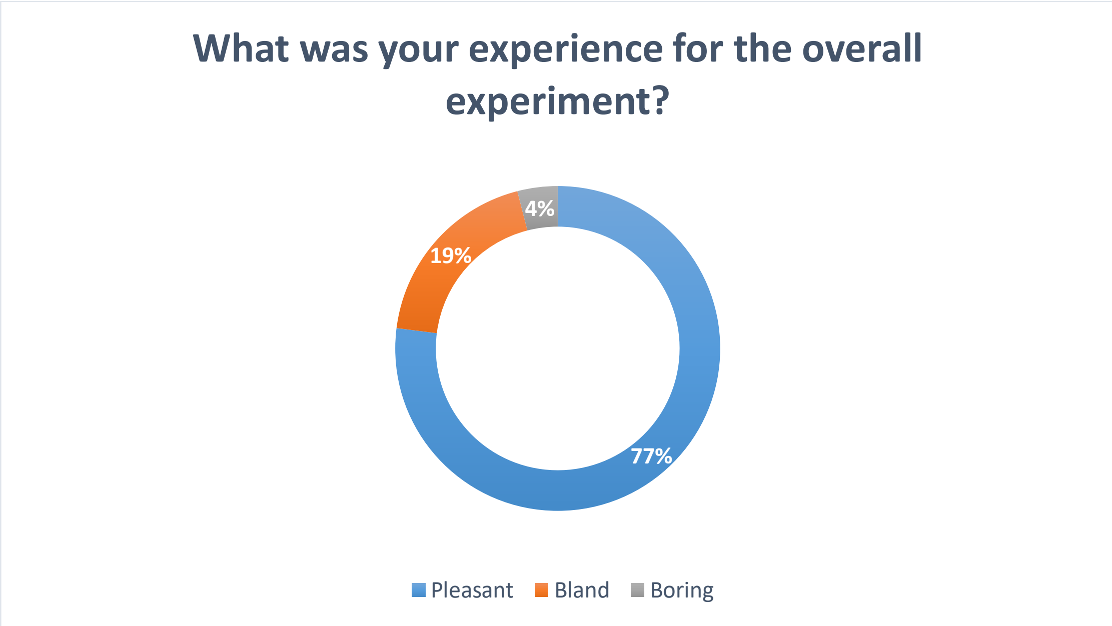

Figure 20. Participants' overview of the experiment's difficulty