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It's Not My Phone, It’s Me: Investigating Smartphone Presence and Predictors of Smartphone Reliance

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Abstract

Objectives: Smartphones are nearly ubiquitous and as a result, researchers have sought to study whether there are negative consequences that result from this inescapable device. Extended exposure to seemingly endless resources, entertainment, and communications has brought forward the issue of smartphone reliance and the effect of smartphone presence on cognition. This dissertation investigated the effect of smartphone presence on cognition and predictors of smartphone reliance using six studies. *Chapter 2 (one study):* A replication of Ward et al.'s (2017) second study was completed. Participants completed a difficult working memory task and a response inhibition task while leaving their smartphone either on their desk, in their pocket or bag, or outside of the testing room (powered on or off in each location). Smartphone use tendencies and a measure of smartphone attachment and dependency were collected. Results did not replicate the original study's main findings: there was no effect of smartphone location on working memory. *Chapter 3 (three studies):* A battery of 12 cognitive tests were used to investigate which aspect of cognition, if any, was affected by smartphone location. Measures of smartphone reliance (nomophobia-the modern fear of being without your phone or the internet, smartphone attachment and dependency, and mobile phone involvement) and smartphone tendencies were also measured. Results from the in-lab study revealed an effect of smartphone location on verbal ability (specifically, verbal short-term memory) but these results were not replicated in a subsequent online-based study. *Chapter 4 (two studies):* The final studies explored personality traits and well-being measures as predictors for smartphone reliance (nomophobia, and smartphone attachment and dependency). Results revealed that higher emotional intelligence and neuroticism were the best and most consistent predictors of smartphone reliance. *Conclusions:* These studies imply that smartphone presence may impact a small aspect of cognition, but not in a reliable manner. Smartphone reliance measures (and their predictors) should be incorporated into future studies to assess if some people are more likely to experience negative effects from smartphone presence or use.

Keywords: Smartphone presence, Smartphone Reliance, Smartphone Use Tendencies, Nomophobia, Cognitive Control, Online-Based

Summary for Lay Audience

Smartphones have become increasingly popular resulting in researchers wanting to understand their impact on our ability to complete tasks while in the presence of your own smartphone. This dissertation explores how being in the presence of our smartphone changes our performance on a task and how our personality can predict how much we rely on our own smartphone. Three projects were used to explore this. The first project tried to recreate findings from a previous study which found that people with their smartphone near them scored lower on a difficult memory task. During a memory and attention task, our participants placed their smartphone in one of three locations: (i) on their desk, (ii) in their pocket or bag, or (iii) outside of the testing room, and turned their smartphone either on or off. We also asked participants about their typical smartphone use to understand how much they rely on their smartphone using two surveys. We found that the results from our study did not compare to those found in the original study. The second project had participants complete 12 tasks which tested a variety of cognitive measures such as memory, attention, and reasoning. During the tasks, participants placed their smartphone either on their desk, in their pocket or bag, or outside of the testing room for an in-person or online study. We found that people who placed their smartphone on their desk had lower scores in the in-person study, however, it had no affect during the online study. The final project looked at the relationship between people who rely on their smartphone and different personality and mental health measures. We found that people with a higher ability to recognize their own emotions and emotional needs, along with those who are more tense or distressed about life relied more heavily on their smartphones. These studies imply that there may be a small impact of smartphone presence, however, not consistently. More research is needed to determine the type of person who is more likely to rely on their smartphone and how this can impact them while in the presence of their smartphone.

Co-Authorship Statement

In Chapter 2, Paul Minda offered helpful experimental design expertise and provided helpful feedback on writing the manuscript. The paper is under review. The citation is:
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Chapter 1

Overview of Dissertation

Look at your desk: is there a smartphone sitting off to the side? It may not always be right by you, but we are rarely farther than earshot from our smartphone. Our smartphones are ever-present and a consistent way to keep us connected to our family, friend, work, and the world in general. This consistent presence is something most of us can relate to, regardless of our circumstances, location, culture, etc. But do you ever feel like it is a distraction to you? From time to time, we get distracted by our smartphones to check the time, social media, or play game. This marvelous device has rapidly evolved into the main communication platform, but it is still unclear how much of a toll it takes to have one, or whether this distraction is guaranteed. My dissertation will explore how your smartphone affects you in your every-day life.

This chapter summarizes Chapters 2-5 in the dissertation. Each chapter will discuss one or more studies which all had the overall goal of investigating the effects of smartphones — their presence and their salience — on cognitive performance (i.e., Chapter 2, and 3) or the individual differences that play a role in this phenomenon (i.e., Chapter 4). For each chapter, I present how the study or studies approached the main goal of this dissertation and a brief account of the findings and implications.

1.1 Chapter 2: Reexamining the "Brain Drain" Effect: A Replication of Ward et al. (2017)

This chapter discusses a direct replication of the "brain drain" effect found in Ward et al.'s (2017) second study: that those who placed their smartphones on their desk performed worse in an automated operation span (OSpan) task (Unsworth et al., 2005) and that this effect was moderated by people's smartphone dependency, where higher dependency was associated with worse performance. Participants placed their smartphones in one of three locations (i.e., on their desk, in their pocket or bag, or outside of their testing room) and had their smartphones powered on or off in their respective locations while completing the OSpan task and a cue-dependent go/no-go task (Bezdjian et al., 2009). Additionally, participants completed a smartphone use questionnaire designed for the study and the Smartphone Attachment and Dependency Inventory (Ward et al., 2017). A significant main effect of smartphone location on OSpan performance was hypothesized: those who placed their smartphones on their desk would have lower OSpan performance. It was predicted that smartphone power would show no significant main effects on task performance. Lastly, it was predicted that smartphone dependence, measured using the smartphone attachment and dependency inventory, would moderate the main effect of smartphone location on OSpan performance: higher dependency associated with lower OSpan performance. The methods, predictions, and data analysis plan was pre-registered on Open Science Framework (OSF; https://osf.io/5fq4r).

Results failed to replicate findings from Ward et al.: no "brain drain" effect of smartphone location was seen for either task. A principal axis factor analysis with varimax rotation on the items in the smartphone attachment and dependency inventory resulted in four factors: dependence, emotional attachment, accessibility, and distractibility. Moderation analyses of these factors on OSpan performance did not show any significant relationships, with emotional attachment showing a non-significant negative trend between the moderator and task performance for those in the on desk condition. Overall, no "brain drain" was seen on task performance. Therefore, Chapter 3 explored whether smartphone salience has an affect on any aspect of cognition.

1.2 Chapter 3: Smartphone's Impact on Your Cognition: Is it Your Phone or How You Use It?

This chapter investigated whether any aspects of cognition are affected by smartphone salience using three studies. Study 1 had two main goals: (1) to explore participant's typical smartphone use (e.g., total screen time, comfort levels, location preferences), and smartphone reliance measures (i.e., how people feel about and interact with their smartphones); and (2) to use the results to determine the design for Study 2. Participants completed three smartphone reliance measures: the Smartphone Attachment and Dependency Inventory (Ward et al., 2017), which measured how dependent one feels towards their phone; the Mobile Phone involvement Questionnaire (Walsh et al., 2010), which measured the level of connection to one's phone; and the Nomophobia Questionnaire (Yildirim and Correia, 2015), which measured fear of being separated from or inability to use one's phone. Additionally, participants completed a smartphone use questionnaire, which was adapted from Chapter 1 and designed for Study 1 to measure typical smartphone use and frequency of use.

It was predicted that, as seen in Ward et al. (2017) and in Chapter 2, the smartphone power condition will not be applicable to the population since most people keep their smartphone turned on. This would imply that the smartphone power condition would not be needed in subsequent studies as it would not be a relevant factor conceptually and for generalizability to the general population. For smartphone location, it was predicted that most participants would report keeping their smartphone either on their desk or in their pocket/bag, with only specific situations, if any, showing participants placing their phones outside of their room. The results of typical smartphone location were used to determine the locations used in Study 2. It was predicted that all reliance measures would be correlated significantly and positively. Typical smartphone use (e.g., total "screen time", most used application) was also described. Results confirmed that most participants placed their smartphone in their pocket or bag, followed by on their desk, and very few reported placing their smartphone on their desk. Participants unanimously reported keeping their smartphone powered on. Most smartphone reliance measures were positively and moderately related to each other. Other trends in smartphone use tendencies are discussed in Chapter 3.

These findings supported the use of three smartphone locations for Study 2, which was an in-person experimental study. Participants placed their smartphone on their desk, in their pocket or bag, or outside of the testing room. While in their respective condition, participants completed the 12 Cambridge Brain Sciences (CBS) tests (Hampshire et al., 2012). Based on the CBS task selection guide (Cambridge Brain Sciences, 2018), these short computerized tests evaluated four cognitive areas: memory, reasoning, verbal ability, and concentration or attention. Then, participants completed the same smartphone reliance measures (i.e., smartphone attachment and dependency, mobile phone involvement, and nomophobia) and smartphone use questionnaire from Study 1. Based on previous studies on smartphone presence (e.g., Courtright and Caplan, 2020; Tanil and Yong, 2020), we predicted a smartphone location effect for the memory and attention-based tests. We predicted similar trends in smartphone reliance and tendencies as in Study 1. Results supported our predictions for the verbal ability cognitive area of the CBS tests: participants who placed their smartphone on their desk performed worse than those who placed their smartphone in their pocket or bag. However, this effect did not generalize to any other CBS test. Similar trends were seen for both the smartphone reliance and typical smartphone use. Study 2 concluded that smartphone presence may in fact impact one aspect of our cognition.

Our final study in Chapter 3 completed a conceptual replication of Study 2 in an online platform. Participants in Study 3 placed their smartphone either (1) on their desk and in their line-of-sight or (2) away from them and outside of their line-of-sight. These conditions provided physical and perceptual distance between a participant and their smartphone and were chosen to mirror the conditions in Study 2. Each participants completed the same 12 CBS tests from Study 2, the same smartphone reliance measures, and a modified version of the smartphone use questionnaire. We hypothesized that, as in Study 2, verbal ability would be affected by smartphone location. We also predicted to continue seeing similar trends for our smartphone reliance and smartphone use tendencies. Our results did not replicate our smartphone location effect: there was no difference in performance between smartphone locations on any CBS measures. We did see similar smartphone reliance and smartphone use tendencies. However, some differences are noted as potential artifacts of unprecedented environmental changes during Study 3 (i.e., the COVID-19 pandemic)[1]. Overall, our studies in Chapter 3 suggest that smartphone presence on its own is not enough to impact our cognition consistently. Additionally, our findings suggest that smartphone reliance, and possibly other individual differences may play a bigger role in how our smartphone impacts us. Therefore, Chapter 4 explored how smartphone reliance and individual differences are related.

1.3 Chapter 4: It's Not My Phone, It's Me: Individual Differences Predict Smartphone Reliance

This chapter investigated individual differences and their relation to smartphone reliance using two studies. Both studies were online survey studies with identical measures. Study 1 recruited participants using an online university pool. Study 2 recruited participants using Amazon's Mechanical Turk (MTurk). Two smartphone reliance measured were used: the Nomophobia Questionnaire (Yildirim and Correia, 2015), which measured the fear of being without your phone or the internet; and the Smartphone Attachment and Dependency inventory (Ward et al., 2017), which measures how dependent you feel towards your phone. Six individual difference measures were used: the Barratt Impulsiveness Scale-Brief (BIS; Steinberg et al., 2013), the International Personality Item Pool NEO (NEO; Maples-Keller et al., 2019), the Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965), the Self-Regulation Scale (SRS; Schwarzer et al., 1999), the Schutte Self-Report Emotional Intelligence Test (SSEIT; Schutte et al., 1998), and the Depression Anxiety and Stress Scale-21 (DASS; Lovibond and Lovibond, 1995). Additionally, a smartphone use questionnaire (modified from Chapter 3) was used to evaluate typical

[1] It is worth noting that Study 3 was completed between December 2020 and April 2021, which was during an variety of province-wide lock downs due to the COVID-19 pandemic. Participants were university students who would have completed their respective academic year fully online.

smartphone use. Each study used a multiple regression model to predict smartphone reliance using the individual difference measures and participant age. Therefore, two separate regression models were done for each study. Additionally, the correlations between the predictors and criteria were explored. It was predicted that more smartphone reliance (i.e., nomophobia and smartphone attachment and dependency) would be predicted by younger participants who had higher impulsivity, extraversion, neuroticism, depression, anxiety, and stress; and lower openness, conscientiousness, agreeableness, self-esteem, self-regulation, and emotional intelligence. We also expected to see similar trends in typical smartphone use as in Chapter 3.

With respect to smartphone use tendencies, we saw a similar trend in Study 1 as in Chapter 2 and Chapter 3, with some nuanced differences in Study 2. Participants in Study 2 had a more diverse demographic (e.g., age, education, country of residence, employment status). This was reflected in their typical smartphone use: participant's most used application was social media and entertainment applications. Screen Time measures depicted less total screen time (in hours), pickups (per day), and notification (per day) than Study 1 and what we saw in Chapter 2 and Chapter 3.

Study 1 found four significant predictors of nomophobia and three significant predictors of smartphone attachment and dependency. Higher nomophobia was predicted by those who were more neurotic and emotionally intelligent, and less open to new experiences and self-regulation. Higher smartphone attachment and dependency was predicted by those who were more neurotic and emotionally intelligent, and less open to new experiences. Study 2 found six significant predictors of nomophobia and eight significant predictors of smartphone attachment and dependency. Higher nomophobia was predicted by those who were younger, more conscientious, extraverted, neurotic, and emotionally intelligent, and less self-regulated. Higher smartphone attachment and dependency was predicted by those who were younger, more conscientious, extraverted, neurotic, emotionally intelligent, and anxious; and less open to new experiences and self-regulated. Overall, our findings showed that neuroticism and emotional intelligence were the best and most consistent predictors of smartphone reliance across both studies. We concluded that age alone may not be the determining predictor of smartphone reliance. So, there may be a personality profile that makes you more susceptible to smartphone reliance, which expands our understanding of how we interact with smartphones and how they affect us. It truly might be us, rather than our smartphone.

1.4 Chapter 5: General Discussion

This final chapter gives a brief overview of Chapters 2-4 and discusses the implication of the dissertation. Additionally, limitations and future research is discussed.

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Chapter 2

Reexamining the “Brain Drain” Effect: A Replication of Ward et al. (2017)

The present study was a pre-registered direct replication of Ward et al.’s (2017) second experiment (OSF pre-registration found at: https://osf.io/5fq4r). This replication assigned both smartphone location (on desk, in pocket/bag, or outside of the testing room) and smartphone power (on, or off) for a total of six conditions. Participants completed an automated operation span (OSpan) task, a cue-dependent go/no-go task, and the smartphone attachment and dependency inventory. It was hypothesized that performance on an attention-demanding task (i.e., the OSpan task) would be worse for those in closer proximity to their smartphone (on desk) and that those with greater smartphone attachment and dependency would have a larger “brain drain” effect. Using the same tasks and conditions as in Ward et al.’s (2017) second experiment, the present study found that the “brain drain” effect did not replicate: there was no difference between smartphone location conditions on performance on either the OSpan task or the go/no-go task. These findings demonstrate that the mere presence of one’s smartphone may not be enough to affect cognitive performance. Understanding these effects is crucial in a time where smartphones are a basic necessity.

Keywords: smartphone presence, attention, response inhibition, smartphone dependency

2.1 Introduction

2.1.1 Increased Smartphone Prevalence

Smartphones provide an easy and effective method of communicating with the world right at our fingertips. They have become a staple in most people’s everyday life: in North America, smartphone ownership has gone from 71 % in 2016 to 81 % in 2019 (Pew Research Center, 2019). Not only are more North Americans owning a smartphone, but also, roughly one in five report using their smartphones primarily for their internet use (Pew Research Center, 2019). The World Health Organization (2015) reported that the “behavioural addictions” associated with internet and smartphone use has occurred comorbid with some psychopathology (e.g., hyperactivity disorder and major depression) and health conditions (e.g., substance use disorders and insomnia). Therefore, there has been an increase in research investigating the possible effects of smartphone use on cognition. An overview of smartphone research, including the “brain drain” effect (Ward et al., 2017), is presented. The present study’s main goal was to investigate if the “brain drain” effect found in Ward et al.’s (2017) second experiment replicated.

2.1.2 Smartphone Research

A Focus on Cognition

Smartphone availability is a relatively recent phenomenon, and research into its effects on cognition have been even more recent. Researchers looked first at the effects of smartphones on attention. Previous research has found attentional costs of smartphone usage during driver performance (Caird et al., 2014). However, the rising prevalence of smartphones has prompted research about how they can impact other cognitive abilities (Stothart et al., 2015; Thornton et al., 2014; Ward et al., 2017; Wilmer and Chein, 2016). This research includes investigating how smartphone use (Stothart et al., 2015; Wilmer and Chein, 2016) and smartphone presence (Thornton et al., 2014; Ward et al., 2017) can impact cognition. Smartphone use has been linked with depletion in cognitive function during day-to-day self-regulation (Wilmer and Chein, 2016). It was found that heavier mobile device users tended to have lower impulse control and a weaker tendency to delay gratification (Wilmer and Chein, 2016). Stothart et al.’s (2015) addressed the impact of smartphone notification on cognitive resources. They found that receiving notifications affected performance on an attention-demanding task. Participants were randomly assigned to one of three conditions: call notification, text notification, or no notification. Those in the notification conditions received a notification during the second block of the main task (Stothart et al., 2015). They showed that, even with no direct contact with a smartphone, participants performed worse under the notification conditions when compared to the no notification condition on a sustained-attention to response task (i.e., a go/no-go task). Additionally, Clayton et al.’s (2015) found that separation from one’s phone led to psychological and physiological anxiety: participants who were unable to answer their ringing phone (which was within viewing distance) during a word search puzzle reported feeling increased anxiousness and unpleasantness, and showed higher physiological measures for anxiety (e.g., heart rate and blood pressure).

Thornton et al.'s (2014) found that smartphones can affect performance on difficult tasks. In study one, participants were tested in pairs (i.e., each sitting on their own desk and facing away from each other) and told that they would complete several tasks that required attention and concentration to complete successfully. For each pair of participants, one would have the experimenter's smartphone (experimental) and the other would have a similar-sized notebook (control) placed on the edge of the table. In study two, participants were tested in a group setting (i.e., a classroom with around 20 students) and were randomly assigned to either place their cell phone on their desk (experimental) or nothing about their cell phones (control). For both study one and two, participants completed two digit cancellation tasks (i.e., measured attention, cognitive capacity, and executive functioning), two trail making tasks (i.e., required attentional processes, mental flexibility, and motor function), and two brief questionnaires (i.e., measuring attentional difficulties and cell phone use and possession). Each task had two versions to each task in order to compare performance on an easier and a difficult version of each task. The digit cancellation task was either the normal/easier (i.e., cross out the target number; 90s) or additive/difficult (i.e., cross out the target number and any adjacent numbers that add up to the target; 180s) version. The trail making task required participants to draw a line connecting either numbers sequentially (i.e. easy; e.g. 1-2-3-4-) or alternating numbers and letters sequentially (i.e., difficult; e.g., 1-A-2-B-3-C-4-D-) for 15s. Results in both studies demonstrated a detriment associated with smartphone presence on the harder, resource-intensive versions of the tasks and no effect on the simpler versions of the same tasks (Thornton et al., 2014). Contrastingly, Hartanto and Yang (2016) found that smartphone separation (i.e., participants who were away from their smartphones) led to significantly worse performance on a measure of task switching (i.e., a color-shape switching task) compared to participants who had their smartphones with them during the study.

The "Brain Drain" Effect

Recently, a study by Ward et al. (2017) found that the mere presence of a participant's smartphone decreased performance on a cognitive task (i.e., a "brain drain" effect). In both experiments, Ward et al. manipulated participant's smartphone location. Each participant's smartphone was placed in one of three locations: (1) on the participant's desk, (2) in their pocket/bag, or (3) outside the testing room.

Experiment 1 investigated the effect of people's smartphone on their available cognitive capacity. Participants were randomly assigned to their smartphone location condition and kept their smartphone on silent (i.e., no vibrations if any notifications were received during the study). Those in the "on desk" location conditions were instructed to keep their devices facing down in a specific location. Participants completed two tasks that measured available cognitive capacity: the Automated Operation Span (OSpan) task (Unsworth et al., 2005) and a 10-item subset of Raven's Standard Progressive Matrices (RSPM) test (Raven et al., 1998). They also completed a third task: the Ending-Digit Drop-Off task.

The OSpan task measured working memory capacity by forcing participants to keep track of task relevant information while engaging in another task. Participants were first presented with the math component of the task: a simple math question (e.g., "(7/7) + 6 = ?") and then indicated whether the correct answer matched a number that was displayed on the next screen (e.g., "7" is "TRUE"). Following the math component, participants were presented with a letter (i.e., the letter component). The math-then-letter component trials were then repeated in blocks. The blocks ranged from a letter string length of three to seven letters, which were randomly displayed. After each block, participants were then asked to recall the letters that were presented between the math questions in order of appearance. Following the recall, participants were given feedback on both math and letter recall performance: they were told how many letters they got in the right order and what percentage of math problems they answered correctly. Only data from those who performed at 85 % math accuracy or higher was used (i.e., to ensure that participants were not ignoring the math component).

The RSPM test was a measure of nonverbal functional fluid intelligence. Participants were given an incomplete pattern matrix and selected an element that would best complete the given pattern. Only 10 items from the original five 12-item series (A-E, ordered according to difficulty; 60 items total) were used. Item series from sets D and E were chosen to measure analytic reasoning (i.e., D2, D4, D6, D8, D10, D12, E1, E2, E4, and E6). The Ending-Digit Drop-Off task measured the tendency to disregard the ending digits of a product's price, which was thought to be more evident in participants whose smartphones were closer to them. Participants estimated how many items (i.e., with either a .99 or .00 price ending) they could buy with a given budget. Overestimating the purchasing power for a .99-item compared to a matched .00-item was considered evidence of a "drop-off" effect. After the three tasks, participants in experiment 1 completed a survey measuring their typical smartphone use and some general demographic questions. Results demonstrated that increased participants in closer proximity to their smartphone had decreased working memory capacity (i.e., OSpan task performance) and fluid intelligence (i.e., RSPM test performance), but showed no effect on the Ending-Digit-Drop-Off task (Ward et al., 2017).

Experiment 2 investigated the effect of smartphone presence on cognitive capacity and sustained attention. There were two independent variables: smartphone location (as in experiment 1) and smartphone power. For smartphone power, a participant's smartphone was either: (1) powered ON or (2) powered OFF in their respective location. For all conditions, participants kept their smartphones on silent (i.e., no vibrations if any notifications were received during the study). Also, participants in the "on desk" location conditions were instructed to keep their devices facing up. Participants completed two counterbalanced tasks: OSpan task (Unsworth et al., 2005), which was identical to experiment 1; and the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009). The Cue-Dependent Go/No-Go task was a behavioural measure of sustained attention. Participants responded to go targets as fast as possible (i.e., a green rectangle) and withhold a response to no-go targets (i.e., a blue rectangle). Targets were first presented as outlines of rectangles and were either vertical or horizontal. The orientation of the initial target was a cue component, which showed the probability that a given target would be either a go (i.e., 80 % vertical and 20 % horizontal) or no-no target (i.e., 80 % horizontal and 20 % vertical). Once both tasks were completed, participants completed an exploratory survey that measured typical smartphone use and included the Smartphone Attachment and Dependency Inventory (Ward et al., 2017). Results in experiment 2 showed that closer proximity to one's smartphone (i.e., the "on desk" location) was associated with decreased cognitive capacity (i.e., OSpan task performance), but not associated with sustained attention (i.e., Cue-Dependent Go/No-Go task performance). There was no effect of smartphone power on either task. This effect was moderated by smartphone attachment and dependency, where higher smartphone attachment and dependency scores showed a greater "brain drain" effect. Therefore, as in experiment 1, those closer to their smartphone showed impaired OSpan performance and this brain drain effect was amplified when participants were more reliant on their smartphone (Ward et al., 2017).

Similar findings were seen in Tanil and Yong (2020), where participants either left their smartphone with the experimenter (i.e., away from the participant) or the participant's smartphone was left with the participant. Then, they completed a computerized working memory task span task. Participants recalled either words with increasing length (i.e., pen, refrigerator), letters, or digits (i.e., "1" to "9"). Each stimuli type was used in a separate 25-trial test, where participants were shown the stimuli in sequence, starting at a minimum length and increasing by one for each correct recall (i.e., in the same order as shown) for a total possible score of 25. Participants who had their smartphone with them showed significantly lower performance. In contrast, Hartmann et al. (2020) found no overall effect of smartphone placement when a participant's smartphones were either present (i.e., on their desk) or absent (i.e., away from their desk, across the testing room) during a short-term memory and prospective memory task. A moderating effect of smartphone dependency was found for prospective memory, where those with less dependency showed better performance in the absent condition. Overall, there is contracting evidence for a "brain drain" effect of smartphone presence.

The Present Study

The purpose of the present study was to carry out a direct replication of Ward et al.'s (2017) second experiment. Ward et al. (2017) found a "brain drain" effect, where closer proximity to one's smartphone impaired working memory capacity (i.e., OSpan performance). This effect was moderated by people's smartphone reliance (i.e., smartphone attachment and dependency score), where higher smartphone reliance resulted in a larger brain drain effect. The evidence provided by experiment 2 in Ward et al. (2017) compliments previous findings (e.g., Thornton et al., 2014; Wilmer and Chein, 2016) that the mere presence of one's smartphone is enough to affect cognition. Additionally, an influx of smartphone research has also led to policy changes. For example, the Ontario government banned cell phones and smartphones in high schools based on the idea that these devices could distract students from their academic work (Jones, 2019). Such policy changes should be based on accurate and reproducible data. Therefore, a direct replication of Ward et al.'s (2017) findings will determine whether the brain drain effect is a stable and reproducible effect.

The present study investigated how the mere presence of one's smartphone affects cognition. Based on findings from Ward and colleagues, three main hypotheses were made: a (1) location effect, (2) power effect, and (3) moderation effect. The location effect hypothesis predicted that those who were closest in proximity to their smartphone (i.e., those with their smartphones on their desk) would show lower performance on the OSpan task (Unsworth et al., 2005) but not on the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009). Secondly, the power effect hypothesis predicted that smartphone power (i.e., either ON or OFF) would not affect performance on both cognitive tasks. Lastly, the moderation effect hypothesis predicted that smartphone attachment and dependency would moderate the location effect: those who reported higher smartphone attachment and dependency would have lower OSpan task performance. Replicating Ward et al.'s (2017) findings will not only help to support their original results, but will also help guide future studies regarding the influence of smartphones on cognition. Understanding these effects are crucial in a time where smartphones are a basic necessity.

2.2 Method

The present study was pre-registered as a direct replication of Ward et al.'s (2017) second experiment on Open Science Framework (OSF; https://osf.io/5fq4r). The study's design, hypotheses, and analysis plan followed this OSF registration.

2.2.1 Participants

A total of 453 students were recruited from Western University's undergraduate research pool. Of the total sample size, 44 participants were excluded due to either testing error (11; e.g., incomplete task data), or experimenter or external confounds (33; e.g., interruption during testing, distracting noise during testing). Only data from participants who scored at85 % accuracy or above (i.e., including 85 % accuracy) on the math component of the testing session of the OSpan (Unsworth et al., 2005) were used for the final analysis. This is the exclusion criteria from the original task, which helped control for participants who did not follow the math component of the task. For the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009), only data from participants who scored higher than chance performance (i.e., responded to at least 50 % of "Go" trials and withheld response to at least 50 % of "No-Go" trials) were used for the final analysis. Additionally, any participants who had a reaction time (RT) that was higher than two standard deviations from the mean RT were not included in the final analysis. This helped control for any participants who did not follow the task instructions[1]. Therefore, 26 participants were removed during the data cleaning phase, which removed participants who met an exclusion criteria (OSpan math criteria: 20; Go/No-Go response criteria, horizontal/no-go cue: 6; Go/No-Go response criteria, vertical/go cue: 6), were identified as having outlier data (OSpan: 0; Go/No-Go Error Analysis: 0; Go/No-Go Accuracy Analysis: 0), and had incomplete or missing data (OSpan: 3; Go/No-Go Error Analysis: 0; Go/No-Go Accuracy Analysis: 3). Overall, 70 participants were removed from the analysis, where a participant may have been removed due to multiple criteria.

Therefore, a total of 383 students (198 females and 185 males) were used in the present study's analyses. The ages ranged from 17-38 years old (M = 18.87, SD = 1.43). Each participant received a course credit for completing the study. Most participants reported being in their first year of their program (68.67 %; second year = 17.23 %; third year = 7.31 %; fourth year = 4.18 %; did not specify = 2.61 %) and in the Social Science faculty (33.94 %; followed by Science, 23.24 % and Medicine & Dentistry, 18.28 %; see Table 2.1 for more details). Inclusion criteria for the present study was as follows: all participants were able to consent as university students (i.e., 17 years old or older) and had normal or corrected-to-normal vision (i.e., glasses and contacts were considered corrected and were therefore, acceptable). Participants were also required to have English as their first language or be fluent in English as a second language. The present study was approved through the WREM Ethics Board at Western University (see Appendix A).

[1]It should be noted that although additional exclusion criteria were not used for the overall performance on the Cue-Dependent Go/No-Go task, participants performed above-chance. That is, participants did show high overall task performance with a median of 249 out of a total possible score of 250 (range = 167-250).

Table 2.1: Demographic descriptive statistics

Demographic measures as descriptive statistics or frequency counts by smartphone power, location, and overall.

	Powered ON			Powered OFF			
Measure	On Desk (70)	Pocket/Bag (67)	Outside (59)	On Desk (58)	Pocket/Bag (65)	Outside (64)	Overall (383)
Age							
M	18.80	18.66	19.10	18.66	19.08	18.95	18.87
SD	0.91	0.88	2.67	1.05	1.33	1.05	1.43
Min.	18	18	18	17	18	18	17
Max.	21	21	38	22	23	22	38
Gender*							
Male	32	32	30	34	32	25	185
Female	38	35	29	24	33	39	198
First Language							
Other	15	12	9	7	10	11	64
English	55	55	50	51	55	53	319
Year of Study							
First Year	46	48	41	42	44	42	263
Second Year	15	10	10	7	10	14	66
Third Year	2	5	3	6	5	7	28
Fourth Year	4	1	3	1	6	1	16
No Selection	3	3	2	2	0	0	10
Faculty							
Arts & Humanities	2	2	0	2	2	1	9
Engineering	1	0	0	0	0	0	1
Health Sciences	10	8	14	6	10	10	58
Information & Media Studies	3	2	1	1	3	3	13
Medicine & Dentistry	14	8	10	14	12	12	70
Music	0	1	2	1	1	0	5
Science	18	17	13	12	11	18	89
Social Science	19	28	18	20	26	19	130
No Selection	3	1	1	2	0	1	8

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Sample size is shown for each group in parentheses.
* Gender options included "Other" and "Prefer not to say", but were not chosen by any participants.

2.2.2 Materials

The Automated Operation Span (OSpan) Task.

The OSpan task (Unsworth et al., 2005) required participants to retain letter strings in memory while solving some simple math problems. This task is a behavioural measure of the attentional control component of working memory. As in Ward et al. (2017), the OSpan task was administered using a computer screen. The present study used a web version of the OSpan task (https://www.millisecond.com/download/library/ospan/), which used the Inquisit 5 software. It was composed of four sessions: three practice sessions (i.e., letter training, math training, and task training) and one testing session.

Letter Training The first practice session trained participants on the letter component of the task. For each trial, a randomly generated letter was presented (i.e., one letter at a time) on a screen for 800ms. A block consisted of a set of 2-3 letters in total. Participants were instructed to remember each letter in their presented order. After the letters were presented, participants recalled the letter string in the correct order by selecting the letters from a 4x3 matrix that displayed all the possible letters (i.e., F, H, J, K, L, N, P, Q, R, S, T, and Y). They were given the option to clear their selection during the recall stage. Also, they had the option to select a "BLANK" box to mark a spot for a missing letter that they did not remember in order to recall the remaining letters in the correct order. Once they completed the recall stage, they indicated they were finished on the screen. Once they indicated they were done, feedback was given regarding the number of letters they correctly recalled (e.g., "You recalled __ out of __ letters correctly."). Participants had no time limit for this practice session. In total, participants completed three letter training blocks. The purpose of the letter training was to allow participants to become familiarized with the letter recall component of the task.

Math Training The second practice session trained participants on the math component of the task. For each trial, participants were presented with a simple math question (e.g., "(7/7) + 6 = ?"). The participant then clicked the left mouse button, which indicated that they solved the problem. Following this, they were asked to indicate whether a displayed answer (e.g., "7") was correct by selecting either "TRUE" or "FALSE" on the screen. Following their selection, participants were given feedback on their performance: the number of correct trials out of the total they had currently completed (e.g., "You were correct on __ of __ math trials.") and the percent accuracy (e.g., "That is, __ percent correct."). Participants were instructed to solve the math problems correctly and as quickly as they could. In total, participants completed 15 math training trials. The purpose of the math training was not only to allow participants to familiarize themselves with the math component of the task, but also to obtain an average math solving time for each participant. The average time it took each participant to indicate they had solved a math problem plus 2.5 SD was used as the maximum time limit to solve math problems in the math component of the task training and testing session.

Task Training The third and final practice session trained participants on the full task: a combination of the letter and math components. For each trial, participants were first presented with a simple math question and, once they indicated they had solved the problem, they indicated whether the following screen depicted the correct answer (i.e., by selecting either "TRUE" or "FALSE"). Then, a randomly generated letter was presented (for 800 ms). Each combination of the math and letter component made up one trial. Each block was made up of three to seven trials in total. After each block, participants recalled the letter string in the order that they were presented. This recall stage was presented and gave the same options as in the letter training. Feedback for the task training was different than the previous letter and math components: participants were then given feedback on their math and letter accuracy. Participants were told how many letters they recalled correctly (e.g., "You recalled __ out of __ letters correctly."), how many math errors they made (e.g., "You made __ math error(s) on this set of trials."), and what percentage of math problems they answered correctly so far (e.g., "__%"; in the top right of the screen). It should be noted that participants had a time restriction to indicate they had solved the math problem, which was determined during the math training. Participants were told that if they took longer than their average time from their math training to indicate they solved the math problem, they would skip to the next letter and have that math problem marked as a math error. Similar to the math training, participants were asked to answer the math questions as fast as possible without sacrificing math or letter accuracy. Participants were told to try to maintain a minimum 85 % math accuracy to ensure that participants were not ignoring the math problems to try to remember the letters. The task training consisted of three blocks. The purpose of the task training was to prepare participants for the testing session.

Testing Session The testing session was the main task. Participants completed 75 blocks identical to the task training blocks (i.e., 75 math problems and 75 letter sets) without any breaks between blocks. The letter sets ranged from three to seven letters in length, which was randomized for each participant. Feedback identical to the task training was given after each block. Once the blocks were completed (i.e., the main task was finished), the following data were presented on the screen: subject number, OSpan absolute score, OSpan total number correct, math total errors, math speed errors, and math accuracy errors. These data were recorded by the experimenter.

The Cue-Dependent Go/No-Go Task

The Cue-Dependent Go/No-Go Task (Bezdjian et al., 2009) measured reaction time (RT) and response accuracy: this task is a behavioural measure of sustained attention. The task was administered on a computer screen using Psychopy (version 1.85.4) and was designed to match the task described in Ward et al. (2017). For each trial, participants were first shown a fixation cross (800ms), followed by a blank screen (500ms), and then an outline of either a vertical or horizontal rectangle (displayed for 100ms, 200ms, 300ms, 400ms, or 500ms; randomized between trials). Then, the rectangle would become filled with either the colour green (i.e., a "go target") or blue (i.e., a "no-go target"). Once the rectangle was filled in, for the "go target", participants were instructed to respond with a key press (i.e., "/" on a standard English

QWERTY keyboard) as fast as possible. For the "no-go targets", participants were instructed to withhold any response (1,000ms). Each trial ended after either a key press or the 1,000ms had elapsed after the target was presented. After 700ms, the next trial began. The cue component of the task determined the probability that the rectangle would be either a "go" or "no-go" target. Vertical targets were more likely to become "go" targets (i.e., 80 % "go" and 20 % "no-go"), while horizontal targets were more likely to become "no-go" targets (i.e., 80 % "no-go" and 20 % "go"). Participants were not explicitly made aware of the cue component. Each participant completed a total of 250 trials (50 % "go" trials, 50 % "no-go" trials) without a break between trials. The data recorded from the task was the following: omission errors (i.e., when a participant fails to respond to a "go" target), commission errors (i.e., when a participant responds to a "no-go" target), and a RT measure.

The Demographic Questionnaire

The demographic items (i.e., four items in total) in the present study asked participants to report their age (i.e., in years), gender (i.e., male, female, other, or prefer not to say), program (e.g., psychology, engineering), and year of study (e.g., first, fourth). Participants reported their program in an open-ended question and grouped into faculties manually. The purpose of these items was to give a brief description of the sample. The demographic questionnaire is shown in Appendix B.

The Smartphone Use Questionnaire

The smartphone use questionnaire was created for the present study and consisted of modified items from Ward et al.'s (2017) exploratory survey measures (i.e., found in the "'BRAIN DRAIN' WEB APPENDIX"). Some items were forced-choice and some were on a 7-point Likert scale ranging from 1 ("Never") to 7 ("Always"). There were 10 items in total and there were three types of items, which measured: (1) smartphone use frequency (three items; e.g., "On average, how many text messages do you send per day?"); (2) smartphone use without external stimulation (two items; e.g., "If I am waiting to meet a friend, I pass the time by using my smartphone."), or during other activities (two items; e.g., "I use my smartphone while driving."); (3) exploratory items, measuring smartphone subjective value (one item; e.g., "How much money would it take for you to give up your phone for a full day?"), smartphone notification type (one item; e.g., "Do you receive notifications (a sound or vibration) on your phone? Please indicate all that apply."), and phantom vibrations (one item; e.g., "Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?"). The purpose of the smartphone use questionnaire was to measure participants' typical smartphone use. The smartphone use questionnaire is shown in Appendix C.

The Smartphone Attachment and Dependency Inventory

The smartphone attachment and dependency inventory (Ward et al., 2017) consisted of 13 items, where participants indicated whether they agreed or disagreed with statements regarding their attachment and dependency to their smartphone. A 7-point Likert scale (ranging from 1, "Strongly Disagree", to 7, "Strongly Agree") was used. Items measured people's smartphone dependency (e.g., "I feel like I could not live without my cell phone.") and emotional attachment (e.g., "I feel lonely when my cell phone does not ring or vibrate for several hours."). The purpose of the smartphone attachment and dependency inventory was to measure each participant's reliance on their smartphone. See Ward et al. (2017) for item details.

2.2.3 Procedure

Participants were randomly assigned to one of six possible conditions. These conditions were based on the two independent variables: smartphone location and smartphone power. For smartphone location, a participant's smartphone was either: (1) on the participant's desk (on desk), (2) in their pocket/bag (pocket/bag), or (3) outside the testing room (outside). For smartphone power, a participant's smartphone was either: (1) powered ON, or (2) powered OFF, in their respective location. Therefore, each participant was in one of six conditions: desk–on (n = 70), pocket/bag–on (n = 67), outside–on (n = 59), desk–off (n = 58), pocket/bag–off (n = 65), and outside–off (n = 64). For all conditions, participants were instructed to keep their smartphones on silent (i.e., no vibrations if any notifications were received during the study). Also, as per Ward et al. (2017), participants in the "on desk" location conditions were instructed to keep their devices facing up. Once a participant was randomly assigned to their condition, all participants then completed two counter-balanced cognitive tasks: the OSpan task (Unsworth et al., 2005) and the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009). The OSpan task took approximately 20 minutes to complete and the Cue-Dependent Go/No-Go task took approximately 15 minutes to complete. After completing both tasks, all participants completed the survey measures (approximately 5 minutes to complete): demographic questionnaire, the smartphone use questionnaire, and the smartphone attachment and dependency inventory (Ward et al., 2017). The entire study took approximately 60 minutes to complete.

2.3 Results

The present study was pre-registered as a direct replication of Ward et al.'s (2017) second experiment on OSF (https://osf.io/5fq4r) along with a data analysis plan.

2.3.1 Scoring

The OSpan Task

As in Ward et al. (2017), cognitive capacity was measured by the OSpan (Unsworth et al., 2005): a behavioural measure of the attentional control component of working memory. Performance, measured with the OSpan absolute score, was shown by how many trials a participant correctly recalled all the letters in a given block (75 blocks in total). For example, a participant who recalled three letters (in a block with three letters), five letters (in a block with five letters), and two letters (in a block with six letters) would have an OSpan absolute score of eight for those blocks (i.e., $3 + 5 + 0 = 8$). Since the OSpan absolute score only increased when a participant recalled all letters in a trial correctly, a score of zero was possible. A participant who did recall some letters correctly in any trial, but either incorrectly recalled or missed one or more letters as well would receive a score of zero. Therefore, the OSpan absolute score showed performance where higher scores represented better performance.

The Cue-Dependent Go/No-Go Task

As in Ward et al. (2017), sustained attention was measured with the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009). Performance was measured with mean omission errors and RT. It should be noted that mean errors can be divided into total error, commission error, and omission error. Commission errors occurred when a participant responded to a target stimulus. Omission errors occurred when a participant failed to respond to a non-target stimulus. Total errors were the sum of commission and omission errors. The present study focused on mean omission errors. Therefore, for each participant, higher mean omission errors represented lower performance. Additionally, higher mean RT also showed lower performance (i.e., indicative of greater interference).

The Smartphone Attachment and Dependency Inventory

Participant's level of smartphone attachment and dependency (i.e., smartphone reliance) was measured with the smartphone attachment and dependency inventory (Ward et al., 2017). The 13-item inventory was scored by calculating a sum total for each item with a range of 13 to 91. Higher scores indicated a higher level of reliance with three levels.

2.3.2 Analyses

The OSpan task

The OSpan absolute score was used. A 3(Smartphone location: desk, pocket/bag, or outside) x 2(Smartphone power: ON or OFF) between-subjects analysis of variance (ANOVA) was conducted. Descriptive statistics are shown in Table 2.2). All analyses assumptions (i.e., independent random sampling, normality, and homogeneity of variance) were met. There was no significant main effect of smartphone location on OSpan performance, $F(2, 377) = 0.10$, $p = .907$, $\eta^2_G < .01$. There was no significant main effect of smartphone power on OSpan performance, $F(1, 377) = 0.21$, $p = .651$, $\eta^2_G < .01$. There was also no significant interaction between smartphone location and power on OSpan performance, $F(2, 377) = 1.19$, $p = .305$, $\eta^2_G = .01$ (Figure 2.1). Since there were no significant main or interaction effects, no post-hoc tests were completed.

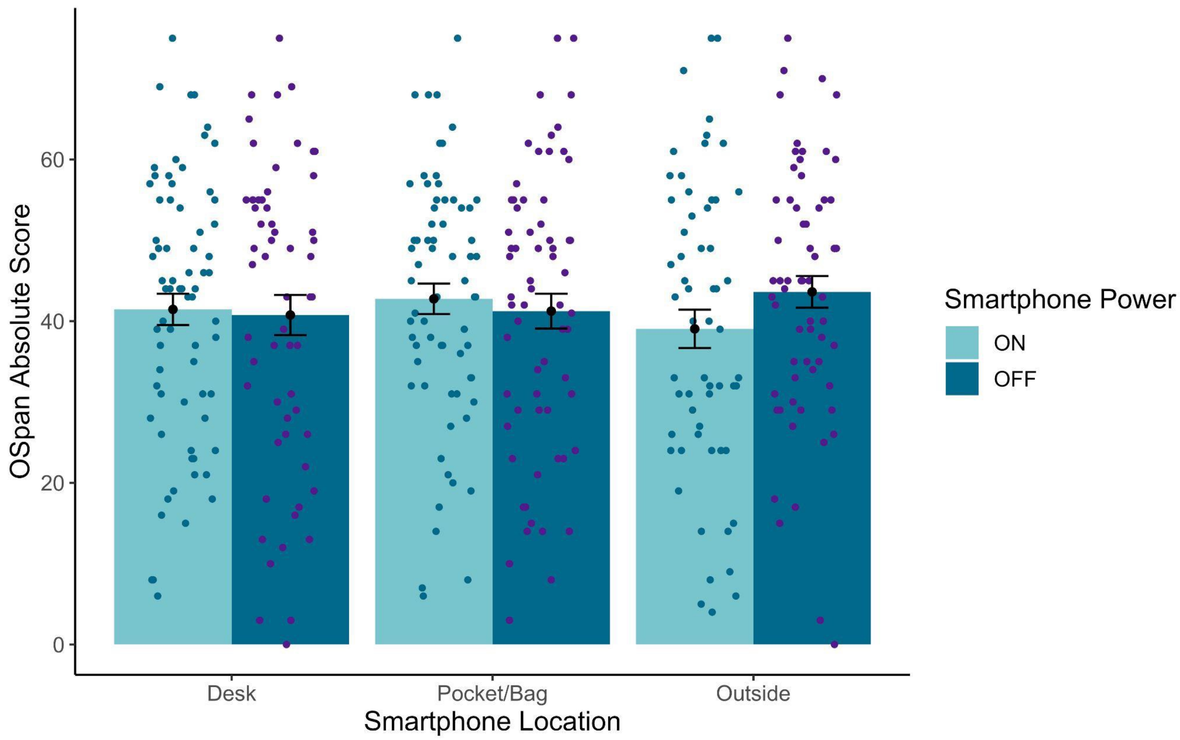
Table 2.2: Task descriptive statistics

Descriptive statistics for the operation span and cue-dependent go/no-go task by smartphone power, location, and overall.

	Powered ON			Powered OFF			
Measure	On Desk	Pocket/Bag	Outside	On Desk	Pocket/Bag	Outside	Overall
OSpan Absolute Score							
M	41.46	42.76	39.05	40.76	41.25	43.63	41.54
SD	16.22	15.44	18.25	18.93	17.33	15.68	16.90
Min.	6	6	4	0	3	0	0
Max.	75	75	75	75	75	75	75
OSpan Math Score (%)							
M	95.03	95.74	94.89	94.99	95.65	95.46	95.3
SD	3.42	3.06	3.22	3.46	3.17	3.32	3.27
Min.	86.67	88	85.33	86.67	86.67	85.33	85.33
Max.	100	100	100	100	100	100	100
Cue-Dependent Go/No-Go: Omission Errors for "Go" Trials							
M	0.70	0.36	0.51	0.97	0.57	0.31	0.56
SD	2.16	0.85	1.06	3.09	2.93	0.73	2.03
Min.	0	0	0	0	0	0	0
Max.	14	4	5	20	23	4	23
Cue-Dependent Go/No-Go: Omission Errors for "No-Go" Trials							
M	0.11	0.09	0.25	0.12	0.22	0.14	0.15
SD	0.36	0.29	0.68	0.50	0.93	0.39	0.56
Min.	0	0	0	0	0	0	0
Max.	2	1	3	3	7	2	7
Cue-Dependent Go/No-Go: Average Reaction Time							
M	1.66	1.66	1.66	1.67	1.66	1.66	1.66
SD	0.05	0.06	0.04	0.09	0.06	0.06	0.06
Min.	1.58	1.56	1.56	1.57	1.56	1.56	1.56
Max.	1.88	1.8	1.77	2.21	1.84	1.87	2.21

N = 383

Figure 2.1: *Comparing Operation Span Performance between Smartphone Location and Power Conditions: Visual Depiction of ANOVA Test.*

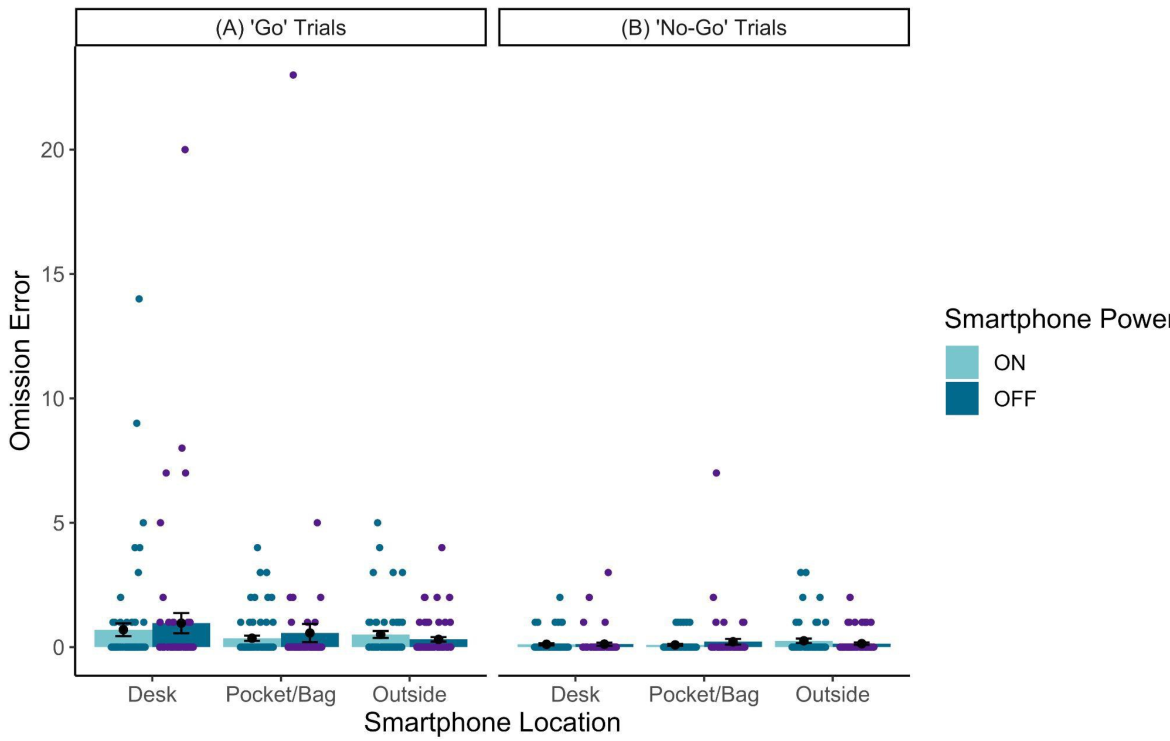


Note. Plots depict the average performance on the Operation Span (OSpan) Task (i.e., OSpan absolute score; y-axis) for participants across smartphone location (i.e., on desk, left bars; pocket/bag, middle bars; or outside, right bars) and smartphone power (i.e., on, light blue bars; or off, dark blue bars). Black dots and multi-coloured dots represent the mean and individual data points for each condition, respectively. Error bars represent standard error. OSpan absolute score was calculated by summing the total letters recalled for each trial where all letters were recalled correctly; therefore, a score of 0 was possible for any participant who either incorrectly recalled or missed one or more letters in every trial.

The Cue-Dependent Go/No-Go Task

An error (i.e., omission errors) and accuracy (i.e., RT) analysis was completed using the average omission errors and RT for each participant. For the error analysis, a 3 (Smartphone location: desk, pocket/bag, or outside) x 2 (Smartphone power: ON or OFF) x 2 (Cue type: Go or No-Go) mixed factorial design with the between-subjects factors of smartphone location and power, and a within-subjects factor of pre-target cue type was completed. Descriptive statistics are shown in Table 2.2). Since the homogeneity assumption was not met for the mixed ANOVA, a White-corrected F-test was completed for the between-subject effects. There was no significant main effect of smartphone location, $F(2, 377) = 0.67$, $p = .513$, $\eta^2_G < .01$), and smartphone power, $F(1, 377) = 0.15$, $p = .700$, $\eta^2_G < .01$. There was a significant main effect of cue type, $F(1, 377) = 23.22$, $p < .001$, $\eta^2_G = .02$) for average omission errors. Additionally, there was no significant interaction between smartphone location and power, $F(2, 377) = 1.01$, $p = .365$, $\eta^2_G < .01$, smartphone power and cue type, $F(1, 377) = 0.26$, $p = .611$, $\eta^2_G < .01$, and between all three factors (i.e., smartphone location, power, and cue type), $F(2, 377) = 0.32$, $p = .723$, $\eta^2_G < .01$. There was a significant interaction between smartphone location and cue type, $F(2, 377) = 3.19$, $p = .042$, $\eta^2_G < .01$, however, post-hoc simple main effects for cue type across smartphone location did not show any significant main effects for the "go", $F(2, 380) = 1.42$, $p = .487$, $\eta^2_G < .01$, and "no-go", $F(2, 380) = 0.60$, $p = .551$, $\eta^2_G < .01$, cue type (see Figure 2.2).

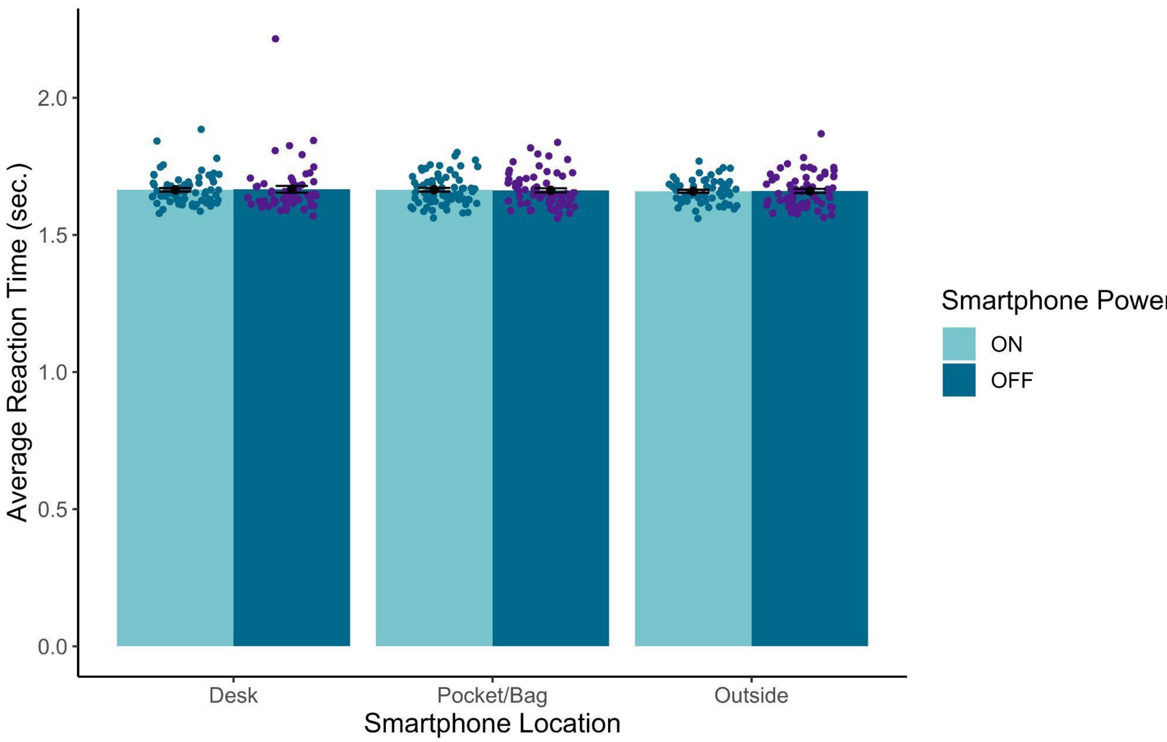
Figure 2.2: *Comparing Cue-Dependent Go/No-Go Omission Errors between Smartphone Location and Power Conditions by Cue Type: Visual Depiction of ANOVA Test.*



Note. Plots depict the average performance on the Cue-Dependent Go/No-Go Task (i.e., omission errors: responding to a "no-go" target; y-axis) for participants across smartphone location (i.e., on desk, left bars; pocket/bag, middle bars; or outside, right bars) and smartphone power (i.e., on, light blue bars; or off, dark blue bars) by cue type: "go" (A) or "no-go" (B). Black dots and multi-coloured dots represent the mean and individual data points for each condition, respectively. Error bars represent standard error.

For the accuracy analysis, a 3 (Smartphone location: desk, pocket/bag, or outside) x 2 (Smartphone power: ON or OFF) between-subjects ANOVA was conducted. Descriptive statistics are shown in Table 2.2). All analyses assumptions (i.e., independent random sampling, normality, and homogeneity of variance) were met. There was no significant main effect of smartphone location on average RT, $F(2, 377) = 0.26$, $p = .770$, $\eta^2_G < .01$. There was no significant main effect of smartphone power on average RT, $F(1, 377) < .01$, $p = .962$, $\eta^2_G < .01$. There was also no significant interaction between smartphone location and power on average RT, $F(2, 377) = 0.04$, $p = .957$, $\eta^2_G < .01$. Since there were no significant main or interaction effects, no post-hoc tests were completed for the accuracy analyses (see Figure 2.3).

Figure 2.3: *Comparing Cue-Dependent Go/No-Go Average Reaction Time between Smartphone Location and Power Conditions: Visual Depiction of ANOVA Test.*



Note. Plots depict the average performance on the Cue-Dependent Go/No-Go Task (i.e., average reaction time in seconds; y-axis) for participants across smartphone location (i.e., on desk, left bars; pocket/bag, middle bars; or outside, right bars) and smartphone power (i.e., on, light blue bars; or off, dark blue bars). Black dots and multi-coloured dots represent the mean and individual data points for each condition, respectively. Error bars represent standard error.

The Smartphone Attachment and Dependency Inventory

As in Ward et al. (2017), responses to the smartphone attachment and dependency inventory were assessed with a factor analysis. A principal axis factor analysis with a Varimax rotation was completed to assess which factors, if any, fit our data and to compare to the two main factors found by Ward et al. (i.e., smartphone dependence and emotional attachment). The results of the factor analysis were also used to form subscale scores for each factor found in the final solution. Factorability of the data was confirmed using: (1) Bartlett's test for correlation adequacy, $\chi^2(78) = 1943.16$, $p < .001$, which confirmed that correlations between the items were sufficiently large; and (2) the Kaiser-Meyer-Olkin measure for sampling adequacy (MSA), which confirmed that both the overall MSA ($MSA_{overall} = 0.88$) and each item's MSA ($MSA_{1-13} = 0.79$ - 0.94) were above the required criteria (0.60 and 0.77, respectively; Kaiser, 1974).

A four-factor solution was chosen for the best fit for the data based on a parallel analysis scree plot, the Kaiser's criterion (i.e., eigen values greater than one), and by comparing the structure for the two-, three-, and four-factor solutions. After an initial four-factor solution was completed using all 13 items in the smartphone attachment and dependency inventory, however, one item (i.e., 4) was split-loaded between factor 1 and 3 and was excluded from further analyses (Costello and Osborne, 2005). This final solution achieved simple structure and was used for subsequent analyses. The final solution showed a good fit (Root Mean Square of the Residual = .03).

The final solution's factors explained 52.97 % of the variance and suggested the following three factors: dependence, emotional attachment, accessibility, and distractibility (see Table 2.3). Dependence was related to the degree of dependence on one's smartphone, it consisted of 3 items (i.e., 1, 2, and 3) and explained 16.68 % of the variance (e.g., "I would have trouble getting through a normal day without my smartphone.", "I feel like I could not live without my smartphone."). Emotional attachment was related to one's smartphone use for emotional support, it consisted of 4 items (i.e., 8, 9, 10, and 11) and explained 15.48 % of the variance (e.g., "I feel lonely when my smartphone does not ring or vibrate for several hours.", "Using my smartphone makes me feel happy."). Accessibility was related to the ability to access the utility of one's phone (e.g., powered on, internet access), it consisted of 3 items (i.e., 5, 6, and 7) and explained 11.84 % of the variance (e.g., "It drives me crazy when my smartphone runs out of battery.", "I feel impatient when the Internet connection speed on my smartphone is slow."). Distractibility was related to one's smartphone retaining one's attention, it consisted of two items and explained 8.97 % of the variance (e.g., "I find it tough to focus whenever my smartphone is nearby.", "I become less attentive to my surroundings when I'm using my smartphone."). All three factors had moderate reliability, measured with Cronbach's alpha ($\alpha_{Dep.} = .83$, $\alpha_{EA} = .76$, $\alpha_{Access.} = .72$, $\alpha_{Dist.} = .63$; Kline, 1999). No increases were seen in Cronbach's alpha by eliminating more items for any of the factors. A composite sum-score was created for each factor, where higher scores indicated higher dependency (possible range = 3-21; $M = 12.63$, $SD = 4.73$), emotional attachment (possible range = 4-28; $M = 16.73$, $SD = 4.91$), accessibility (possible range = 3-21; $M = 9.98$, $SD = 2.70$), and distractibility (possible range = 2-14; M = 6.25, SD = 1.03), respectively. Descriptive statistics for the four factors are shown in Table 2.4.

Table 2.3: Factor analysis results

Summary of exploratory factor analysis of the 13 items in the Smartphone Attachment and Dependency Inventory from Ward et al. (2017).

Item	Description	Rotated Factor Loadings 1 (*)	2 (*)	3 (*)	4
Factor 1: Dependency					
1	I would have trouble getting through a normal day without my smartphone.	**.72** (.85)	.21	.24	.12
2	It would be painful for me to give up my smartphone for a day.	**.82** (.81)	.28	.19	.05
3	I feel like I could not live without my smartphone.	**.61** (.79)	.18	.24	.17
Factor 2: Emotional Attachment					
8	I feel lonely when my smartphone does not ring or vibrate for several hours.	.18	**.44** (.73)	.32	.19
9	Using my smartphone relieves me of my stress.	.24	**.58** (.71)	.20	.09
10	I feel excited when I have a new message or notification.	.10	**.73** (.70)	.21	.13
11	Using my smartphone makes me feel happy.	.30	**.67** (.68)	.09	.11
Factor 3: Accessibility					
5	It drives me crazy when my smartphone runs out of battery.	.37 (.66)	.20	**.56**	.14
6	I am upset and annoyed when I find I do not have reception on my smartphone.	.26 (.64)	.21	**.68**	.19
7	I feel impatient when the Internet connection speed on my smartphone is slow.	.15 (.52)	.25	**.48** (.43)	.21
Factor 4: Distractibility					
12	I find it tough to focus whenever my smartphone is nearby.	.15	.18 (.64)	.09	**.67**
13	I become less attentive to my surroundings when I'm using my smartphone.	.06	.08	.24 (.90)	**.63**
	Eigen Values	2.00	1.89	1.42	1.08
	Percent of Variance Explained (*)	16.68 (31.02)	15.48 (21.65)	11.84	8.97
	α(*)	.83 (.89)	.76 (.79)	.72	.63

Note: Items have been sorted based on rotated (varimax) factor loading. Strongly loaded items for present study (>.40) are shown in bold font. Item four was removed due to split-loading between factors 1 (.58) and 2 (.41): "I am upset and annoyed when I find I do not have reception on my smartphone.". This loading was .75 in Ward et al. (2017).
* Values given in Ward et al. (2017). Only two strong factors (smartphone dependency and emotional attachment) were included with respective strong loadings.
N = 383

The present study's findings partially supported Ward et al.'s (2017) findings and provided the groundwork for the moderator analysis. To examine if smartphone dependency, emotional attachment, accessibility, or distractibility were moderators of the relationship between the experimental manipulation and OSpan performance, a pre-registered analysis using a univariate generalized linear model was used. As in Ward et al. (2017), OSpan performance was the criterion, smartphone location (i.e., desk, pocket/bag, and outside) was the independent variable, and the following were used as possible predictors, each in a separate analyses: the mean-

Table 2.4: Smartphone attachment and dependency inventory descriptive statistics

Descriptive statistics for the smartphone attachment and dependency inventory for subscales and across all items by smartphone power, location, and overall.

	Powered ON			Powered OFF			
Measure	On Desk	Pocket/Bag	Outside	On Desk	Pocket/Bag	Outside	Overall
Dependency							
M	11.73	12.51	12.42	13.31	12.2	13.77	12.63
SD	5.57	4.61	5.07	4.39	4.38	3.98	4.73
Min.	3	3	3	3	3	5	3
Max.	21	21	21	21	20	21	21
Emotional Attachment							
M	16.8	16.3	16.39	16.55	16.43	17.88	16.73
SD	5.05	5.32	5.07	4.58	4.73	4.63	4.91
Min.	4	4	4	5	4	6	4
Max.	28	28	27	26	26	28	28
Accessibility							
M	14.67	15.01	14.98	15.31	14.6	15.55	9.98
SD	4.01	3.43	3.84	3.95	3.68	3.32	2.70
Min.	3	6	3	6	4	8	2
Max.	21	21	21	21	21	21	14
Distractibility							
M	10.1	10.36	9.66	10.07	9.75	9.88	6.25
SD	2.84	2.49	2.78	2.89	2.43	2.82	1.03
Min.	2	2	4	2	3	2	1.50
Max.	14	14	14	14	14	14	7
All items							
M	57.67	58.94	58.08	59.86	57.32	62.23	58.99
SD	15.32	13.58	14.60	13.15	12.39	12.46	13.66
Min.	19	27	22	25	19	32	19
Max.	89	87	86	87	79	87	89

N = 383

centered dependency, emotional attachment, accessibility, and distractibility composite score. Additionally, all independent variable x moderator interaction terms were included as predictors in the model (Baron and Kenny, 1986). Therefore, each regression model had the following predictors for the criterion (i.e., OSpan absolute score): (1) moderator, (2) smartphone location comparisons (i.e., desk vs. pocket/bag, desk vs. outside, and outside vs. pocket/bag), and (3) all interaction between (1) and (2). Outliers were removed if participants fell outside of both the Leverage and Cook's criteria, for dependency (N = 376), emotional attachment (N = 379), accessibility (N = 377), and distractibility (N = 375). For all models, the assumptions of multicollinearity, linearity, normality, and homogeneity were met.

Smartphone Dependency The overall model predicting OSpan performance using smartphone location and dependency score failed to account for the data and was not significant, $F(5, 370) = 0.31$, $p = .908$, $R^2 < .01$. Dependency, $p = .297$, smartphone location, $p > .617$, and the dependency x smartphone location interactions, $p > .364$, were not significant predictors of OSpan absolute score (see Table 2.5A for more details). A visual inspection of the model did not show any trends (Figure 2.4A).

Smartphone Emotional Attachment The overall model predicting OSpan performance using smartphone location and emotional attachment score failed to account for the data and was not significant, $F(5, 373) = 1.05$, $p = .386$, $R^2 = .01$. Emotional attachment approached a significant predictor of OSpan performance, $p = .047$. Smartphone location, $p > .702$, and emotional attachment x smartphone location interactions, $p > .180$, were not significant predictors of OSpan absolute score (see Table 2.5B for more details). A visual inspection of the data showed a trend in the desk condition, where participants who reported lower smartphone emotional attachment showed higher OSpan performance. This trend was weaker in the outside condition and not seen in the pocket/bag condition (Figure 2.4B). This trend was investigated using an exploratory simple slopes analysis using emotional attachment score as a predictor of OSpan performance for each smartphone location condition. Emotional attachment score was a marginally significant predictor of OSpan performance, $b = -0.63$, $t(125) = -1.94$, $p = .055$, in the desk condition. However, this trend was not seen in the pocket/bag, $b = -0.31$, $t(129) = -1.07$, $p = .285$, or outside, $b = -0.02$, $t(119) = -0.07$, $p = .944$, conditions.

Smartphone Accessibility The overall model predicting OSpan performance using smartphone location and accessibility score failed to account for the data and was not significant, $F(5, 371) = 0.27$, $p = .930$, $R^2 < .01$. Accessibility, $p = .421$, smartphone location, $p > .634$, and moderator x smartphone location interactions, $p > .288$, were not significant predictors of OSpan absolute score (see Table 2.5C for more details). A visual inspection of the model did not show any trends (Figure 2.4C).

Smartphone Distractibility The overall model predicting OSpan performance using smartphone location and distractibility score failed to account for the data and was not significant, $F(5, 369) = 0.23$, $p = .949$, $R^2 = .003$. Distractibility, $p = .589$, smartphone location, $p > .572$, and moderator x smartphone location interactions, $p > .674$, were not significant predictors of OSpan absolute score (see Table 2.5D for more details). A visual inspection of the model did not show any trends (Figure 2.4D).

Table 2.5: Moderation analysis results

Summary of moderation analyses of OSpan performance.

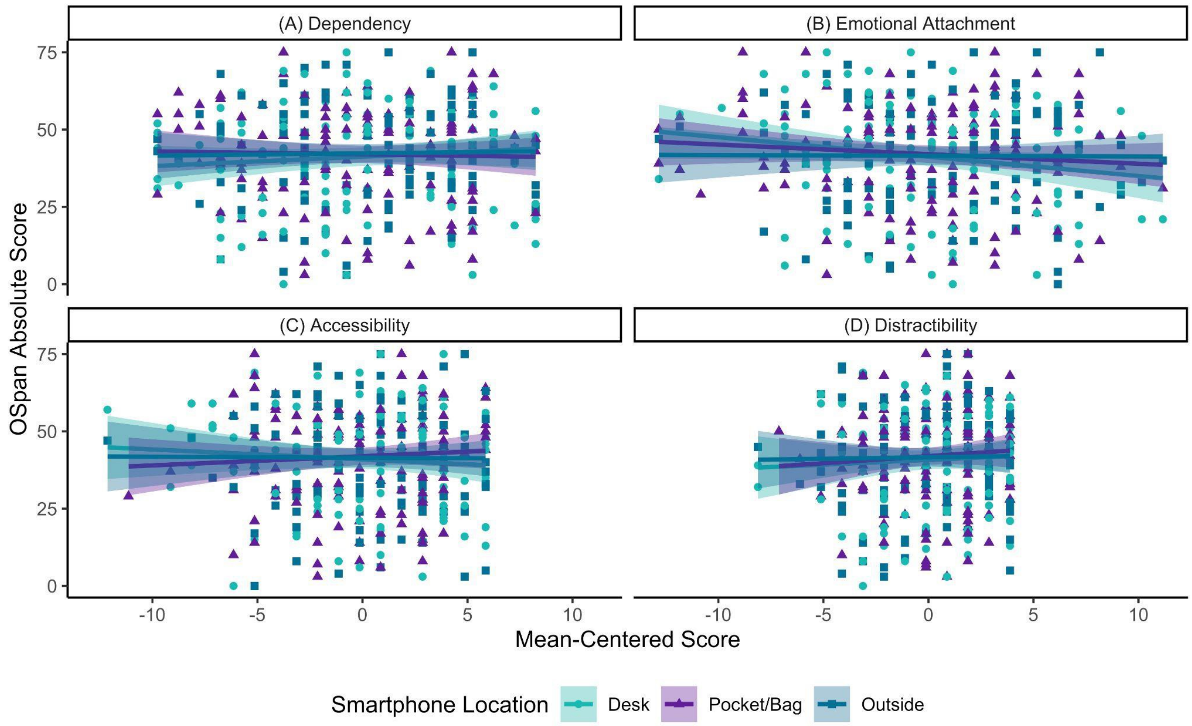
		Smartphone Location Comparisons			Interactions		
	M	(i) Desk vs. Pocket/Bag	(ii) Desk vs. Outside	(iii) Outside vs. Pocket/Bag	M x (i)	M x (ii)	M x (iii)
(A) Dependency							
b	0.31	0.75	1.06	-0.31	-0.40	-0.23	-0.17
t(370)	1.04	0.36	0.50	-0.15	-0.91	-0.51	-0.36
p	.30	.72	.62	.88	.36	.61	.72
(B) Emotional Attachment							
b	-0.63	0.80	0.27	0.53	0.32	0.61	-0.29
t(373)	-1.99	0.38	0.13	0.25	0.74	1.34	-0.66
p	.05	.70	.90	.80	.46	.18	.51
(C) Accessibility							
b	-0.32	1.00	0.52	0.48	0.62	0.29	0.33
t(371)	-0.81	0.48	0.24	0.23	1.06	0.48	0.54
p	.42	.63	.81	.82	.29	.63	.59
(D) Distractibility							
b	0.31	1.19	0.83	0.36	0.14	-0.21	0.36
t(369)	0.54	0.57	0.39	0.17	0.17	-0.26	0.42
p	.59	.57	.70	.87	.87	.79	.67

Note. Moderation analyses showed no significant predictors of Operation Span (OSpan) performance (i.e., absolute score) for each moderator (M); smartphone location comparisons, desk vs. pocket/bag (i), desk vs. outside (ii), and outside vs. pocket/bag (iii); and interactions.

The Smartphone Use Questionnaire

Smartphone use frequency was measured with respect to average daily text messages sent, social media based messages sent, and social media posts. Most participants reported sending more than 15 text messages (60.31 %), more than 15 social media based messages (64.23 %), and only zero to five social media based posts (80.94 %) per day. Average smartphone use without external stimulation (M = 6.25, SD = 1.03) was higher than use during other activities (M = 2.73, SD = 1.22). Smartphone subjective value showed that most people reported willingness to go without their phone for a day for only \$0-\$20 (36.55 %). With respect to smartphone notification type, out of all the notifications participants reported receiving (1,256 total), Snapchat (23.33 %) was the application they most receive a sound or vibration notification on their phone (followed by Email, 22.05 %; Instagram, 19.27 %; and, Facebook, 18.23 %, respectively). Finally, most participants (86.42 %) reported they had felt a phantom vibration (i.e., perceiving they received a notification on their phone, when in fact there was no notification) in the past (see Table 2.6 for more details).

Figure 2.4: *Moderation Analyses of Operation Span Performance for Each Subscale in the Smartphone Attachment and Dependency Inventory Grouped by Smartphone Location: Visual Depiction of Moderation Models.*



Note. Plots depict the average performance on the Operation Span (OSpan) Task (i.e., OSpan absolute score; y-axis) vs. the mean-centered score (x-axis) for Dependency (A), Emotional Attachment (B), Accessibility (C), and Distractibility (D) across the smartphone location conditions (i.e., on desk, light blue; pocket/bag, purple; or outside, dark blue). Shaded region depicts the 95 % confidence interval. Individual data points are shown for each condition, respectively.

2.4 Discussion

Smartphones provide an easy and effective method of communicating with the world right at our fingertips. The rising prevalence of smartphones (Pew Research Center, 2019) has prompted research including possible behavioural addictions (WHO, 2015) and how these might affect cognitive abilities. Although there are many benefits to using a smartphone in terms of communication, the present study investigated how smartphones affect performance on cognitively demanding tasks. This was done by reexamining the "brain drain" effect (i.e., those who were in closer proximity to their smartphone performed worse on a cognitively demanding task, which is moderated by smartphone reliance) found by Ward et al.'s (2017) second experiment.

The three main hypotheses (i.e., location effect, power effect, and moderation effect) from

Table 2.6: Smartphone use questionnaire descriptive statistics

Smartphone use questionnaire responses as descriptive statistics and frequency counts by smartphone power, location, and overall.

	Powered ON			Powered OFF			
Measure	On Desk	Pocket/Bag	Outside	On Desk	Pocket/Bag	Outside	Overall
Smartphone use in the absence of other stimulation							
M	6.12	6.28	6.21	6.19	6.32	6.36	6.25
SD	1.14	1.06	1.04	1.04	0.92	0.97	1.03
Min.	1.50	2	2.50	4	3.50	3.50	1.50
Max.	7	7	7	7	7	7	7
Smartphone use during other actions							
M	2.71	2.93	2.51	2.84	2.78	2.58	2.73
SD	1.24	1.38	1.06	1.18	1.24	1.16	1.22
Min.	1	1	1	1	1	1	1
Max.	6	7	6.50	6	7	7	7
Average text messages per day							
0-5	18	11	10	10	10	9	68
6-10	5	11	9	6	6	8	45
11-15	8	3	5	5	10	8	39
>15	39	42	35	37	39	39	231
Average social media based messages per day							
0-5	12	7	9	10	12	12	62
6-10	12	6	9	4	7	3	41
11-15	5	8	5	5	7	4	34
>15	41	46	36	39	39	45	246
Average social media based posts per day							
0-5	60	58	45	44	52	51	310
6-10	5	3	1	6	8	6	29
11-15	2	1	5	5	1	3	17
>15	3	5	8	3	4	4	27
Smartphone subjective value							
$0-$20	32	24	25	12	23	24	140
$21-$40	13	13	12	22	21	12	93
$41-$60	8	11	11	12	16	9	67
>$60	17	19	11	12	5	19	83
Type of notification(s) *							
Email	47	45	47	46	39	53	277
Facebook	42	41	38	36	36	36	229
Twitter	13	22	14	14	11	22	96
Instagram	44	46	39	33	37	43	242
LinkedIn	5	2	4	5	1	7	24
Snapchat	53	51	47	43	49	50	293
Other	23	16	10	11	17	18	95
Phantom vibrations							
Experienced	62	54	52	53	54	56	331
Not Experienced	8	13	7	5	11	8	52

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
* Multiple selections were allowed across notification types.
$N = 383$

Ward et al. (2017) were evaluated in the present study. There were no significant main or interaction effects of smartphone location on performance on OSpan absolute score. There was a significant main effect of cue type and an interaction effect of cue type and smartphone location on omission errors in the Cue-Dependent Go/No-Go task (Bezdjian et al., 2009). However, this effect was explored with tests of simple main effects and found no significant effect of smartphone location for either cue type. Overall, the present study did replicate Ward et al. (2017)'s null effect on the Cue-Dependent Go/No-Go task performance. More notably, however, the present study's findings failed to replicate Ward et al.'s main effect concerning performance on the OSpan task (Unsworth et al., 2005). Therefore, the "brain drain" effect was not replicated in the present study. The smartphone power effect hypothesis was supported: there was no significant difference between power conditions (i.e., powered ON vs. OFF) on performance for both tasks. This was a replication of Ward et al. (2017)'s findings. Findings from a principal components analysis on the smartphone attachment and dependency inventory (Ward et al., 2017) partially supported the two-factor findings from Ward et al. (i.e., smartphone dependence and emotional attachment), but also added a third factor: smartphone distractibility. Finally, the moderation effect did not replicate: smartphone dependency, emotional attachment, and distractibility were not significant moderators of OSpan performance. In contrast with Ward and colleagues, emotional attachment showed a trend for those in the desk condition, where higher emotional attachment predicted lower OSpan performance. It should be noted that this analysis was completed as a pre-registered analysis and was exploratory in nature. Overall, the present study demonstrated that the "brain drain" effect may not be a replicable effect of smartphone presence on cognition. Possible reasons for this are given.

A stark difference in performance was observed between the present study's OSpan performance and in Ward et al.'s (2017) second experiment. This was one of the critical results in Ward et al., because they described the OSpan as a difficult working memory task intended to be sensitive to a decrease in cognitive capacity. They argued that this difficulty difference was the reason why they found an effect on OSpan performance but not on the Cue-Dependent Go/No-Go (Bezdjian et al., 2009) performance, and indeed this was the locus of the "brain drain" effect. However, participants in our study did not find the OSpan as challenging and the presence of their own smartphone on the desk did not seem to interfere with their performance on the task. Not only was mean-difference in OSpan performance for the present study was much smaller ($M_{desk-outside}$ = 0.29, $M_{desk-pocket/bag}$ = 0.88, $M_{pocket/bag-outside}$ = 0.59) than for Ward et al. (2017; $M_{desk-outside}$ = 4.67, $M_{desk-pocket/bag}$ = 2.30, $M_{pocket/bag-outside}$ = 2.37), but also, the average performance between the present study (M_{desk} = 41.14, $M_{pocket/bag}$ = 42.02, $M_{outside}$ = 41.43) and Ward et al. (approximate values: $M_{desk} \approx 28.50$, $M_{pocket/bag} \approx 30.80$, $M_{outside} \approx 33.10$) implies that participants in the present study did not find the OSpan task as challenging as in Ward et al.'s study. This difference was also seen when compared to Ward et al.'s first experiment, where average OSpan performance was lower than a score of 34. These differences may explain why participants in our experiment did not experience a "brain drain" in their performance: the task did not diminish their available cognitive capacity. In fact, the present study showed participants with perfect performance on both the math and letter recall components and, consequently, there was a possible ceiling effect. This defeated the purpose of the OSpan as a more difficult cognitive task. Therefore, to determine the underlying mechanisms behind smartphones' impact on cognition, future work should use reliable and normed cognitive tasks. The Cambridge Brain Sciences (CBS; Hampshire et al., 2012) test battery, for example, evaluates a broad range of cognitive abilities such as selective attention, response inhibition, reasoning, and working memory. These short cognitive tests have been used across different populations (Wild et al., 2018) to test people across three main components (i.e., short-term memory, reasoning, and verbal ability) with varying difficulty levels. Therefore, using this test battery could examine how smartphone presence affects an overview of cognitive aspects and could explain why the present study did not replicate the "brain drain" effect.

2.4.1 Limitations and Implications of the Present Study

Another limitation to consider in the present study was the measure for smartphone reliance. In order to directly compare the present study to Ward et al.'s (2017) second experiment, the smartphone attachment and dependency inventory (Ward et al., 2017) was used to measure smartphone attachment and dependency (i.e., reliance). However, current research typically uses additional measures to measure things such as nomophobia (i.e., the fear of being without one's phone or the internet; Yildirim and Correia, 2015) and smartphone involvement (Walsh et al., 2010). Although the use of the smartphone attachment and dependency inventory (Ward et al., 2017) allowed the present study to directly compare findings to Ward et al.'s second experiment, measuring smartphone reliance based on only one scale limited the present study. Therefore, future research should expand on other measures of smartphone reliance.

2.4.2 Conclusion

The present study reexamined the "brain drain" effect found in Ward et al.'s (2017) second experiment. The "brain drain" effect found that those who were in closer proximity with their smartphones (i.e., those with their smartphones on their desk during the task) performed worse on a cognitively demanding task (i.e., the OSpan). In order to investigate this effect, the materials, methods, and analyses were completed based on the original study (all of which was pre-registered through OSF; Ruiz Pardo et al., 2018). Although some findings were replicated (e.g., the non-significant effect of smartphone power, the partial support for the same factors in the smartphone attachment and dependency inventory), the main "brain drain" effect was not replicated in the present study. This is an important finding because it presents an interesting new question in the field: what effect can smartphone presence, if any, have on cognition? It is possible that the mere presence of one's smartphone is not the cause of a cognitive deficit. Some possible reasons include individual differences (e.g., gender, age, personality differences) or simply the task used to investigate the effect. The continued increase in global smartphone ubiquity (Pew Research Center, 2019) makes this gap in the field relevant to every-day life. Finding and understanding these possible impacts remains critical to deciphering how smartphones may impact cognition and provide scientific evidence for means to help thwart these effects.

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Chapter 3

Smartphone's Impact on Your Cognition: Is it Your Phone or How You Use It?

With an average of 85 % of people owning a smartphone, its prevalence and the potential effect on our cognition has gained not only media attention, but also grown its own field of research. In three studies, we explored smartphone tendencies (e.g., type and frequency of use, typical smartphone location), smartphone reliance measures (e.g., nomophobia or fear of being without your phone or the internet, dependency), and the impact of smartphone presence on different aspects of cognition. Study 1 was an online study which evaluated smartphone tendencies and reliance measures, and was used to decide the smartphone locations for Study 2. Study 2 was an in-lab experiment where participants placed their smartphone in one of three locations (i.e., on their desk, in their pocket or bag, and outside of the testing room) while completing the 12 Cambridge Brain Sciences tests. Additionally, the same smartphone tendency and reliance measures were used. Study 3 was an online conceptual replication of Study 2. Participants placed their smartphone either on their desk within their line-of-sight or away from them and outside of their line-of-sight while completing the same cognitive tests and smartphone tendency and reliance measures. Although Study 2 showed an effect of smartphone location on verbal ability, where those who placed their smartphone on their desk had lower performance, Study 3 did not replicate these findings. It seems that smartphone presence may impact cognition, but this effect is localized and may not be as alarming as previously thought.

Keywords: smartphone presence, Cambridge Brain Sciences tests, smartphone reliance, smartphone dependency, nomophobia

3.1 Introduction

3.1.1 The Ubiquitous Smartphone

Smartphones are nearly ubiquitous and as a result, researchers have sought to study whether or not there are negative consequences that result from this ubiquity. According to the Pew Research Center, mobile phone ownership is still increasing with 97 % of Americans reporting cell phone ownership, 85 % of those being smartphones 2021. Notably, smartphone ownership is still higher than both tablet (52 %) and computer (i.e., desktop or laptop; 74 %) ownership. The rising prevalence of both internet and smartphone use has prompted research about how they can impact our cognitive abilities (Courtright and Caplan, 2020; Firth et al., 2019; Liebherr et al., 2020). Extended exposure to seemingly endless resources, entertainment, and communications has brought forward the issue of problematic or addictive smartphone use (e.g., Harris et al., 2020) and how it, or even typical smartphone use, might be negatively effecting the smartphone user. These revolutionary devices provide users with an abundance of utility (e.g., facilitating communication, keeping track of one's daily activities, accessing entertainment). The marvels of the modern smartphone should be acknowledged; however, the constant access to the outside world begs the question: can they impact us negatively?

3.1.2 Prior Research on the Psychological Effects of Smartphone Presence

Recent researchers have focused on that question and found that smartphone use has been linked with worse performance during day-to-day self-regulation (Caird et al., 2014; Stothart et al., 2015). Although there is value and interest for investigating how active smartphone use can impact us (Caird et al., 2014; Courtright and Caplan, 2020; Liebherr et al., 2020), researchers have also investigated how the mere presence of one's smartphone affects our social interactions (Courtright and Caplan, 2020; Linares and Sellier, 2021; Przybylski and Weinstein, 2013) and cognition (Hartanto and Yang, 2016; Hartmann et al., 2020; Ruiz Pardo and Minda, 2021; Tanil and Yong, 2020; Ward et al., 2017). Przybylski and Weinstein (2013) found that smartphone presence during social interactions caused a reduced perception of trust and empathy–more so for meaningful topics. However, Linares and Sellier (2021) completed a direct replication and failed to replicate these results. A meta analysis of both active smartphone use and smartphone presence showed that there tends to be a negative effect of mobile phone use on interpersonal interaction, but the mere presence of smartphones has shown inconsistent results (Courtright and Caplan, 2020). Another review of smartphone's effects on cognitive aspects such as attention, inhibition, and working memory found that active smartphone use has been linked with deficits in cognition (Liebherr et al., 2020). However, these findings are not always replicated and focused on how using or interacting with one's smartphone (e.g., receiving a notification).

Inconsistencies in the Literature

Both Tanil and Yong (2020) and Ward et al. (2017) found that the mere presence of one's smartphone negatively affected cognitive functioning and attention. Tanil and Yong (2020) found that participants with their smartphone on their desk performed worse on a working memory task compared to those who left their phones with the experimenter. Ward et al. (2017) found a smartphone location effect: participants completed cognitive tasks that required attention while leaving their smartphones either on the desk, in their pocket/bag, or outside the testing room. Results showed that closer proximity to one's smartphone (i.e., the "on desk" location) was associated with decreased cognitive performance. This effect was moderated by smartphone attachment and dependency, where higher dependency showed greater "brain drain" effect. In contrast, some research has found either no effect (Hartmann et al., 2020) or the opposite effect (Hartanto and Yang, 2016) of smartphone presence. Hartmann et al. (2020) investigated whether smartphone presence (i.e., on one's desk) versus absence (i.e., across the room, with the experimenter) affected short-term memory and prospective memory. They found no overall effect of smartphone presence and a moderating effect of smartphone dependence. Ruiz Pardo and Minda (2021) directly replicated Ward et al.'s 2017 second study and did not replicate the "brain drain" effect. Hartanto and Yang (2016) found that those who were separated from their smartphones (as opposed to having their smartphone with them during the study) performed worse during a task switching task. Overall, the effect of smartphone presence on cognition is mixed, with most studies focusing on measures of memory and or attention.

3.1.3 Problematic Smartphone Tendencies

A key aspect of smartphone research is the concept of problematic smartphone tendencies. This is conceptually similar to addictive tendencies (e.g., low impulse control, dependency, exercise use) but has not received a consistent definition in the literature (Harris et al., 2020; Starcevic, 2013). This is due to the standing debate of whether "behavioural addictions" (e.g., internet use, gambling, video games) should be considered equivalent to typically recognized addictions. American Society of Addiction Medicine's (2011) defines addiction as the "impairment in behavioural control, craving and diminished recognition of significant problems with one's behaviour and interpersonal relationships". However, Starcevic (2013) argued that directly applying this definition to behavioural addictions would yield an epidemic due to a low threshold. Instead, the behaviour should be associated with five characteristics: salience (i.e., being engrossed with the activity), loss of control (i.e., inability to cease the activity), tolerance (i.e., increase in required time to receive the same pleasurable effect), withdrawal (i.e., negative mood states, behaviours, and or physical symptoms without the activity), and negative consequences (i.e., interference with one's life caused by the activity). These five characteristics should be considered when measuring problematic smartphone tendencies to provide a better view of how smartphones impact their users. Previous literature has shown a wide range and therefore inconsistent description of these tendencies (e.g., using terms such as dependence, attachment, nomophobia, compulsion, overuse). In a review of problematic mobile phone scales, Harris et al. (2020) stated the importance of using these measures in conjunction with a focus on the motivation for use to better represent the individual differences in problematic smartphone tendencies. Several measures are briefly discussed.

3.1.4 Individual Differences in Smartphone Reliance

Nomophobia

Yildirim and Correia (2015) defined nomophobia as a situational phobia of being disconnected from one's mobile phone or the internet and causes anxiety-related symptoms or behaviours. The term "nomophobia" was originally coined in England and is a neologism derived from the expression "No Mobile Phobia" (King et al., 2014). Yildirim and Correia (2015) found that 53 % of mobile phone users suffer from nomophobia. Although the reasons for suffering from nomophobia may differ (e.g., social communications, emergency communications, social anxiety buffer), the fear of being away from one's phone is a highly relevant issue to consider in the field of smartphone research. Therefore, Yildirim and Correia (2015) developed the Nomophobia Questionnaire (NMPQ) to measure people's severity of nomophobia and found that more nomophobia participants experienced more anxiety when separated from their mobile phones.

Mobile Phone Use

Walsh et al. (2010) investigated the effects of mobile phone involvement and developed the Mobile Phone Involvement Questionnaire (MPIQ), which measures the level of connection to one's phone and distinguishes between measures: smartphone involvement, self-identity, and validation from others. Involvement was defined based on previous measures of behavioural addiction and measure how involved one is with one's phone. The self-identity measure looked at how much one's self construct is attached to one's phone and the validation from others measure looked at the tendency to use one's phone for validation. (Walsh et al., 2010) found that both self-identity and validation from others predicted mobile phone use, while only self-identity predicted frequency of use. This shows the importance of measuring people's individual psychological relationship with their phone rather than just mobile phone use.

Attachment and Dependency

Ward et al.'s (2017) Smartphone Attachment and Dependency Inventory measures the level to which someone feels attached and or dependent on their smartphone. This was divided into dependence and emotional attachment by Ward et al. (2017), and into dependence, emotional attachment, accessibility, and distractibility by Ruiz Pardo and Minda (2021). Ward et al. (2017) found that their dependence measure moderated the effect of smartphone location, where those with more dependency showed lower performance on an attentionally-demanding task. However, Ruiz Pardo and Minda (2021) found no moderating effect with their measures (i.e., dependence, emotional attachment, accessibility, and distractibility). Since everyone is unique in their feelings towards and interactions with their phone, research investigating the impact that smartphones have on cognition should consider these measures of problematic smartphone tendencies.

3.1.5 Overview of the Studies

Previous research dictates that smartphones can be detrimental to cognitive function; however, the exact mechanisms that occur during this interference are not yet clear. Therefore, a similar methodology to previous studies (e.g., Hartmann et al., 2020; Ruiz Pardo and Minda, 2021; Tanil and Yong, 2020; Ward et al., 2017) was used to assess which cognitive functions might be impacted by smartphones and consequently, how this interruption occurred.

We used three studies to explore the hypothesis that your own smartphone's presence affects performance on your cognition. Therefore, the three studies (1) evaluated participant's typical smartphone use (e.g., location preferences, levels of reliance on their smartphone), including which smartphone location and power conditions were relevant to people's every-day use; (2) determined which aspect of cognition is affected by smartphone presence; and (3) determined if individual differences in smartphone reliance play a role in this effect. Study 1 focused on determining which smartphone location and power conditions should be used. Study 2 and Study 3 evaluated the effect of smartphone presence on a variety of cognitive tasks. Study 2 was run with participants in-person; Study 3 was run online with nearly identical instructions to Study 2. All studies can be found on Open Science Framework (OSF; osf.io/n3vrz). This includes all materials used in the present studies. The present studies were approved through the WREM Ethics Board at Western University (see Appendix D).

3.2 Study 1: Determining People's Typical Smartphone Use

Study 1 was designed to investigate people's typical smartphone use (e.g., where people typically keep their smartphones) and therefore determine the conditions for Study 2 and 3. Typical smartphone use included questions which asked participants about where they typically place (e.g., on their desk, in their pocket/bag, outside of the room) their smartphone during different situations (e.g., during a lecture, while they study, during a social setting). Additionally, smartphone power tendencies (i.e., powered on or off) during different situations (e.g., in an exam, in a lecture) were assessed. It was predicted that a greater percentage of participants would report having their smartphone on their desk or in their pocket/bag and power on during most situations. Fewer participants were predicted to report placing their smartphone outside of their room. It was predicted that little to no participants would report keeping their smartphone powered off. The smartphone location and power questions were used to determine which conditions were used in Study 2. Individual differences in measures of smartphone reliance were collected to gauge differences in how participants interact with their smartphones (i.e., dependency, involvement, and nomophobia). It was predicted that all reliance measures would be correlated significantly and positively. Typical smartphone use (e.g., total "screen time", most used application) was also described.

3.2.1 Method

Participants

In total, 126 students at Western University were collected from an online research pool. Each participant received course credit for their participation. Four participants were removed because they did not finish the study. Participants had normal or corrected-to-normal vision. Participants were required to have English as their first language or be fluent in English as a second language (i.e., moderate or high language proficiency). Of the collected sample, 69.67 % reported English as their first language (30.33 % other; e.g., Mandarin, Arabic) and 81.15 % reported high English proficiency (18.85 % moderate, 0 % low). No participants were excluded based on language proficiency. Therefore, 122 participants (63 females and 59 males) were included in the final analyses for Study 1. Participant age ranged from 17-25 years old (M = 19.09, SD = 1.49). The majority of participants were in their first year of their program (72.13 %) and most students reported being in the Science program (36.89 %; see Table 3.1 for more details).

Table 3.1: Descriptive statistics for demographic measures in Study 1.

Demographic measures as descriptive statistics or frequency counts by smartphone location and overall for study 1.

Measure	Statistic / Frequency (122)
Age	
M	19.09
SD	1.49
Min.	17
Max.	25
Gender*	
Male	59
Female	63
First Language	
English	85
Other	37
English Proficiency*	
Moderate	23
High	99
Year of Study	
First Year	88
Second Year	14
Third Year	5
Fourth Year	10
Fifth Year	4
Graduate Student	1
Faculty*	
Arts & Humanities	4
Music	2
Engineering	1
Health Sciences	11
Information & Media Studies	2
Business	21
Science	45
Social Science	36

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Sample size is shown in parentheses.
* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Other" and "Prefer not to say" for Gender; "Low" for English Proficiency; "Education", "Law", "Schulich Dentistry", "Graduate Studies", and "Other" for Faculty.

Materials: Measures of Smartphone Use and Smartphone Reliance

General Demographic Questions The demographic items (i.e., six items in total) asked participants to report their age (in years), gender (i.e., male, female, other, or prefer not to say), first language, English proficiency (i.e., low, moderate, or high), program (e.g., psychology, engineering), and year of study (e.g., first, fourth; see Appendix F). This information was collected in order to provide a brief description of the sample.

The Smartphone Use Questionnaire This measure was created for the present study and consisted of modified items from Ruiz Pardo and Minda (2021). Some items were forced-choice and some were on a 7-point Likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). In total, there were 35 items and six types of items (see Appendix G).[1]

Smartphone Use One item measured general smartphone information (e.g., "*At what age did you first get a smartphone?*"). Eight items measured frequency of smartphone use and typical smartphone use for all smartphone users (three items; e.g., "*What is your most used app on your smartphone (excluding text message/messenger apps)?*") and for iPhone users only (five items). Items for iPhone users asked participants to report their use based on the Screen Time application available on Apple devices (e.g., "*What is your weekly total screen time in hours (e.g., 5)?*"). This application is for Apple products only and records how much time you spend on your device, including: time spent on specific applications; how many times you pick up your phone, regardless of using it; number of notifications received, etc.

Smartphone Distraction A total of five items assessed participant's self-perceived distraction with respect to their smartphone. Two items asked participants whether they found their smartphone distracting either during their daily activities (e.g., "*I find my phone can distract me from my daily activities (e.g., work, school, social interactions).*") or during their study. Three items asked participants to select the most distracting electronic device (e.g., computer, phone) in different situations such as while studying or working or in a social context (e.g., "*I find the following the most distracting when I am studying/working*").

Paradigm Decision Items Seventeen items were used to gauge participant's typical smartphone use with respect to (1) whether they typically have their smartphone turned on or off in different situations (seven items; e.g., "*When I study, I typically keep my phone on.*"), (2) their typical smartphone location (i.e., on their desk, in their pocket or bag, in another room) in various situations (five items; e.g., "When I study, I keep my phone…"), and (3) their comfort level leaving their smartphone unattended (five items; e.g., "*I would feel comfortable leaving my phone in another room while completing a task.*"). These items were specifically designed to determine the paradigm for Study 2.

Other or Exploratory Items There were four additional items. One item measured the subjective value placed on one's smartphone by asking participants a forced-choice question:

[1]The Smartphone Use Questionnaire was designed for Study 1 and 2, and was also used in a preliminary analysis for an undergraduate project (Foreman-Tran et al., 2020).

"*How much money would it take for you to give up your phone for a full day?*". This measure was explored to compare to previous research which found there was no "set" threshold on the value people place on their smartphone. One item measured participant's subjective experience of "phantom vibrations" or "phantom ringing", first coined by Laramie (2007), is a phenomenon where people feel a notification (e.g., text, call, social media) on their smartphone without an actual notification occurring (Deb, 2015; e.g.,"*Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?*"). This measure was explored to compare to previous research which found that most people do experience phantom vibrations (Deb, 2015; Laramie, 2007). Lastly, there were two exploratory items that asked what participants tend to use their smartphones for (e.g., "*Who do you mostly communicate with on your phone?*").

Measures of Smartphone Reliance Three questionnaires were used to measure participant's smartphone reliance (e.g., involvement, dependency). For each measure, participants responded to statements by stating how much they agreed or disagreed based on a 7-point Likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). A total sum-score was calculated for each measure, where higher scores corresponded with higher levels of each respective measure.

The Nomophobia Questionnaire (NMPQ) The NMPQ consisted of 20 items that measured participant's nomophobia, which is the tendency to fear being away from one's smartphone and or the internet (King et al., 2014; Yildirim and Correia, 2015). This included items such as: "*I would feel uncomfortable without constant access to information through my smartphone.*" and "*If I did not have a data signal or could not connect to Wi-Fi, then I would constantly check to see if I had a signal or could find a Wi-Fi Network.*". The total score for the NMPQ can range from 20 to 140, with higher scores depicting greater nomophobia. See Yildirim and Correia (2015) for item details.

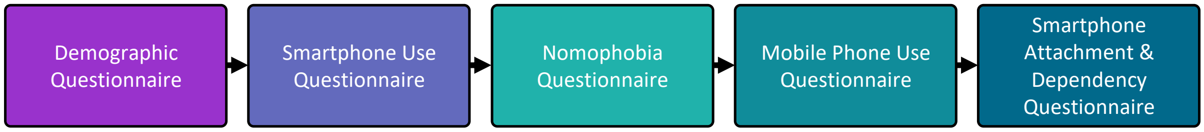
The Mobile Phone Involvement Questionnaire (MPIQ) This questionnaire measured how participants associated with their phone (Walsh et al., 2010) and was designed based on both addictive behavioural components and descriptions of phone behaviour (Walsh et al., 2008). There were three subscales: involvement, self-identity, and validation from others. The involvement subscale measured connectedness with one's phone (eight items; e.g., "*I often think about my mobile phone when I am not using it.*"). Specifically, the items in the involvement subscale measured cognitive salience, behavioural salience, interpersonal conflict, conflict with other activities, euphoria, loss of control, withdrawal, and relapse and reinstatement, respectively. Involvement score was calculated by adding up the items (ranged from 8 to 56), with higher score representing more phone involvement. The self-identity subscale measured how much one's phone was an extension of your self identity (three items; e.g., "*I feel as though a part of me is missing when I am without my mobile phone.*"). The total self-identity score ranged from 1 to 21, with higher scores representing more tendency to use one's phone for your self-identity. The final subscale, validation from others, measured how important it is to receive assurance through active phone use (three items; e.g., "*I feel valued when I receive lots of mobile calls or messages.*"). The validation from others total sum-scores ranged from 1 to 21 and higher scores represented a greater tendency to want validation from others through one's phone. See Walsh et al. (2010) for item details.

The Smartphone Attachment and Dependency Inventory-Modified The original questionnaire measured participant's tendency to feel attached to their smartphone using 13 items (Ward et al., 2017). Based on Ruiz Pardo and Minda (2021), four subscales were used (using 12 items from the original measure). These four subscales measured dependency, emotional attachment, accessibility, and distractibility, using a total sum-score for each subscale. The dependency subscale measured how dependent participants tended to be on their phone (three items; e.g., "*I would have trouble getting through a normal day without my smartphone.*"). This subscale's score ranged from 1 to 21, with higher scores showing more dependency. The emotional attachment subscale measures the level of emotional need a participant has from their smartphone (four items; e.g., "*I feel lonely when my smartphone does not ring or vibrate for several hours.*"). The total score ranged from 1 to 28 with higher scores depicting greeter emotional attachment to one's smartphone. The accessibility subscale measured participants need to have access to use their smartphone (three items; e.g., "*It drives me crazy when my smartphone runs out of battery.*"). The total score ranged from 1 to 21 and higher scores depicted great need for accessibility. The final subscale, distractibility, measured a participant's difficulty attending to external stimuli while using or in the presence of their smartphone (two items; e.g., "*I find it tough to focus whenever my smartphone is nearby.*"). This subscale's total score ranged from 1 to 21, with higher scores depicting greater smartphone distractibility. See Ruiz Pardo and Minda (2021) for item details.

Procedure

Participants were recruited via an online study pool and completed the study through an online platform on Qualtrics. Once they provided implied consent, participants were instructed to complete the study honestly. All participants completed the demographic questionnaire, followed by the smartphone use questionnaire, and then the smartphone reliance measures in

Figure 3.1: *Study 1 paradigm.*



Note. Schematic depicts the sequence of questionnaires completed by participants in Study 1. All participants completed the five questionnaires in the same order, online, and in a single 20 minute session.

the following order: the NMPQ (Yildirim and Correia, 2015), the MPIQ (Walsh et al., 2010), and the smartphone attachment and dependency inventory-modified (Ruiz Pardo and Minda, 2021). Once they finished the questionnaires, participants were shown a downloadable debriefing form. The study took approximately 20 minutes to complete. Participants received credit for their participation (see Figure 3.1).

3.2.2 Results

The present study's analyses, including and exploratory analyses can be found on OSF (osf.io/n3vrz).

The Smartphone Use Questionnaire

Typical Smartphone Use On average, participants reported getting their first smartphone at 12.94 years old (*SD* = 1.84, range = 9-18). Smartphone users (82.79 %) and iPhone users (77.32 %) reported their most used application was a social media application. This coincided with most participants who reported that their most typical type of phone use was for social media (77.87 %), followed by calling or testing (17.21 %). Participants reported that they mainly used their smartphone to communicate with their friends (90.16 %). Similar to Ruiz Pardo and Minda (2021), subjective value for one's phone (i.e., how much participants would be willing to "give up" their smartphone for a day) was the lowest presented option of $0-$20 (31.15 %). Unlike Ruiz Pardo and Minda, this was closely followed by the highest option (29.51 %). As seen in previous studies (e.g., Deb, 2015; Ruiz Pardo and Minda, 2021), most participants reported experiencing phantom vibrations (81.97 %; see Table 3.2 for more details).

The exploratory Screen Time items showed that, for iPhone users only, most reported the highest (i.e., 40+) total Screen time (in hours; 26.80 %), one of the lowest (i.e., 51-100) "pick-ups" (per day; 34.02 %), and the highest (i.e., 200+) notifications (per day; 39.18 %; see Table 3.3 for more details).

Table 3.2: Descriptive statistics and frequency counts for smartphone use questionnaire measures for all smartphone users in Study 1.

Smartphone use questionnaire responses as descriptive statistics and frequency counts for all smartphone users by smartphone location and overall for study 1.

Measure	Statistic / Frequency
Age of first smartphone	
M	12.94
SD	1.84
Min.	9
Max.	18
Most used application	
Games	4
Social Networking	101
Entertainment	17
Other	0
Subjective value	
\$0-\$20	38
\$21-\$40	26
\$41-\$60	22
>\$60	36
Phantom vibrations	
Yes	100
No	22
Main communication	
Family	11
Friends	110
Work	1
Other	0
Type of phone use	
Calling / Texting	21
Social media	95
Games	2
Email	0
Other	4

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
$N = 122$

Distraction and Comfort Levels Participants reported their phone as the most distracting device in general (87.70 %), while studying or working (85.25 %), and in a social context (95.90 %). Participants reported being somewhat distracted by their smartphone during daily activities (M = 5.50, SD = 1.56), but neutral during the study (M = 4.02, SD = 2.07). With respect to comfort levels of being without one's smartphone, participants reported being reluctant to leave their phones with others or unattended, and tended to report leaving their phone locked while out of their possession. Interestingly, they reported being neutral to almost in agreement when asked if they would feel comfortable leaving their phone in another room during a task (see Table 3.4 and Table 3.5 for more details).

Table 3.3: Descriptive statistics and frequency counts for smartphone use questionnaire measures for iPhone user in Study 1.

Smartphone use questionnaire responses as frequency counts for all iPhone users for study 1.

Measure	Frequency
Most used application	
Games	7
Social Networking	75
Entertainment	15
Other	0
Most used application was text/messenger	
Yes	39
No	58
Screen Time (hours)	
0-10	8
11-20	21
21-30	24
31-40	18
40+	26
Pickups (per day)	
0-50	11
51-100	33
101-150	30
151-200	15
200+	8
Notifications (per day)	
0-50	16
51-100	15
101-150	13
151-200	15
200+	38

Note. Only those who reported having an iPhone (n = 97) completed the measures. All measures self-reported from participant's Screen Time application on their iPhone, which tracks their device use (i.e., the type and duration of use).
N = 97

Paradigm Decision Measures: Smartphone Power and Location Unsurprisingly, participants reported a tendency to keep their smartphone powered on when they are not using it, with notifications turned on, and on vibrate. Aside from during an exam, participants tended to keep their smartphone powered on in different situations (i.e., while studying, in a lecture, while sleeping; see Table 3.6 for more details).

With respect to smartphone location, 62.30 % participants reported leaving their smartphone in their pocket/bag across situations (followed by on their desk, 35.58 %; and in another room, 2.12 %; see Table 3.7). This trend was explored further by looking at which location represented more than half of the participants for each situation (i.e., more than 61 participants) across the assigned conditions. As shown in Figure 3.2, over half of participants reported keeping their smartphone on their desk for one situation (i.e., while studying), in their pocket or bag for four situations (i.e., during an exam, a lecture, in a social setting, and typically), and in

Table 3.4: Descriptive statistics and frequency counts for distraction measures in Study 1.

Smartphone use questionnaire responses for distraction measures as frequency counts for study 1.

Measure	Statistic / Frequency
Distracted during daily activities	
M	5.50
SD	1.56
Min.	1
Max.	7
Distracted during study	
M	4.02
SD	2.07
Min.	1
Max.	7
Most distracting device: General	
Computer	10
Phone	107
iPad / Tablet	4
Smartwatch	0
Other	1
Most distracting device: Studying/Working	
Computer	14
Phone	104
iPad / Tablet	4
Smartwatch	0
Other	0
Most distracting device: Social Context	
Computer	4
Phone	117
iPad / Tablet	1
Smartwatch	0
Other	0

N = 122

Table 3.5: Descriptive statistics and frequency counts for comfort measures in Study 1.

Smartphone use questionnaire responses for the comfort level measures as descriptive statistics for study 1.

Measure	*M*	*SD*	Min.	Max.
I am comfortable with letting others use my phone.	3.80	1.70	1	7
I leave my phone unattended.	3.35	1.66	1	7
I leave my phone with other people.	3.25	1.60	1	7
I make sure my phone is locked when it is not in my hands.	5.39	1.56	1	7
I would feel comfortable leaving my phone in another room while completing a task.	4.56	1.73	1	7

N = 122

another room for no situations. Therefore, the most frequent phone placement was in one's pocket or bag, across most situations.

Table 3.6: Descriptive statistics and frequency counts for smartphone power measures in Study 1.

Smartphone use questionnaire responses for the power paradigm decision measures as descriptive statistics for study 1.

Measure	*M*	*SD*	Min.	Max.
I tend to turn my phone off when I am not using it.	2.69	1.93	1	7
I tend to have my notifications turned on.	4.75	2.05	1	7
I tend to have my phone on vibrate.	5.15	2.12	1	7
Phone is on: Study	5.30	1.65	1	7
Phone is on: Exam	2.67	2.03	1	7
Phone is on: Lecture	5.55	1.55	1	7
Phone is on: Sleep	5.34	1.86	1	7

N = 122

Table 3.7: Descriptive statistics and frequency counts for smartphone location measures in Study 1.

Smartphone use questionnaire responses for the location paradigm decision measures as frequency counts for study 1.

Situation	On Desk	Pocket / Bag	Another Room
Typical	53	69	0
Studying	85	33	4
Exam	3	111	8
Lecture	41	80	1
Social setting	35	87	0

N = 122

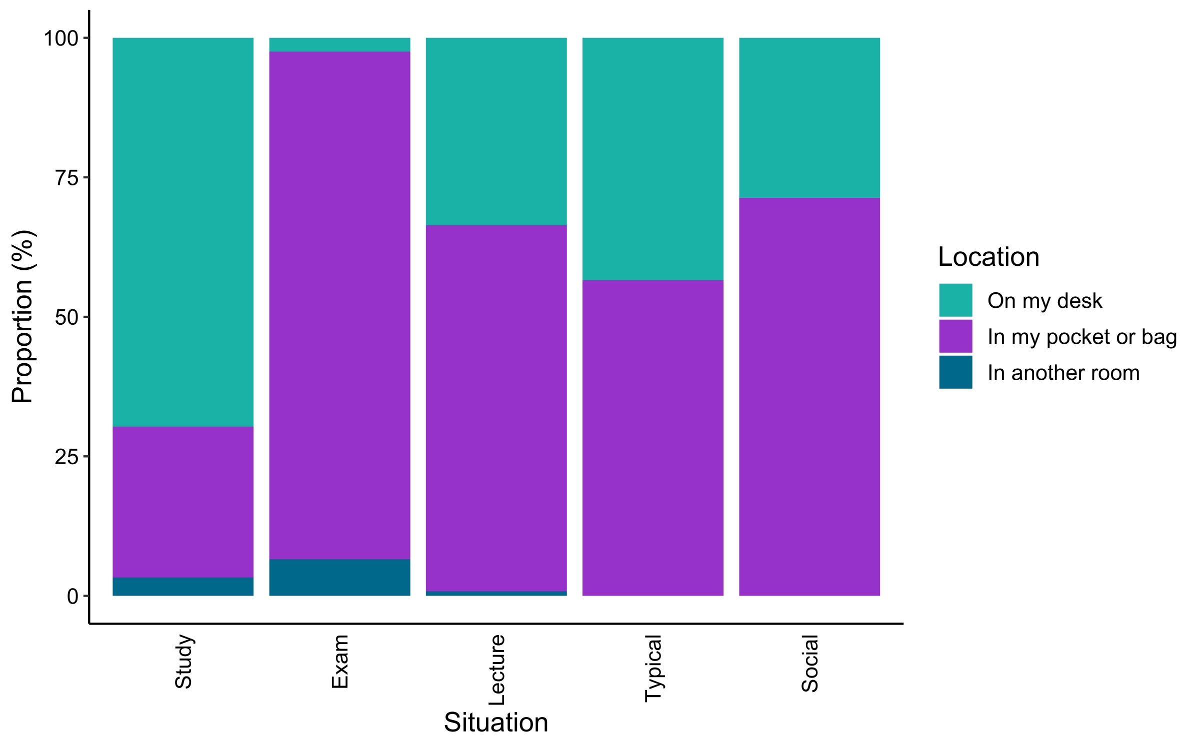
Measures of Smartphone Reliance

As shown in Figure 3.3, most reliance measures were significantly and positively correlated, $p < .001$. The only non-significant correlations were weak, positive correlations between distractibility and self-identity, $r(120) = .17$, $p = .056$, and validation from others, $r(120) = .10$, $p = .261$. The strongest correlations were between nomophobia and involvement, nomophobia and self-identity, and dependency and self-identity, $r(120) = .80$, $p < .001$ (see Table 3.8 for more details)[2].

In order to compare the level of reliance for each measure, each was split into levels: low, moderate, and high. Each measure's range in total sum score was split into levels and the frequency of participants within each level was tallied, which resulted in three levels for each measure. For example, nomophobia was split into low (i.e., score of 20-59), moderate (i.e.,

[2]Our measures in Study 1 generally displayed adequate levels of internal consistency (i.e., standardized Cronbach's $\alpha \geq .70$; $\alpha_{Nomophobia} = .94$, $\alpha_{Involvement} = .92$, $\alpha_{Self-Identity} = .94$, $\alpha_{ValidationfromOthers} = .47$, $\alpha_{Dependency} = .84$, $\alpha_{EmotionalAttachment} = .81$, $\alpha_{Accessibility} = .74$, $\alpha_{Distractibility} = .69$). It should be noted that the Validation from Others subscale of the Mobile Phone Involvement Questionnaire (Walsh et al., 2010) and the Distractibility subscale of the Smartphone Attachment and Dependency Questionnaire (Ward et al., 2017) were below the cut-off and our findings regarding these measures should be interpreted with caution.

Figure 3.2: *Smartphone location by situations for Study 1.*



Note. Responses to smartphone location measures in the Smartphone Use Questionnaire for all participants in Study 1 (N = 122). Most participants showed a tendency to keep their smartphone in their pocket or bag across all situations, excluding the study situation, where most reported keeping their smartphone on their desk.

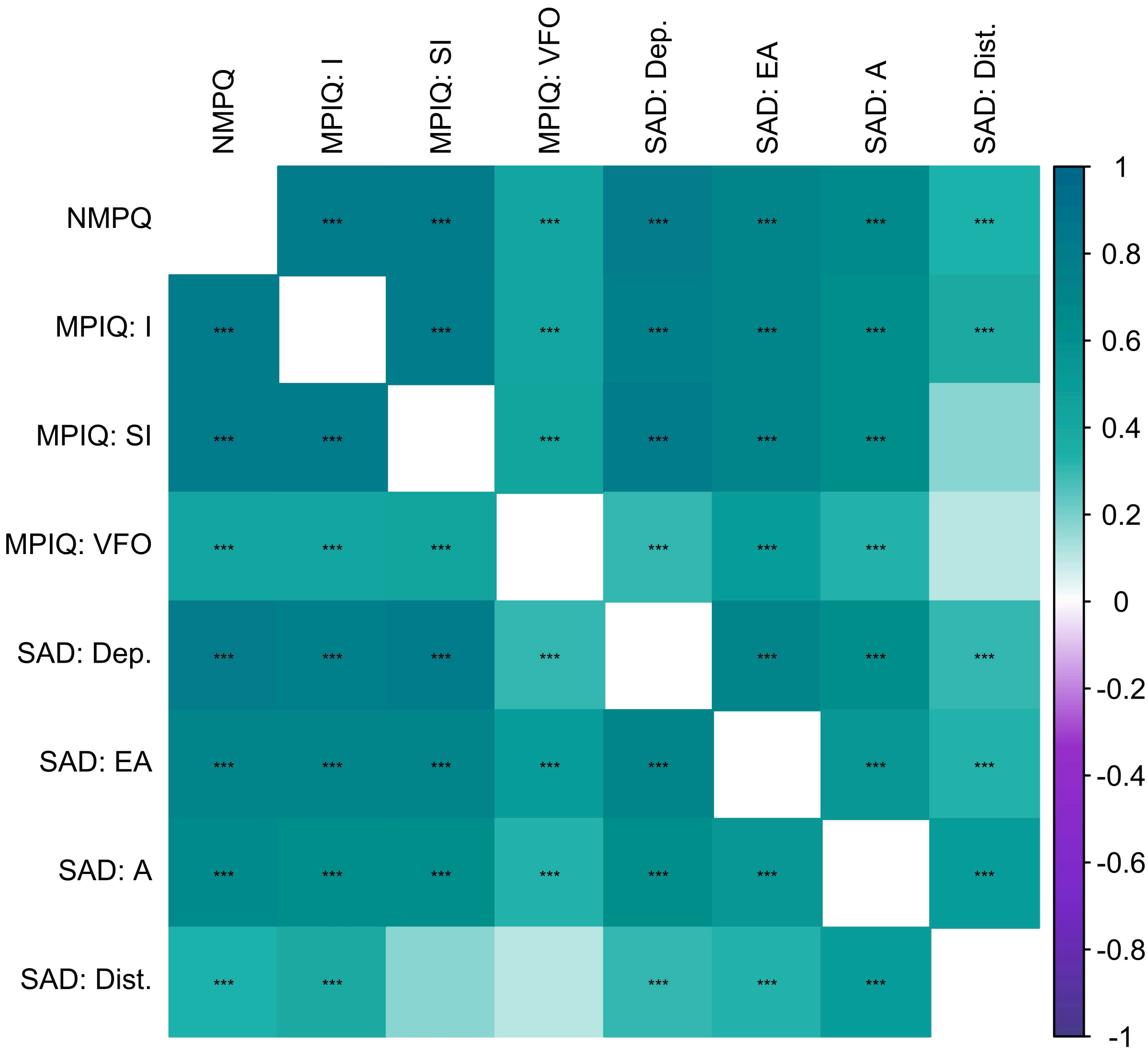
Table 3.8: Descriptive statistics and correlation results for smartphone reliance measures in Study 1.

Smartphone reliance measures as descriptive statistics and Pearson r correlations for study 1.

Measure	*M*	*SD*	1	2	3	4	5	6	7	8
1. Nomophobia Questionnaire	87.03	22.17	–							
Mobile Phone Involvement Questionnaire										
2. Involvement	34.34	9.44	.80	–						
3. Self-Identity	13.52	4.53	.80	.79	–					
4. Validation from Others	13.49	3.53	.41	.41	.44	–				
Smartphone Attachment and Dependency Inventory										
5. Dependency	12.56	4.41	.77	.75	.80	.31	–			
6. Emotional Attachment	17.52	5.10	.68	.70	.70	.50	.68	–		
7. Accessibility	14.18	3.74	.66	.63	.63	.32	.62	.55	–	
8. Distractibility	9.67	2.48	.33	.38	.17	.10	.30	.32	.48	–

Note. Self-Identity and Validation from Other were not significantly correlated with Distractibility, $p = .06$, $p = .26$, respectively. All other correlations were significant, $p < .001$.
$N = 122$

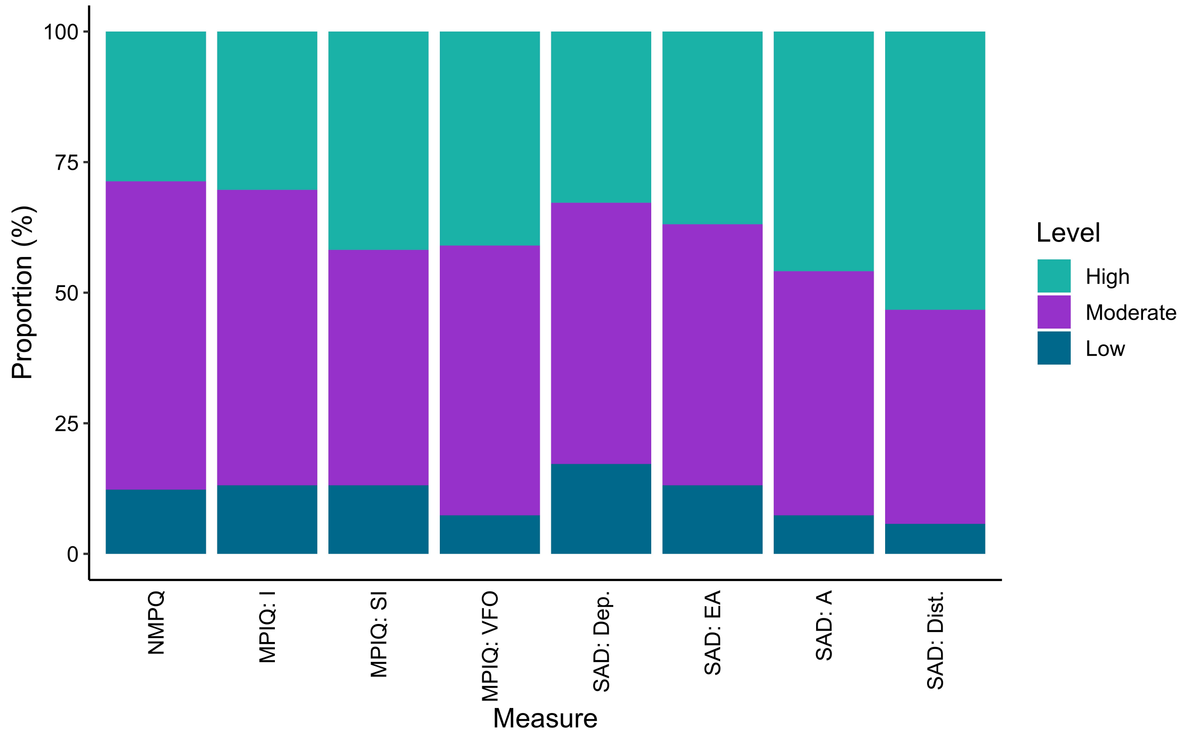
Figure 3.3: *Correlation matrix of smartphone reliance measures in Study 1.*



Note. Correlation matrix for smartphone reliance measures for the three questionnaires: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). N = 122. *p < .05. **p < .01. ***p < .001.

60-99), and high (i.e., 100-140). Overall, 50.00 % of participants were in the moderate level of a reliance measure, followed by 38.83 % in high level and 11.17 % in the low level. As shown in Figure 3.4, nomophobia, involvement, and validation from others were the only reliance measure with more than half of participants in the moderate level. Distractibility was the only reliance measure that had more than half of participants in the high level (53.29 %) compared to the moderate (40.98 %) and low (5.73 %) levels. For further details, please see Table 3.9.

Figure 3.4: *Smartphone reliance measures as proportion of participants in the low, moderate, or high level in Study 1.*



Note. Stacked bar graph for smartphone reliance measures by levels as proportions. Each level was decided by splitting up the range of possible scores for each each measure into three levels: low, moderate, and high. Each reliance measure is shown as an acronym for visualization purposes: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). N = 122.

3.2.3 Interim Discussion

Results from Study 1 depicted that most participants tend to use their smartphones for social media applications, keep their smartphone powered on, and keep their smartphone in their pocket or bag in most situations. This partially supported the typical smartphone location predictions and fully supported the smartphone power predictions. Surprisingly, most participants did not report feeling extremely distracted by their smartphone, but did identify their phone as the most distracting device across situations. Measures of smartphone reliance (e.g., nomophobia, involvement, dependency) showed a pattern of reliance where most participants were moderately or highly reliance on their smartphone. Although there was no relationship between distractibility and self-identity and validation from others, all other reliance measures were strongly and significantly related to each other. Therefore, those who had higher levels

Table 3.9: Frequency counts for smartphone reliance measures by level in Study 1.

Smartphone reliance measures as frequency counts by levels for study 1.

Measure	# Items	Likert Range	Possible Score	Levels: Low	Moderate	High
Nomophobia Questionnaire						
Nomophobia	20	1-7	20-140	15	72	35
				(20-59)	(60-99)	(100-140)
Mobile Phone Involvement Questionnaire						
Involvement	8	1-7	8-56	16	69	37
				(8-23)	(24-39)	(40-56)
Self-Identity	3	1-7	3-21	16	55	51
				(3-8)	(9-14)	(15-21)
Validation from Others	3	1-7	3-21	9	63	50
				(3-8)	(9-14)	(15-21)
Smartphone Attachment and Dependency Inventory						
Dependency	3	1-7	3-21	21	61	40
				(3-8)	(9-14)	(15-21)
Emotional Attachment	3	1-7	3-21	16	61	45
				(3-8)	(9-14)	(15-21)
Accessibility	4	1-7	4-28	9	57	56
				(4-11)	(12-19)	(20-28)
Distractibility	2	1-7	2-14	7	50	65
				(2-5)	(6-9)	(10-14)

Note. Score value ranges for each respective level shown in parentheses.
$N = 122$

of one reliance measure tended to have higher levels in the other measures. These findings partially supported the predictions for the correlation analysis.

The goal of Study 1 was to decide which smartphone power and location conditions (based on Ward et al., 2017 and Ruiz Pardo and Minda, 2021) to use in an experimental study. The results support the notion that a “powered off” condition would not be necessary (i.e., since most participants reported leaving their smartphone powered on). There was some variability in where people placed their smartphone, but most reported keeping their smartphone in their pocket or bag, which indicates that this would be the most realistic condition to use. Participants also commonly reported keeping their smartphone on their desk, specifically in situations where they would be studying (i.e., when they would benefit from being attentive towards their task). For this reason, this location condition should be used. The final location condition, in another room, was not reported as frequently. This condition would be the most extreme difference from typical use and would provide a contrast to smartphone presence since it would be far from participants and out of their line of sight. Since participants also reported that they would not be distracted by leaving their smartphone in another room during a task, it seems that this final location condition would be useful to depict a wide spectrum of distance between a participant and their phone. Therefore, Study 1 determined that the three smartphone locations (i.e., on desk, in pocket or bag, and outside of the testing room) and only one smartphone power (i.e., powered on) should be used in Study 2.

3.3 Study 2: The Effect of Smartphone Presence on Cognition

Study 2 investigated how smartphone presence affected a variety of cognitive measures, specifically, how one's smartphone location affects performance on the CBS test battery. Previous literature has looked at mainly memory and attention measures of cognition when investigating the effect of both active smartphone use and smartphone presence. However, a wider range of cognitive measures has yet to be investigated in one study. The CBS test battery used short, computer-based tasks that assessed a broad range of aspects of cognition, including attention, working memory, and reasoning (Hampshire et al., 2012). Study 2 used the CBS test battery to explore which cognitive aspects, if any, are affected by the presence of one's own smartphone in three locations: on your desk (desk), in your pocket or bag (pocket/bag), and outside of the testing room (outside).

Our predictions for Study 2 were based on the previous literature, which mainly focused on measuring smartphone presence (Hartmann et al., 2020; Ruiz Pardo and Minda, 2021; Tanil and Yong, 2020; Ward et al., 2017) or smartphone use (Caird et al., 2014; Courtright and Caplan, 2020) on cognitive aspects such as: attention, memory, and response inhibition. Therefore, we predicted that closer proximity to one's smartphone (i.e., the "on desk" condition) would decrease performance on memory (e.g., digit span, monkey ladder) and attention-based (e.g., double trouble, feature match) tasks (see Table 3.10 for more details). Since it is not typically the focus in smartphone research, our predictions for the reasoning tasks were mainly exploratory (e.g., rotations, spatial planning). These predictions were addressed with a primary analysis of the four cognitive areas measured by the CBS tests, as described by the Cambridge Brain Sciences (2018c) test selection guide: memory, reasoning, verbal ability, and concentration or attention. The CBS task selection guide was used because they are described as a set of core cognitive concepts, which were used in numerous clinical and research applications. Based on the results from the primary analysis, a secondary analysis explored whether there was a driving test(s) for any given cognitive area. This gave us not only insights into the aspect(s) of cognition, but also any individual test(s) that is/are affected by smartphone location.

Typical smartphone use, location, and power tendencies were also assessed. It was predicted that, as seen in Study 1, participants would mostly report placing their smartphone in their pocket or bag during most situations (e.g., exam, lecture, social context) and keeping their smartphone powered on during most situations (e.g., study, lecture). The individual difference measures in smartphone reliance (e.g., nomophobia, involvement, and attachment and dependency) were also predicted to have significant positive relationships (except for distractibility and involvement or validation from others). It was predicted that each composite score would significantly correlate with each other, and with their respective tests. Additionally, it was predicted that the individual CBS tests would significantly correlate to their "family" tests (i.e., the other tests grouped into the same cognitive area).

Table 3.10: Predictions for Cambridge Brain Sciences tests in Study 2.

Cambridge Brain Sciences test battery cognitive areas, test name, outcome measure, and predictions for study 2.

Cognitive Area	Test Name	Outcome Measure	Prediction
Memory	Monkey Ladder	Visuospatial Working Memory	Desk < Pocket/Bag < Outside
	Spatial Span	Spatial Short-Term Memory	Desk < Pocket/Bag < Outside
	Token Search	Working Memory	Desk < Pocket/Bag < Outside
	Paired Associates	Episodic Memory	Desk < Pocket/Bag < Outside
Reasoning	Rotations	Mental Rotation	Desk = Pocket/Bag = Outside
	Polygons	Visuospatial Processing	Desk = Pocket/Bag = Outside
	Odd On Out	Deductive Reasoning	Desk = Pocket/Bag = Outside
	Spatial Planning	Planning	Desk = Pocket/Bag = Outside
Verbal Ability	Grammatical Reasoning	Verbal Reasoning	Desk = Pocket/Bag = Outside
	Digit Span	Verbal Short-Term Memory	Desk < Pocket/Bag < Outside
Concentration/Attention	Feature Match	Attention	Desk < Pocket/Bag < Outside
	Double Trouble	Response Inhibition	Desk < Pocket/Bag < Outside

Note. Cognitive area is defined by the Cambridge Brain Science task selection guide (Cambridge Brain Sciences, 2018c). Participants placed their smartphone in one of three locations: on their desk (desk), in their pocket or bag (pocket/bag), or outside of the testing room (outside). Primary analysis investigated the effect of smartphone location on each of the four cognitive areas. Based on the results from the primary analysis, a secondary analysis explored whether there was a driving test(s) for any given cognitive area.

3.3.1 Method

Participants

A total of 296 students were recruited from Western University's research pool. Of the total sample size, a total of 20 participants were flagged for either data collection related errors (e.g., testing errors, technical issues) and 23 were flagged for having at least one invalid CBS test score as defined by (Cambridge Brain Sciences, 2019; see Appendix E for more details).

During the data cleaning phase 23 outlying CBS scores were removed, where any test that was greater than three standard deviations from the mean was removed. This was completed for each CBS test. The primary analysis required that all participants completed the 12 CBS tests, so 3 participants were removed for having less than 12 tests completed. Any participants who either had an invalid CBS score, an outlying CBS score, or did not have 12 CBS tests scores was removed. Overall, 59 participants were removed from the analysis, where a participant may have been removed due to multiple criteria.

Therefore, a total of 237 students (164 females and 73 males) were used in the analyses. All participants consented as university students (i.e., 17 years old or older) and were required to have normal or corrected-to-normal vision (i.e., glasses and contacts were acceptable). The ages ranged from 17-27 years old (M = 18.57, SD = 1.22). Participants were also required to have English as their first language or be fluent in English as a second language. The final sample had 76.37 % who reported English as their first language (23.63 % other; e.g., Mandarin, Arabic, Korean) and 89.87 % reported high English proficiency (10.13 % moderate; 0 % low). No participants were excluded based on language proficiency. Most participants reported being in their first year of their program (84.39 %) and 34.18 % were in the Science faculty. The majority of participants had no knowledge (88.61 %) or had never completed any CBS tests (79.32 %) to the study. For more details, see Table 3.11.

Materials

Battery of Cognitive Tests: The Cambridge Brain Sciences (CBS) Tests The 12 CBS tests were brief computerized cognitive tests designed to measure participants' cognitive performance (Hampshire et al., 2012). The four aspects of cognition measured by the CBS tests, as described by the CBS test selection guide (Cambridge Brain Sciences, 2018c), were: memory, reasoning, verbal ability, and concentration or attention. The following outlines the 12 tests. For each test, a description is given including the main outcome variable and the scoring for the outcome variable with respect to the test. The outcome measure definitions and descriptions were adapted from the CBS Task Selection Guide[3] (Cambridge Brain Sciences, 2018c), the CBS Task Overview for patients[4] (Cambridge Brain Sciences, 2018b), and the CBS Scientific Overview[5] (Cambridge Brain Sciences, 2018a). See Figure 3.5 for an example of a single trial for each CBS test.

[3]Original CBS Task Selection Guide found at: https://www.cambridgebrainsciences.com/assets/resources/task-selection-guide.pdf

[4]Original CBS Task Overview found at: https://www.cambridgebrainsciences.com/assets/partners/cbs-health-overview-for-patients-1543011008.pdf

[5]Original CBS Scientific Overview found at: https://www.cambridgebrainsciences.com/assets/resources/CBS-Health—Scientific-Overview.pdf

Table 3.11: Descriptive statistics for demographic measures in Study 2.

Demographic measures as descriptive statistics or frequency counts by smartphone location and overall for study 2.

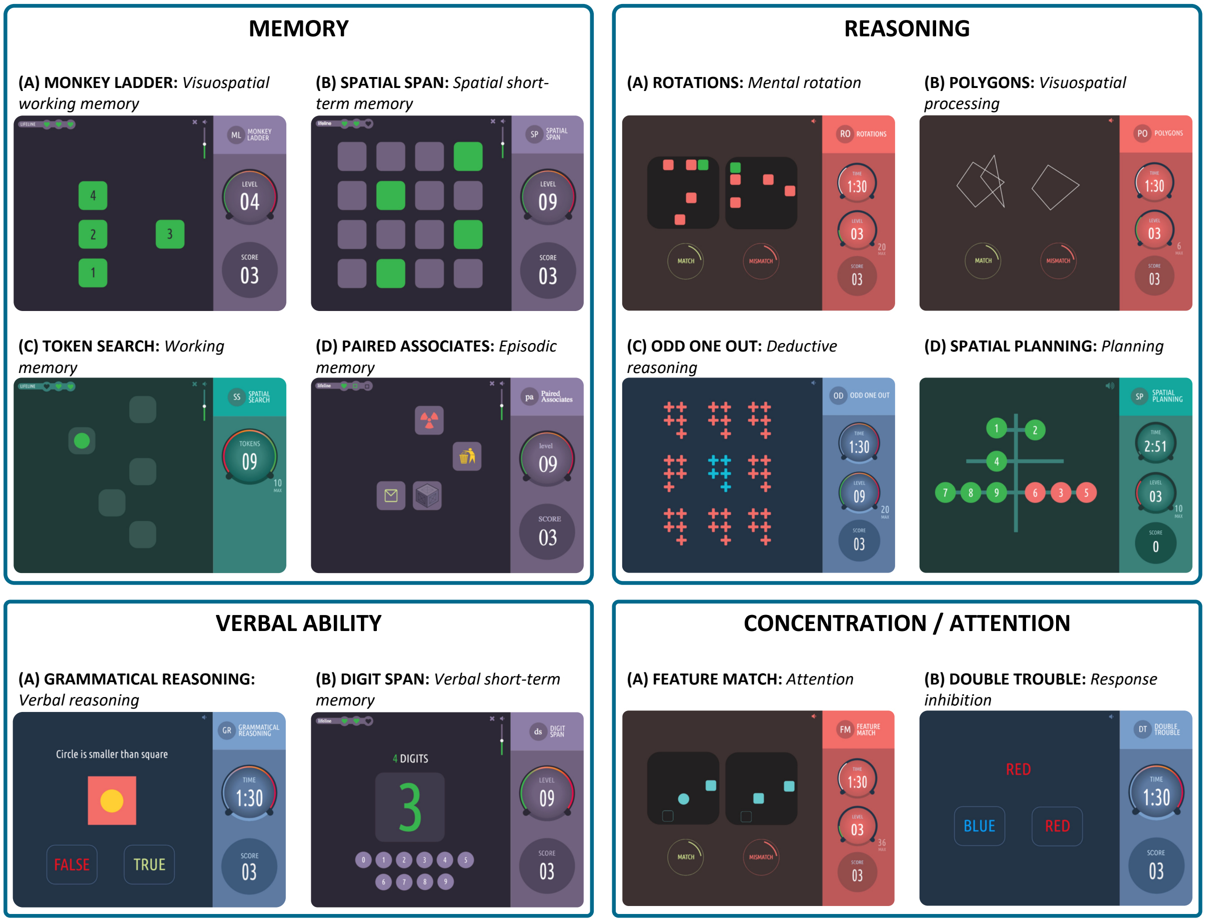
Measure	On Desk (75)	Pocket/Bag (85)	Outside (77)	Overall (237)
Age				
M	18.59	18.49	18.65	18.57
SD	0.96	1.51	1.10	1.22
Min.	17	17	17	17
Max.	22	27	23	27
Gender*				
Male	26	31	16	73
Female	49	54	61	164
First Language				
English	60	61	60	181
Other	15	24	17	56
English Proficiency*				
Moderate	8	5	11	24
High	67	80	66	213
Year of Study*				
First Year	62	74	64	200
Second Year	6	7	9	22
Third Year	4	0	2	6
Fourth Year	3	3	2	8
Fifth Year	0	1	0	1
Faculty*				
Arts & Humanities	1	2	2	5
Music	0	1	0	1
Health Sciences	18	10	8	36
Information & Media Studies	1	4	3	8
Business	14	11	10	35
Science	26	30	25	81
Social Science	14	27	29	70
Other	1	0	0	1

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Sample size is shown for each group in parentheses.
* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Other" and "Prefer not to say" for Gender; "Low" for English Proficiency; "Graduate Student" for Year of Study; "Education", "Engineering", "Law", "Schulich Dentistry", "Graduate Studies", and "Other" for Faculty.
$N = 237$

Memory Memory was composed of four tests: Monkey Ladder, Spatial Span, Token Search, and Paired Associates.

The Monkey Ladder Test measured visuospatial working memory (i.e., "the ability to temporarily hold information in memory and manipulate or update it based on changing circumstances or demands."; (Cambridge Brain Sciences, 2018b). Each trial begins with randomly ordered numbered squares are shown on a screen. Numbers disappear, leaving only the squares after a variable interval of time. Participant responds by selecting the squares (with mouse) in ascending order of the numerical sequence shown with the numbers prior to disappearing. After response is given, the trial ends and a new one begins. Level of difficulty is increases (if previous trial was completed correctly) or decreased (if previous trial was com-

Figure 3.5: *Cambridge Brain Sciences tests example trials.*



Note. Example of single trial for each of the 12 Cambridge Brain Sciences (CBS) tests grouped by cognitive aspects defined by the CBS test selection guide (Cambridge Brain Sciences, 2018c). For each test, the main outcome variable is presented in italics following the name of the test[a].

[a]Adapted with permission from Cambridge Brain Sciences.

pleted incorrectly) by one digit (and corresponding square). The task continues until three errors are made. Outcome measure was the maximum level completed: the number of squares in the trial with the highest number-square pairings successfully completed. The task is a variant from non-human primate literature (Inoue and Matsuzawa, 2007). See (A) in the memory panel in Figure 3.5 for an example trial.

The Spatial Span Test measured spatial short-term memory, which is "the ability to temporarily store spatial information in memory" (Cambridge Brain Sciences, 2018b). Each trial begins with 16 squares shown on the screen in a 4x4 grid. Some of the squares are flashed in a different colour (rate or 1 flash per 900ms). After flashing is done, participants must repeat the sequence by selecting the square (with mouse) in the same order of the flashed sequence.

After participant has selected the sequence, the trial ends. Difficulty for subsequent trials is increased by one square after a correct response and decreased by one square after an incorrect response. The task continues until three errors are made. The outcome measure was the maximum level completed: the number of squares in the trial with the highest square sequence successfully completed. The task is a variant from the Corsi Block Tapping Task, which measures short-term memory capacity (Corsi, 1972). See (B) in the memory panel in Figure 3.5 for an example trial.

The Token Search Test measured working memory, which is "the ability to temporarily hold information in memory and manipulate or update it based on changing circumstances or demands" (Cambridge Brain Sciences, 2018b). Each trial starts with randomly located squares shown on the screen. Participants must "search" for a hidden "token" by selecting the squares one-by-one. Once a token is found, it is hidden within another square. The participant continues to search for a token until all squares had the token hidden once. Participants must not check any square twice before finding the next token and must not check a square that previously had the token. If either error is made, the trial ends automatically. The task continues until three errors are made. The difficulty of the task is increased or decreases by one square if the participant answered the previous trial correctly or incorrectly, respectively. The outcome measure is the maximum level completed: the highest number of tokens successfully collected in one trial. The task was adapted from Collins et al.'s (1998) task which measures strategy search behaviours. See (C) in the memory panel in Figure 3.5 for an example trial.

The Paired Associates Test measured episodic memory, which is "the ability to remember and recall specific events, paired with the context in which they occurred, such as identifying when and where an object was encountered" (Cambridge Brain Sciences, 2018b). Each trial begins with randomly displayed squares shown on a screen. Each square contains an object (e.g., envelope, box, hazard symbol, plane) which are all briefly shown and then disappear with the squares remaining in their original locations on the screen. Participants are then shown one of the now hidden objects one at a time in the center of the screen. The participant must select the square hiding the shown object using their mouse until all objects have been found. The difficulty of the task is increased or decreases by one square-object pairing if the participant answered the previous trial correctly or incorrectly, respectively. The task continues until the participant makes three errors when finding the hidden object. The outcome measure is the maximum level completed: the highest number of objects successfully found in one trial. The task was adapted from a commonly used assessment for memory impairments in aging (Gould et al., 2006). See (C) in the memory panel in Figure 3.5 for an example trial.

Reasoning Reasoning was composed of four tests: Rotations, Polygons, Odd One Out, and Spatial Planning.

The Rotations Test measured the ability to do mental rotations, which is "the ability to efficiently manipulate mental representations of objects in order to make valid conclusions about what objects are and where they belong" (Cambridge Brain Sciences, 2018b). Two sections, displayed beside each other, show different coloured squares on a grid. One section depicts the grid in the other section rotated by a multiple of 90 degrees. The rotated section will either depict the exact same configuration (but rotated) as the first section or identical with one square differing in position. For each trial, the participant will be shown the two sections on their screen at once and then must select whether the section is a "match" or "mismatch" with their mouse. Once a selection is made, they are given feedback on whether they were correct or not and the trial ends. The difficulty level increased by one after each correct trial and decreased by one after each incorrect trial. The trials continue until 90 seconds have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of the difficulty level of all incorrect trials from the sum of the difficulty level of all correct trials. The task was based on a measure for the ability to manipulate objects in one's mind (Silverman et al., 2000). See (A) in the reasoning panel in Figure 3.5 for an example trial.

The Polygons Test measured visuospatial processing, which is "the ability to effectively process and interpret visual information, such as complex visual stimuli and relationships between objects" (Cambridge Brain Sciences, 2018b). Two overlapping polygons are presented on one side of the screen, and another single polygon is presented on the other side of the screen. For each trial, a participant must indicate whether the single polygon is identical (i.e., "match" or "mismatch") to one of the two overlapping polygons on the other side of the screen (i.e., with a mouse click). The trial ends with feedback on whether the correct answer was given. The difficulty of each trial is increased (i.e., more subtle differences) or decreased (i.e., more pronounces differences) respective to the previous correct or incorrect trial response. The trials continue until 90 seconds have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of the difficulty level of all incorrect trials from the sum of the difficulty level of all correct trials. The task was modelled after Folstein et al.'s (1975) Interlocking Pentagons Task. See (B) in the reasoning panel in Figure 3.5 for an example trial.

The Odd One Out Test measured deductive reasoning, which is "the ability to apply rules to information in order to arrive at a logical conclusion" (Cambridge Brain Sciences, 2018b). A 3x3 grid of patterns is presented on the screen. Each pattern has three dimensions (i.e., colour, shape, and number of objects) that are related to each other by some rules. For each trial, all 3x3 patterns are shown on the screen and the participant must deduce the rule in order to select (i.e., with a mouse click) the pattern that does not "belong" to the set of rules. The difficulty of each trial is increased (i.e., harder rules) or decreased (i.e., easier rules) respective to the previous correct or incorrect trial response. The trials continue until 3 minutes have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of incorrect trials from the sum of correct trials. The task was based on a part of Cattell's (1949) Culture Fair Intelligence Test. See (C) in the reasoning panel in Figure 3.5 for an example trial.

The Spatial Planning Test measured planning, which is "the ability to act with forethought and sequence behaviour in an orderly fashion to reach specific goals, which is a fundamental property of intelligent behavior" (Cambridge Brain Sciences, 2018b). For each trial, numbered circles are placed on a tree-shaped line figure. Participants must move the circles so that they are placed consecutively in ascending numerical order. They are told to make a few "moves" as possible to solve the problem. Once they solve a problem, the trial ends. The difficulty for each new trial is either increased by one numbered circle. The trials continue until 3 minutes have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of the total moves made in the solved trials from twice the sum of the minimum number of moves required from the solved trials. The task was directly based on the "Tower of London" task, which measures planning ability (Shallice, 1982). See (D) in the reasoning panel in Figure 3.5 for an example trial.

Verbal Ability Verbal ability consisted of two tests: Grammatical Reasoning and Digit Span.

The Grammatical Reasoning Test measured verbal reasoning, which is "the ability to quickly understand and make valid conclusions about concepts expressed in words" (Cambridge Brain Sciences, 2018b). For each trial, a participant is shown two shapes below a brief description of the relationship between two shaped (e.g., "Circle is smaller than square."). The participant must select whether the description is "True" or "False" based on the image of the two shapes shown. Once they make their choice, the trial ends. The trials continue until 90 seconds have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of incorrect trials from the sum of correct trials. The task was modeled after Baddeley's (1968) grammatical reasoning test. See (A) in the verbal ability panel in Figure 3.5 for an example trial.

The Digit Span Test measured verbal short-term memory, which is "the ability to temporarily store information in memory" (Cambridge Brain Sciences, 2018b). For each trial, the participant is shown a series of numbers (i.e., digit from 0-9) within a large square, varying in the total number of digits in the sequence. After the sequence is shown, participants must repeat the sequence (i.e., in the same order) by using their mouse to click on circles containing digits one-by-one. Throughout the trial, the number of digits for that trial's sequence is shown above the large square (i.e., "4 digits"). Once the participant either repeats the sequence correctly or makes a mistake while repeating the sequence, the trial ends. The difficulty of the next trial is either increased or decreased by one digit in the sequence after a correct or incorrect previous trial, respectively. The task continues until three errors are made. The outcome measure was the maximum level completed: the number of digits in the sequence for the trial with the highest digit sequence successfully completed. The task was modeled after the working memory part of the WAIS-R intelligent test (Wechsler, 1997). See (B) in the verbal ability panel in Figure 3.5 for an example trial.

Concentration or Attention Concentration used two tests: Feature Match and Double Trouble. **The Feature Match Test** measured attention, which is "the ability to draw upon mental concentration and focus in order to monitor for a specific stimulus or difference" (Cambridge Brain Sciences, 2018b). Two sections, displayed beside each other, show different abstract shapes (e.g., square, circle). Half of the trials will show identical shapes between sections and the other half will show one section differing by one shape. For each trial, the participant must select whether the two sections are a "match" or "mismatch" using their mouse. Once selected, the participant is given feedback telling them if they were correct or incorrect and the trial ends. The difficulty of the next trial is either increased or decreased by one shape in the sequence after a correct or incorrect previous trial, respectively. The trials continue until 90 seconds have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of the difficulty level of all incorrect trials from the sum of the difficulty level of all correct trials. The task was based on Treisman and Gelade's (1980) feature search measures of attentional processing. See (A) in the concentration / attention panel in Figure 3.5 for an example trial.

The Double Trouble Test measured response inhibition, which is "the ability to concentrate on relevant information in order to make a correct response despite interference or distracting information" (Cambridge Brain Sciences, 2018b). One coloured word is presented centered above two additional coloured words. The words say either "red" or "blue" and are coloured in either of those colours. This provides a colour-word mapping that can be congruent, incongruent, or doubly incongruent. Congruent mappings were when all words had matching colours to the colour they spelled out (e.g., the word "red" written in the colour red). Incongruent mappings were when only the top word was written in a different colour (e.g., the word "red" written in the colour blue). Doubly incongruent mappings were when all words had mismatching colours with their spelled out word. Each trial began by showing the participant all three words. Participants then selected (i.e., with a mouse click) which of the bottom words described the "ink" colour of the top word, regardless of the ink colour of the bottom words. The trial ends after the selection is made. The trials continue until 90 seconds have passed: participants must solve as many as possible during this time. The outcome measure is the overall score, which was calculated by subtracting the sum of the incorrect trials from the sum of the correct trials. The task was a modified Stroop Test (Stroop, 1935). See (B) in the concentration / attention panel in Figure 3.5 for an example trial.

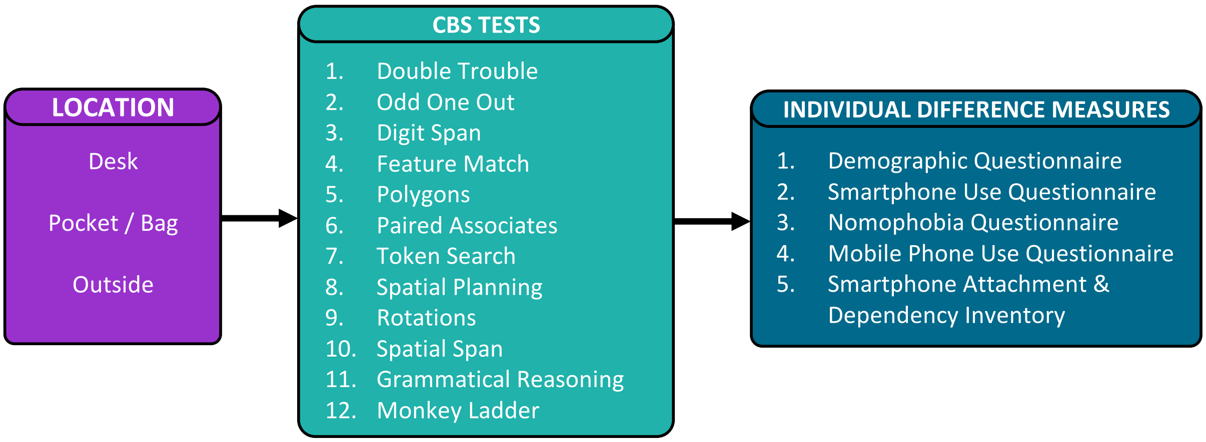
Measures of Smartphone Use and Smartphone Reliance The same Smartphone Use Questionnaire from Study 1 was used with two additional questions in the Demographic Questionnaire that asked participants if they had ever heard of or completed any of the CBS tests prior to the study (see Appendix F). The exact same smartphone reliance measures from Study 1 were used: the NMPQ (Yildirim and Correia, 2015), the MPIQ (Walsh et al., 2010), and the smartphone attachment and dependency inventory-modified (Ruiz Pardo and Minda, 2021).

Procedure

Participants were recruited via an online study pool and completed the study in person at the Western Interdisciplinary Research Building at Western University. Once consent was collected, each participant was asked to place their smartphone in one of three randomly assigned conditions: (1) on their desk (on desk); (2) in their pocket or bag (pocket/bag); or (3) in the experimenter's room (outside). For all three conditions, participants were instructed to leave their phones powered on and on silent (i.e., no vibrations or sounds for any notifications). These conditions are similar to previous studies (e.g., Ruiz Pardo and Minda, 2021; Ward et al., 2017) with the exception that participants placed their smartphone face-down. This was done to prevent a potential confound, where a participant saw an incoming notification. Since only those in the on desk condition would be impacted by a potential visual distraction, all participants were asked to place their phone face-down in their respective location.

Once participants placed their smartphone in their assigned locations, all participants completed the CBS test battery in the same randomized order: Double Trouble, Odd One Out, Digit Span, Feature Match, Polygons, Paired Associates, Token Search, Spatial Planning, Rotations, Spatial Span, Grammatical Reasoning, and Monkey Ladder. For each test, participants were shown a brief tutorial which included instructions on the test, any time-related component, how scoring worked, and three practice trials with feedback. Participants were allowed to repeat the tutorials as needed and were told to ask for further explanation if needed. All 12 tests were completed without a break between tests and took 30 minutes. Then, participants completed the same questionnaires from Study 1 with the addition of two CBS exposure questions. Participants were then debriefed and received course credit. The questionnaires were completed on Qualtrics and the cognitive tests were completed through a custom CBS link created for Study 2. The entire study took 60 minutes to complete (see Figure 3.6 for a schematic of Study 2).

Figure 3.6: *Study 2 paradigm.*



Note. Schematic depicts the paradigm for Study 2. Each participant was first randomly assigned to one of three location conditions: desk, pocket/bag, or outside. Then, participants completed the 12 Cambridge Brain Sciences (CBS) tests in the same randomized order. Finally, participants completed the five individual difference measures in the same order. All participants completed Study 2 in-person over a single 60-minute session.

3.3.2 Results

The present study's analyses, including and exploratory analyses can be found on OSF (osf.io/n3vrz).

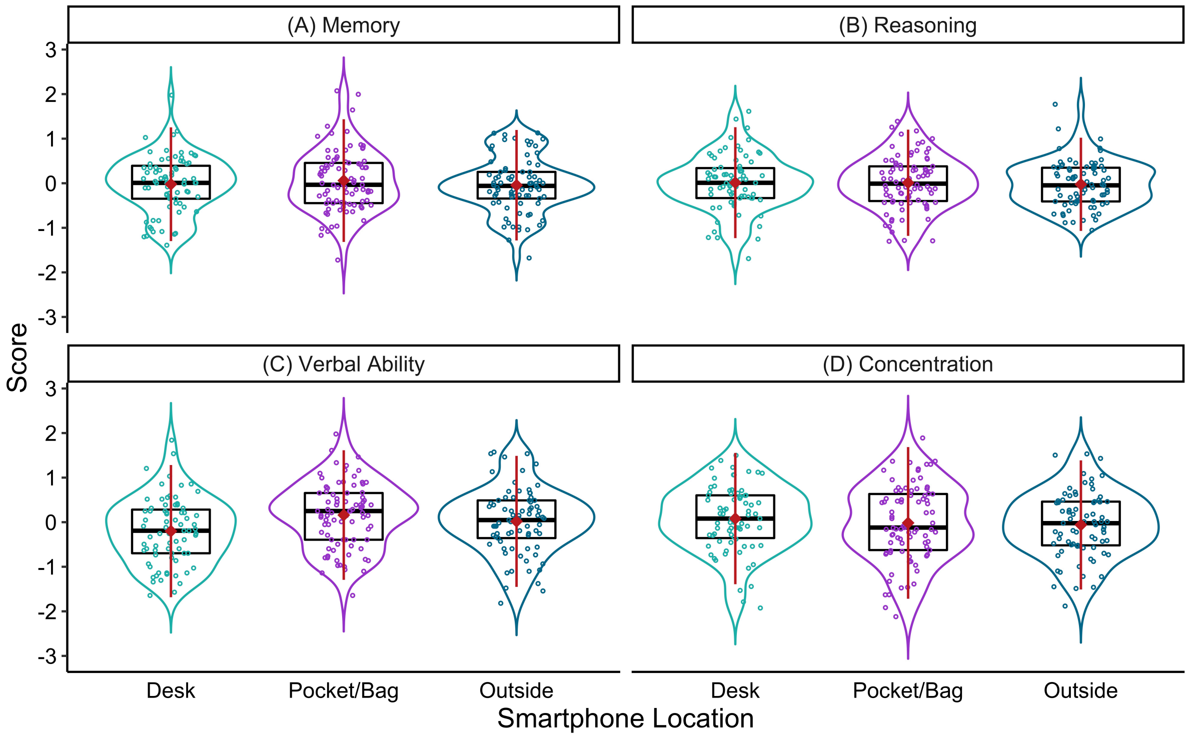
Battery of Cognitive Tests

Cambridge Brain Sciences Composite Scores Since the present study was exploratory in nature, the analyses were designed to provide a comprehensive analysis of how smartphone location effected performance on the CBS test. Therefore, four composite scores based on the aspects of cognition measured by the CBS tests, as described by the CBS test selection guide (Cambridge Brain Sciences, 2018c), were used. Each composite score was calculated by averaging the standardized score for the included CBS tests for each participant. Therefore, the memory composite score included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. The reasoning composite score included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. The verbal ability composite score included performance on Grammatical Reasoning and Digit Span. The concentration or attention composite score included performance on Feature Match and Double Trouble.

Assessing the Effect of Smartphone Location The effect of smartphone location on performance was assessed using a one-way ANOVA for each composite score. Therefore, four one-way between-subject ANOVAs with the independent variable of smartphone location (i.e., desk, pocket/bag, and outside) and dependent variable of CBS composite score were completed. For all ANOVAs, the assumptions of normality and homogeneity were met. Since multiple ANOVAs were completed on the same data, a Holm-Bonferroni adjustment was used to account for multiple comparisons. Smartphone location did not significantly effect performance on memory, $F(2, 233) = 0.59$, $p = .553$, $p_{adj.} = 1.000$, $\eta_p^2 < .01$, reasoning $F(2, 233) = 0.06$, $p = .944$, $p_{adj.} = 1.000$, $\eta_p^2 < .01$, and concentration or attention, $F(2, 233) = 0.73$, $p = .485$, $p_{adj.} = 1.000$, $\eta_p^2 < .01$. There was a significant effect of smartphone location on verbal ability, $F(2, 233) = 4.82$, $p = .009$, $p_{adj.} = .035$, $\eta_p^2 = .04$, with a small-moderate effect size. Therefore, a Tukey HSD post hoc test was completed to investigate the differences between smartphone locations for the verbal ability composite score. The pairwise comparisons showed a significant difference between the desk and pocket/bag condition, $p = .006$, and no significant differences between desk and outside, $p = .180$, and pocket/bag and outside, $p = .408$ (see Table 3.12 for descriptive statistics). Therefore, those who placed their smartphone on their desk had lower verbal ability performance compared to those in who placed their smartphone in their pocket or bag (see Figure 3.7).

This finding was explored further to determine the driving force of the effect on verbal ability. Since verbal ability was a composite score for the digit span and grammatical reasoning tests, each of these tests was evaluated separately in a secondary analysis. Therefore, two one-way ANOVAs were completed to determine the effect of smartphone location on digit span and grammatical reasoning score. For all ANOVAs, the assumptions of normality and homogeneity were met. A significant effect of smartphone location was found for digit span scores, $F(2, 233) = 3.30$, $p = .038$, $\eta_p^2 = .03$, with a small-moderate effect size; but not for grammatical reasoning score, $F(2, 233) = 2.05$, $p = .131$, $\eta_p^2 = .02$ (see Table 3.13 for descriptive statistics). Therefore, a Tukey HSD post hoc test was completed to investigate the differences between smartphone locations for the digit span test. The pairwise comparisons showed a significant difference between the desk and pocket/bag condition, $p = .029$, and no significant differences between desk and outside, $p = .337$, and pocket/bag and outside, $p = .501$ (see Table 3.12 for descriptive statistics). Therefore, as seen in the verbal ability composite score, those who placed their smartphone on their desk had lower verbal ability performance compared to those

Figure 3.7: *Comparing performance on the four CBS composite scores between smartphone location conditions in Study 2: Visual depiction of ANOVA tests.*



Note. For each composite score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Cambridge Brain Sciences (CBS) composite scores were calculated by averaging the standardized score for the included CBS tests for each participant. Panel A depicts the memory composite score, which included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. Panel B depicts the reasoning composite score, which included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. Panel C depicts the verbal ability composite score, which included performance on Grammatical Reasoning and Digit Span. Panel D depicts the concentration or attention composite score, which included performance on Feature Match and Double Trouble. N = 237.

in who placed their smartphone in their pocket or bag (see Figure 3.8)[6].

Correlation Analysis An exploratory Pearson correlation analysis was completed to explore the relationship between all 12 CBS scores and the four composite scores. As shown in Figure 3.9, most CBS tests were positively and significantly correlated with all four composite scores. Interestingly, the odd one out test was the only CBS test that was only significantly correlated to reasoning (i.e., the composite score it belongs to), $r(235) = .45$, $p < .001$. All other individual CBS tests were significantly correlated to all other composite scores, regardless of which

[6]A supplementary analysis completed one-way ANOVAs for all Cambridge Brain Sciences tests and found no effect of smartphone location on any test. See Appendix L for more details.

Table 3.12: Descriptive statistics for CBS composite scores by smartphone location and overall in Study 2.

Composite CBS scores as descriptive statistics by smartphone location and overall for study 2.

	Measure	On Desk	Pocket/Bag	Outside	Overall
Memory					
	M	-0.02	0.06	-0.04	2.03E-16
	SD	0.64	0.69	0.62	0.65
	Min.	-1.39	-1.72	-1.68	-1.72
	Max.	1.98	2.07	1.13	2.07
Reasoning					
	M	0.01	0.01	-0.02	1.82E-17
	SD	0.62	0.60	0.52	0.58
	Min.	-1.69	-1.30	-1.05	-1.69
	Max.	1.61	1.39	1.77	1.77
Verbal Ability					
	M	-0.20	0.16	0.02	-2.37E-16
	SD	0.74	0.73	0.73	0.75
	Min.	-1.64	-1.64	-1.82	-1.82
	Max.	1.84	1.98	1.57	1.98
Concentration/Attention					
	M	0.08	-0.02	-0.06	-4.31E-17
	SD	0.74	0.85	0.72	0.77
	Min.	-1.92	-2.12	-1.88	-2.12
	Max.	1.50	1.89	1.53	1.89

Note. Cambridge Brain Science (CBS) composite scores were calculated by averaging the standardized score for the included CBS tests for each participant. Memory included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. Reasoning included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. Verbal Ability included performance on Grammatical Reasoning and Digit Span. Concentration/Attention included performance on Feature Match and Double Trouble.
N = 237

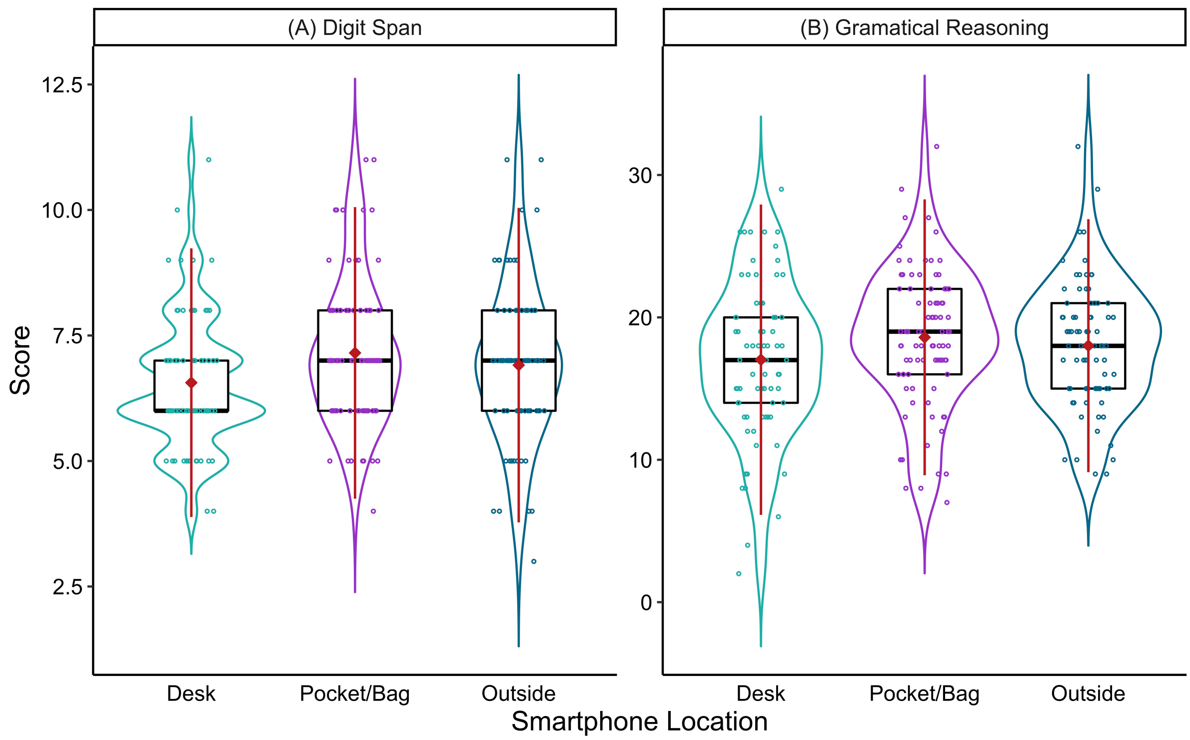
Table 3.13: Descriptive statistics for digit span and grammatical reasoning by smartphone location and overall in Study 2.

Raw CBS scores for verbal ability tests as descriptive statistics by smartphone location and overall for study 2.

	Measure	On Desk	Pocket/Bag	Outside	Overall
Grammatical Reasoning					
	M	17.03	18.60	18.01	17.91
	SD	5.45	4.84	4.44	4.94
	Min.	2	7	9	2
	Max.	29	32	32	32
Digit Span					
	M	6.56	7.15	6.91	6.89
	SD	1.34	1.45	1.57	1.47
	Min.	4	4	3	3
	Max.	11	11	11	11

Note. Cambridge Brain Science (CBS) score was the overall score (Grammatical Reasoning) or maximal level completed (Digit Span).
N = 237

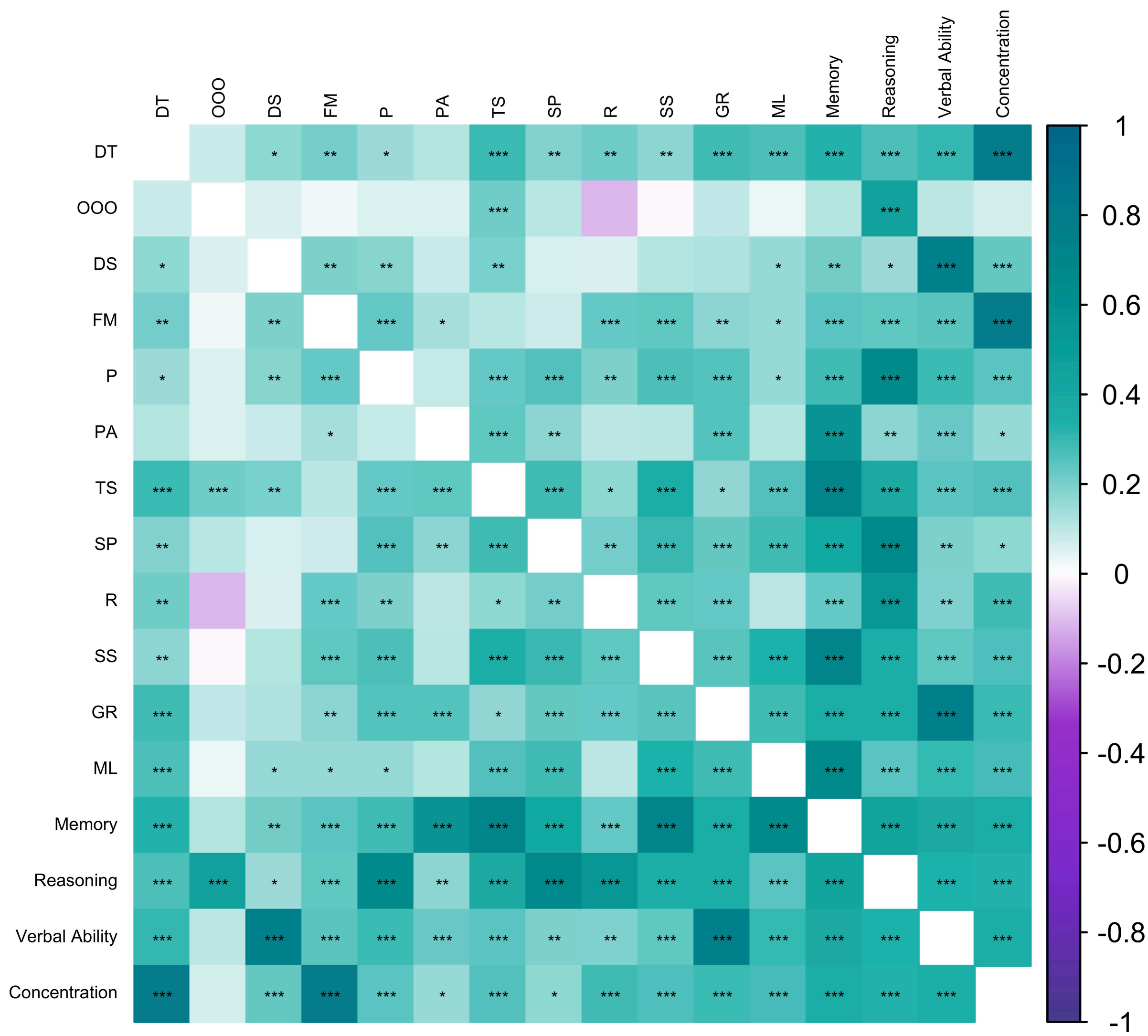
Figure 3.8: *Comparing performance on digit span and grammatical reasoning scores between smartphone location conditions in Study 2: Visual depiction of ANOVA tests.*



Note. For each Cambridge Brain Sciences (CBS) test score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Test were assessed for a secondary analysis exploring the driving force behind the effect of smartphone location on the verbal ability composite score. Panel A depicts performance on the digit span test. Panel B depicts performance on the grammatical reasoning test. $N = 237$.

composite score they were associated with, $r(235) = .15$ to $.77$, $p < .023$. Additionally, most CBS tests were inter-correlated, with some interesting exceptions. For the memory tests, all except paired associates and spatial span, $r(235) = .10$, $p = .109$, and monkey ladder, $r(235) = .11$, $p = .092$, were significantly correlated with each other, $r(235) = .25$ to $.34$, $p < .001$ (see Table 3.14 for descriptive statistics). For the reasoning composite score, the odd one out test did not strongly or significantly correlate with the other tests included in the composite score (i.e., rotations, polygons, and spatial planning), and was negatively correlated with the rotations test, $r(235) = .05$ to $-.11$, $p > .087$. It should be noted that these other reasoning tests did have weak to moderate, positive, and significant correlations with each other, $r(235) = .19$ to $.25$, $p < .003$ (see Table 3.15 for descriptive statistics). For the verbal ability composite score, digit span and grammatical reasoning had a non-significant correlation, $r(235) = .11$, $p = .083$ (see Table 3.13 for descriptive statistics). Lastly, for the concentration or attention composite score, the feature match and double trouble test scores were significantly correlated, $r(235) = .20$ $p = .002$ (see Table 3.16 for descriptive statistics). For more details about the correlation results, see Table 3.17.

Figure 3.9: *Correlation matrix of the 12 CBS test scores and composite scores in Study 2.*



Note. Correlation matrix for the 12 Cambridge Brain Sciences (CBS) tests and composite scores (calculated by averaging the standardized score for the included CBS tests for each participant). The memory composite score included performance on Monkey Ladder (ML), Spatial Span (SS), Token Search (TS), and Paired Associates (PA). The reasoning composite score included performance on Rotations (R), Polygons (P), Odd One Out (OOO), and Spatial Planning (SP). The verbal ability composite score included performance on Grammatical Reasoning (GR) and Digit Span (DS). The concentration or attention composite score included performance on Feature Match (FM) and Double Trouble (DT). $N = 237$.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3.14: Descriptive statistics for the memory CBS tests by smartphone location and overall for Study 2.

Raw CBS scores for memory tests as descriptive statistics by smartphone location and overall for study 2.

	Measure	On Desk	Pocket/Bag	Outside	Overall
Monkey Ladder					
	M	7.77	8.07	7.88	7.92
	SD	1.21	1.27	1.18	1.23
	Min.	4	5	5	4
	Max.	10	11	11	11
Spatial Span					
	M	5.99	6.13	5.97	6.03
	SD	0.97	1.04	0.99	1.00
	Min.	4	4	4	4
	Max.	9	9	8	9
Token Search					
	M	8.07	8.26	7.94	8.09
	SD	1.61	1.88	1.73	1.75
	Min.	5	3	4	3
	Max.	12	13	12	13
Paired Associates					
	M	5.07	4.89	4.97	4.97
	SD	1.03	1.05	1.00	1.02
	Min.	3	2	3	2
	Max.	7	8	8	8

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
$N = 237$

The Smartphone Use Questionnaire

Since Study 2 collected the same smartphone use measures, the following results describe not only how the data described the sample, but also how this compared to Study 1. This comparison was explored to ensure that the sample in Study 2 was comparable to Study 1 since paradigm decisions were made from the sample in Study 1.

Typical Smartphone Use Overall, participants reported getting their first smartphone at a similar age to Study 1 (M = 13.36, SD = 1.66, range = 8-19). Smartphone users (75.52 %) and iPhone users (74.05 %) reported their most used application was a social media application, which was comparable but lower that in Study 1. In contrast to Study 1, most participants reported that their most typical type of phone use was for calling or texting (70.04 %), which did not coincide with their reported most used application. As in Study 1, participants reported that they mainly used their smartphone to communicate with their friends (84.39 %). Also inline with Study 1, subjective value for one's phone was the lowest presented option of $0-$20 (37.13 %). As seen in Study 1 and in previous studies (e.g., Deb, 2015; Ruiz Pardo and Minda, 2021), most participants reported experiencing phantom vibrations (76.37 %; see Table

Table 3.15: Descriptive statistics for the reasoning CBS tests by smartphone location and overall for Study 2.

Raw CBS scores for reasoning tests as descriptive statistics by smartphone location and overall for study 2.

	Measure	On Desk	Pocket/Bag	Outside	Overall
Rotations					
	M	88.32	84.49	82.99	85.22
	SD	35.97	33.34	31.15	33.45
	Min.	-4	10	6	-4
	Max.	148	193	157	193
Polygons					
	M	43.41	47.06	46.22	45.63
	SD	25.02	25.95	25.40	25.42
	Min.	-7	-5	-5	-7
	Max.	114	107	108	114
Odd One Out					
	M	9.97	10.20	10.05	10.08
	SD	3.42	3.43	3.24	3.35
	Min.	0	1	3	0
	Max.	15	18	17	18
Spatial Planning					
	M	20.31	19.53	19.39	19.73
	SD	8.07	7.11	7.19	7.43
	Min.	4	4	2	2
	Max.	41	38	37	41

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
$N = 237$

Table 3.16: Descriptive statistics for the concentration or attention CBS tests by smartphone location and overall for Study 2.

Raw CBS scores for concentration/attention tests as descriptive statistics by smartphone location and overall for study 2.

	CBS Composite Score	On Desk	Pocket/Bag	Outside	Overall
Feature Match					
	M	129.23	127.91	124.21	127.12
	SD	28.53	30.12	23.35	27.53
	Min.	61	57	72	57
	Max.	182	192	182	192
Double Trouble					
	M	26.69	24.56	25.21	25.45
	SD	14.28	15.02	14.05	14.45
	Min.	-3	-5	-3	-5
	Max.	51	49	59	59

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
$N = 237$

3.18 for a more detailed breakdown by smartphone location).

In contrast to Study 1, the Screen Time items showed that, for iPhone users only, most reported the middle option for total Screen time (i.e., 21-30 hours; 28.48 %) and for pickups per day (i.e., 101-150; 32.91 %). In line with Study 1, the highest notifications per day was

Table 3.17: Correlation matrix of the 12 CBS test scores and composite scores in Study 2.

CBS tests and composite scores as Pearson r correlations for study 2.

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Individual CBS Tests																
1. Double Trouble	–															
2. Odd One Out	.08	–														
3. Digit Span	.16*	.06	–													
4. Feature Match	.20**	.02	.19**	–												
5. Polygons	.14*	.05	.18**	.23***	–											
6. Paired Associates	.11	.05	.08	.13*	.08	–										
7. Token Search	.29***	.21***	.20**	.10	.23***	.24***	–									
8. Spatial Planning	.18**	.10	.06	.07	.25***	.17**	.28***	–								
9. Rotations	.21**	-.11	.05	.22***	.19**	.10	.16*	.20**	–							
10. Spatial Span	.17**	-.01	.11	.24***	.27***	.10	.34***	.30***	.23***	–						
11. Grammatical Reasoning	.28***	.09	.11	.17**	.25***	.25***	.16*	.23***	.23***	.24***	–					
12. Monkey Ladder	.27***	.03	.15*	.16*	.15*	.11	.26***	.28***	.10	.33***	.28***	–				
CBS Composite Scores																
13. Memory	.32***	.11	.21**	.24***	.28***	.56***	.70***	.39***	.23***	.68***	.36***	.65***	–			
14. Reasoning	.26***	.45***	.15*	.23***	.65***	.17**	.38***	.67***	.55***	.34***	.34***	.24***	.44***	–		
15. Verbal Ability	.30***	.10	.75***	.24***	.29***	.22***	.24***	.19**	.19**	.24***	.75***	.29***	.38***	.33***	–	
16. Concentration / Attention	.77***	.06	.23***	.77***	.24***	.15*	.25***	.16*	.28***	.26***	.29***	.27***	.36***	.32***	.35***	–

Note. Pearson correlations between the 12 Cambridge Brain Science (CBS) individual tests and four composite scores. Four tests were included in the memory composite score (i.e., Monkey Ladder, Spatial Span, Token Search, and Paired Associates). Four tests were included in the reasoning composite score (i.e., Rotations, Polygons, Odd One Out, and Spatial Planning). Two tests were included in the verbal ability composite score (i.e., Grammatical Reasoning and Digit Span). Two tests were included in the concentration or attention composite score (i.e., Feature Match and Double Trouble).
$N = 237$
* $p < .05$. ** $p < .01$. *** $p < .001$.

more highly chosen (i.e., 200+; 39.87 %; see Table 3.19 for more details).

Distraction and Comfort Levels In line with Study 1 and with increased proportions, participants reported their phone as the most distracting device in general (91.11 %), while studying or working (87.76 %), and in a social context (96.62 %). Participants reported being somewhat distracted by their smartphone during daily activities ($M = 5.70$, $SD = 1.41$), but disagreed with being distracted by their smartphone during the study ($M = 2.60$, $SD = 1.93$), which aligned with Study 1. With respect to comfort levels of being without one's smartphone, participants reported being neutral to leave their phones with others or unattended, and tended to report leaving their phone locked while out of their possession. Interestingly, they reported being neutral to almost in agreement when asked if they would feel comfortable leaving their phone in another room during a task (see Table 3.20 and Table 3.21 for more details). These findings were in agreement with results from Study 1.

Smartphone Power and Location Participants reported a tendency to keep their smartphone powered on when they are not using it, with notifications turned on, and on vibrate. Aside from during an exam, participants tended to keep their smartphone powered on in different situations (i.e., while studying, in a lecture, while sleeping; see Table 3.22 for more details). These patterns were the same as in Study 1.

The same trends from Study 1 were seen with respect to smartphone location: 65.49 % participants reported leaving their smartphone in their pocket or bag across situations (followed

Table 3.18: Descriptive statistics and frequency counts for smartphone use questionnaire measures for all smartphone users in Study 2.

Smartphone use questionnaire responses as descriptive statistics and frequency counts for all smartphone users by smartphone location and overall for study 2.

Measure	On Desk	Pocket/Bag	Outside	Overall
Age of first smartphone				
M	13.29	13.45	13.32	13.36
SD	1.58	1.75	1.64	1.66
Min.	8	8	10	8
Max.	17	18	19	19
Most used application				
Games	0	1	1	2
Social Networking	53	61	65	179
Entertainment	22	21	10	53
Other	0	2	1	3
Subjective value				
\$0-\$20	30	36	22	88
\$21-\$40	17	15	22	54
\$41-\$60	16	16	16	48
>\$60	12	18	17	47
Phantom vibrations				
Yes	59	59	63	181
No	16	26	14	56
Main communication				
Family	9	13	13	35
Friends	66	70	64	200
Work	0	1	0	1
Other	0	1	0	1
Type of phone use*				
Calling / Texting	56	53	18	166
Social media	1	3	57	5
Games	1	1	1	2
Email	0	4	1	5
Other	0	0	0	0

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
N = 237

by on their desk, 31.22 %; and in another room, 3.29 %; see Table 3.23). This trend was explored further by looking at which location represented more than half of the participants for each situation (i.e., more than 119 participants) across the assigned conditions. As shown in Figure 3.10, over half of participants reported keeping their smartphone on their desk for one situation (i.e., while studying), in their pocket or bag for four situations (i.e., during an exam, a lecture, in a social setting, and typically), and in another room for no situations. These results matched Study 1 exactly: the most frequent phone placement was in one's pocket or bag, across most situations.

Table 3.19: Descriptive statistics and frequency counts for smartphone use questionnaire measures for iPhone user in Study 2.

Smartphone use questionnaire responses as frequency counts for all iPhone users for study 2.

Measure	On Desk (56)	Pocket/Bag (50)	Outside (52)	Overall (158)
Most used application				
Games	1	0	2	3
Social Networking	39	38	40	117
Entertainment	15	11	8	34
Other	1	1	2	4
Most used application was text/messenger				
Yes	15	14	14	43
No	41	36	38	115
Screen Time (hours)				
0-10	13	10	12	35
11-20	10	14	10	34
21-30	15	13	17	45
31-40	12	11	6	29
40+	6	2	7	15
Pickups (per day)				
0-50	8	5	7	20
51-100	12	14	17	43
101-150	22	16	14	52
151-200	10	8	6	24
200+	4	7	8	19
Notifications (per day)				
0-50	5	6	3	14
51-100	11	9	12	32
101-150	12	11	6	29
151-200	8	3	9	20
200+	20	21	22	63

Note. Only those who reported having an iPhone completed the measures. All measures self-reported from participant's Screen Time application on their iPhone, which tracks their device use (i.e., the type and duration of use).
N = 158

Measures of Smartphone Reliance

Since Study 2 collected the same smartphone reliance measures, the following results describe not only the results in Study 2, but also how this compared to Study 1. This comparison was explored to ensure that the sample in Study 2 was comparable to Study 1 since paradigm decisions were made from the sample in Study 1. Additionally, this comparison gave us insights into how stable these measurements were across multiple studies with similar populations.

As shown in Figure 3.11, all reliance measures were significantly and positively correlated, $p < .001$. In contrast to Study 1, there were no non-significant correlations: all correlations were moderate to strong, $r(235) > .34$, $p < .001$. As in study 1, the strongest correlation was between nomophobia and involvement, $r(235) = .75$, $p < .001$ (see Table 3.24 and Table 3.25 for more details on the correlations, and descriptive statistics, respectively)[7].

[7]Our measures in Study 2 generally displayed adequate levels of internal consistency (i.e., standardized Cronbach's $\alpha \geq .70$; $\alpha_{Nomophobia} = .93$, $\alpha_{Involvement} = .89$, $\alpha_{Self-Identity} = .89$, $\alpha_{ValidationfromOthers} = .38$, $\alpha_{Dependency} = .85$,

Table 3.20: Descriptive statistics and frequency counts for distraction measures in Study 2.

Smartphone use questionnaire responses for distraction measures as frequency counts for study 2.

Measure	On Desk	Pocket/Bag	Outside	Overall
Distracted during daily activities				
M	5.68	5.75	5.65	5.70
SD	1.32	1.30	1.60	1.41
Min.	2	1	1	1
Max.	7	7	7	7
Distracted during study				
M	2.61	2.47	2.74	2.60
SD	1.94	1.92	1.95	1.93
Min.	1	1	1	1
Max.	7	7	7	7
Most distracting device: General				
Computer	5	3	6	14
Phone	68	71	77	216
iPad / Tablet	0	2	2	4
Smartwatch	2	1	0	3
Other	0	0	0	0
Most distracting device: Studying/Working				
Computer	8	11	5	24
Phone	65	72	71	208
iPad / Tablet	0	2	0	2
Smartwatch	2	0	1	3
Other	0	0	0	0
Most distracting device: Social Context				
Computer	0	3	1	4
Phone	74	81	74	229
iPad / Tablet	0	0	1	1
Smartwatch	1	0	1	2
Other	0	1	0	1

N = 237

In order to compare the level of reliance for each measure, each was split into levels: low, moderate, and high. This was done exactly as in Study 1. Overall, 53.80 % of participants were in the moderate level of a reliance measure, followed by 27.05 % in high level and 19.15 % in the low level. These proportions were similar to Study 1. As shown in Figure 3.12, all measures (excluding dependency and distractibility) had more than half of participants in the moderate level. No reliance measure had a large proportion in the high or low levels. These findings extended those from Study 1, where most participants have moderate levels of smartphone reliance. For further details, please see Table 3.26.

$\alpha_{EmotionalAttachment} = .79$, $\alpha_{Accessibility} = .76$, $\alpha_{Distractibility} = .62$). It should be noted that, as in Study 1, the Validation from Others subscale of the Mobile Phone Involvement Questionnaire (Walsh et al., 2010) and the Distractibility subscale of the Smartphone Attachment and Dependency Questionnaire (Ward et al., 2017) were below the cut-off and our findings regarding these measures should be interpreted with caution.

Table 3.21: Descriptive statistics and frequency counts for comfort measures in Study 2.

Smartphone use questionnaire responses for the comfort level measures as descriptive statistics for study 2.

Measure	On Desk	Pocket/Bag	Outside	Overall
I am comfortable with letting others use my phone.				
M	4.53	4.34	4.39	4.42
SD	1.67	1.71	1.68	1.68
I leave my phone unattended.				
M	4.01	3.52	3.81	3.77
SD	1.74	1.89	1.82	1.82
I leave my phone with other people.				
M	4.00	3.20	3.83	3.66
SD	1.78	1.84	1.82	1.84
I make sure my phone is locked when it is not in my hands.				
M	5.35	5.40	5.66	5.47
SD	1.55	1.51	1.43	1.49
I would feel comfortable leaving my phone in another room while completing a task.				
M	5.36	4.62	5.26	5.06
SD	1.62	1.83	1.62	1.72

Note. Minimum value (1) and maximum value (7) for each measure was identical.
N = 122

Table 3.22: Descriptive statistics and frequency counts for smartphone power measures in Study 2.

Smartphone use questionnaire responses for the power paradigm decision measures as descriptive statistics for study 2.

Measure	On Desk	Pocket/Bag	Outside	Overall
I tend to turn my phone off when I am not using it.				
M	2.65	2.56	2.52	2.58
SD	1.75	1.65	1.54	1.64
I tend to have my notifications turned on.				
M	4.55	4.76	4.57	4.63
SD	2.00	1.74	2.10	1.94
I tend to have my phone on vibrate.				
M	4.75	5.24	4.96	4.99
SD	2.34	2.12	2.23	2.22
Phone is on: Study				
M	5.03	5.29	5.23	5.19
SD	1.75	1.68	1.75	1.72
Phone is on: Exam				
M	2.03	2.39	2.12	2.19
SD	1.66	1.79	1.81	1.75
Phone is on: Lecture				
M	5.24	5.32	5.58	5.38
SD	1.84	1.64	1.56	1.68
Phone is on: Sleep				
M	5.07	5.19	5.05	5.11
SD	2.05	1.77	2.06	1.95

Note. Minimum value (1) and maximum value (7) for each measure was identical.
N = 237

Table 3.23: Descriptive statistics and frequency counts for smartphone location measures in Study 2.

Smartphone use questionnaire responses for the location paradigm decision measures as frequency counts for study 2.

Measure	On Desk	Pocket/Bag	Outside	Overall
Location: Typical				
On Desk	26	25	28	79
Pocket / Bag	49	60	49	158
Another room	0	0	0	0
Location: Study				
On Desk	55	66	57	178
Pocket / Bag	16	16	11	43
Another room	4	3	9	16
Location: Exam				
On Desk	1	0	0	1
Pocket / Bag	68	78	70	216
Another room	6	7	7	20
Location: Lecture				
On Desk	19	25	32	76
Pocket / Bag	56	60	45	161
Another room	0	0	0	0
Location: Social Setting				
On Desk	12	11	13	36
Pocket / Bag	61	73	64	198
Another room	2	1	0	3

N = 237

Table 3.24: Correlation results for smartphone reliance measures in Study 2.

Smartphone reliance measures as correlations for study 2.

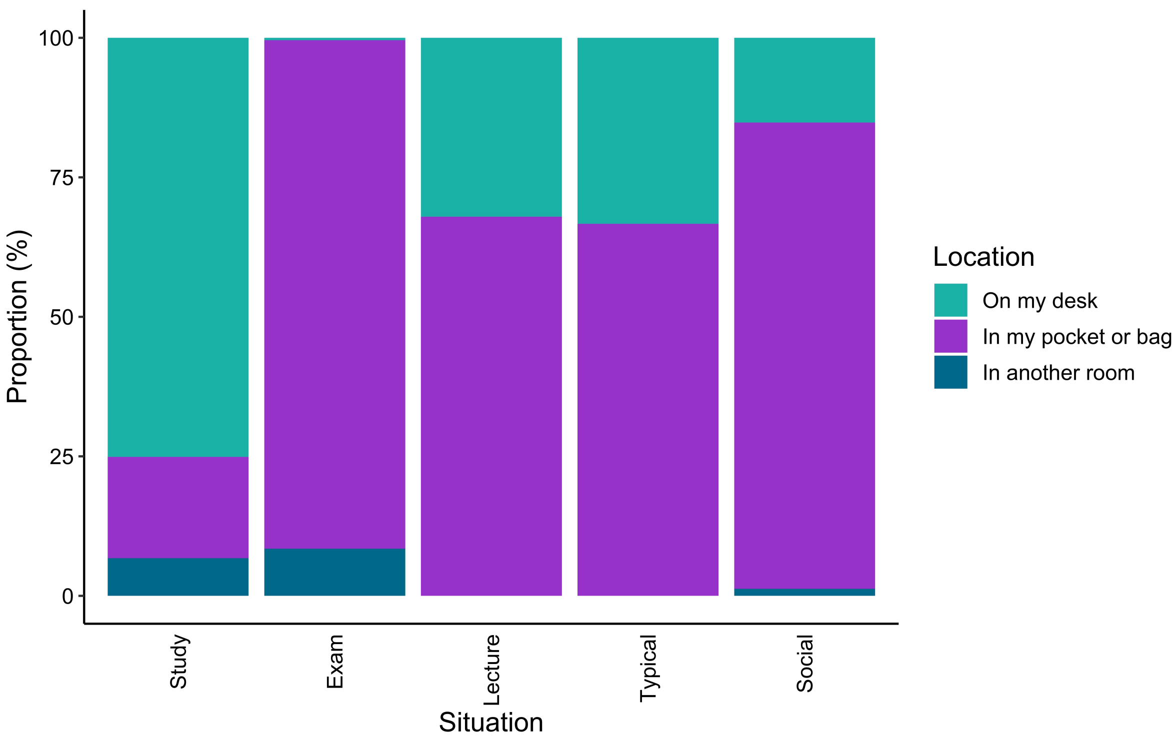
Measure	1	2	3	4	5	6	7	8
1. Nomophobia Questionnaire	–							
Mobile Phone Involvement Questionnaire								
2. Involvement	.75	–						
3. Self-Identity	.71	.66	–					
4. Validation from Others	.45	.44	.38	–				
Smartphone Attachment and Dependency Inventory								
5. Dependency	.72	.65	.74	.43	–			
6. Emotional Attachment	.64	.67	.59	.55	.62	–		
7. Accessibility	.72	.64	.67	.44	.72	.56	–	
8. Distractibility	.50	.64	.44	.34	.48	.46	.52	–

Note. All correlations were significant, $p < .001$.
N = 237

3.3.3 Interim Discussion

Study 2 investigated the effect of smartphone location on different aspects of cognition using a battery of cognitive tests. We predicted that cognitive areas such as memory and concentration or attention (as defined by Cambridge Brain Sciences, 2018c) would be affected by smartphone location. That is, that those who placed their smartphone on their desk would have

Figure 3.10: *Smartphone location by situations for Study 2.*

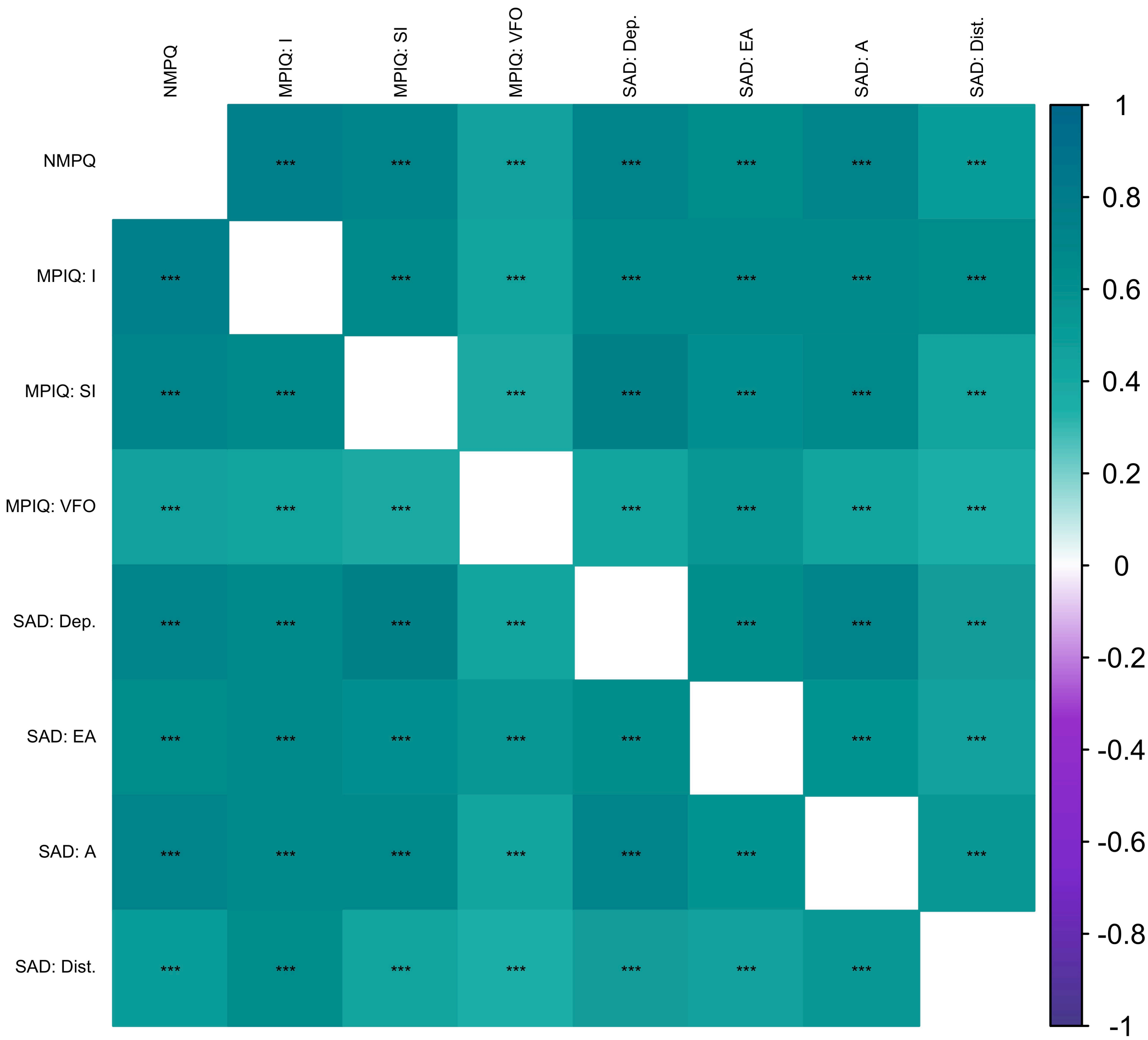


Note. Responses to smartphone location measures in the Smartphone Use Questionnaire for all participants in Study 2 (N = 237). Most participants showed a tendency to keep their smartphone in their pocket or bag across all situations, excluding the study situation, where most reported keeping their smartphone on their desk.

the worst performance. For further details, see Table 3.10. The primary analysis showed no effect of smartphone location was seen for memory, reasoning, and concentration or attention. This supported the predictions for the reasoning cognitive area, but not for memory and concentration or attention. There was a significant effect of smartphone location on verbal ability performance, where those in the desk condition performed significantly worse than those in the pocket/bag condition. This supported the predictions that verbal ability would be affected by participants' smartphone location. A secondary analysis of verbal ability explored which of the tests associated with that cognitive area was driving the effect. We found that only the digit span test was affected by smartphone location. Similar to the effect on verbal ability, participants who placed their smartphone on their desk performed worse on the digit span test than those who placed their smartphone in their pocket or bag. This effect was not found in the grammatical reasoning test. It should be noted that although our study supports that smartphones can impact our cognition, it seems that this effect might be limited to one aspect.

The correlations between the CBS composite scores and themselves, and the individual

Figure 3.11: *Correlation matrix of smartphone reliance measures in Study 2.*



Note. Correlation matrix for smartphone reliance measures for the three questionnaires: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). $N = 237$. *$p < .05$. **$p < .01$. ***$p < .001$.

CBS tests were mixed. Overall, the findings supported that each test was related to the other test(s) in the same cognitive area (i.e., memory, reasoning, verbal ability, and concentration or attention). Interestingly, one of the exceptions to this pattern were the verbal ability tests: digit span and grammatical reasoning. No relationship was found between these two tests. This poor relationship between the two tests not only provides a reason for why only one individual test was affected by smartphone location (i.e., digit span), but also provides evidence against the

Table 3.25: Descriptive statistics for smartphone reliance measures in Study 2.

Smartphone reliance measures as descriptive statistics by smartphone location and overall for study 2.

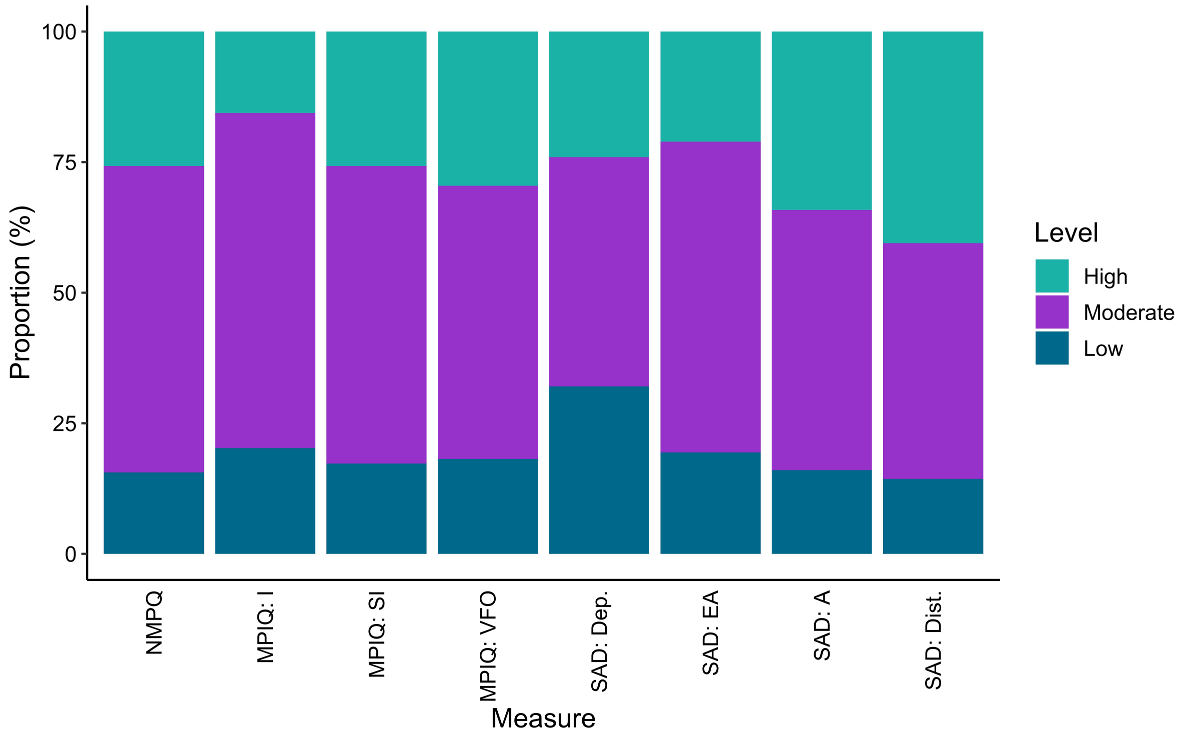
Measure	On Desk	Pocket/Bag	Outside	Overall
Nomophobia				
M	79.56	83.99	86.25	83.32
SD	22.32	21.84	20.58	21.67
Min.	34	28	39	28
Max.	132	119	121	132
Mobile Phone Involvement Questionnaire				
Involvement				
M	30.85	32.54	32.96	32.14
SD	8.79	8.57	8.05	8.49
Min.	12	12	14	12
Max.	49	50	52	52
Self-Identity				
M	12.49	13.13	13.45	13.03
SD	4.04	3.95	3.63	3.88
Min.	3	3	4	3
Max.	21	21	21	21
Validation from Others				
M	13.20	12.67	12.96	12.93
SD	3.76	3.79	4.26	3.93
Min.	3	3	3	3
Max.	19	20	21	21
Smartphone Attachment and Dependency Inventory				
Dependency				
M	11.01	12.52	12.09	11.90
SD	4.63	4.52	4.47	14.56
Min.	3	3	3	3
Max.	21	21	20	21
Emotional Attachment				
M	16.73	16.65	16.23	16.54
SD	4.69	4.68	4.92	4.75
Min.	4	4	5	4
Max.	28	24	27	28
Accessibility				
M	12.84	14.07	14.04	13.67
SD	4.01	3.95	3.85	3.96
Min.	4	5	4	4
Max.	21	21	21	21
Distractibility				
M	9.36	9.56	9.84	9.59
SD	2.58	2.63	2.63	2.61
Min.	4	2	3	2
Max.	14	14	14	14

N = 237

task selection guide's (Cambridge Brain Sciences, 2018c) cognitive areas. It appears that the digit span and grammatical reasoning tests were measuring vastly different aspects of cognition and perhaps should be grouped with memory and reasoning, respectively. Future studies should consider assessing the memory tests (e.g., spatial span, token search, digit span).

All smartphone reliance measures (e.g., nomophobia, involvement, dependency) were at least moderately related. Therefore, those who had higher levels of one reliance measure

Figure 3.12: *Smartphone reliance measures as proportion of participants in the low, moderate, or high level in Study 2.*



Note. Stacked bar graph for smartphone reliance measures by levels as proportions. Each level was decided by splitting up the range of possible scores for each each measure into three levels: low, moderate, and high. Each reliance measure is shown as an acronym for visualization purposes: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). N = 122.

tended to have higher levels in the other measures. This expanded results from Study 1, which found no relationship between distractibility and self-identity and validation from others. Comparing low, moderate, and high levels of each reliance measure confirmed that, as in Study 1, most participants have moderate reliance.

Smartphone use patterns depicted that most participants tend to use their smartphones for social media applications, communicate with their friends, keep their smartphone powered on, and keep their smartphone in their pocket or bag in most situations. The most distracting device was unanimously identified as one's phone. However, participants did not report feeling distracted by their smartphone during daily activities or during the study. With respect to people's Screen Time (i.e., for iPhone users only), only the notification frequency reached the ceiling of the presented choices, with the middle options prevailing for both total screen time and pickups per day. As predicted, these patterns were similar to Study 1 and confirmed that

Table 3.26: Frequency counts for smartphone reliance measures by level in Study 2.

Smartphone reliance measures as frequency counts by levels for study 2.

Measure	# Items	Likert Range	Possible Score	Levels: Low	Moderate	High
Nomophobia Questionnaire						
Nomophobia	20	1-7	20-140	37 (20-59)	139 (60-99)	61 (100-140)
Mobile Phone Involvement Questionnaire						
Involvement	8	1-7	8-56	48 (8-23)	152 (24-39)	37 (40-56)
Self-Identity	3	1-7	3-21	41 (3-8)	135 (9-14)	61 (15-21)
Validation from Others	3	1-7	3-21	43 (3-8)	124 (9-14)	70 (15-21)
Smartphone Attachment and Dependency Inventory						
Dependency	3	1-7	3-21	76 (3-8)	104 (9-14)	57 (15-21)
Emotional Attachment	3	1-7	3-21	46 (3-8)	141 (9-14)	50 (15-21)
Accessibility	4	1-7	4-28	38 (4-11)	118 (12-19)	81 (20-28)
Distractibility	2	1-7	2-14	34 (2-5)	107 (6-9)	96 (10-14)

Note. Score value ranges for each respective level shown in parentheses.
$N = 237$

the samples were comparable.

There are several limitations to the findings in Study 2. The collected sample, although comparable to Study 1, was primarily university-aged students from one university. Therefore, the sample was primarily composed of people who have used or owned a smartphone for a large part of their life. Additionally, this age cohort tends to be familiar with smartphone utility, including how to avoid the potential distractor during a demanding task. All participants would have a baseline education, and a need for developing strategies to avoid being distracted by their smartphone. Therefore, it is likely that this age cohort would be desensitized to their smartphone's presence, especially during a demanding task or set of tasks. The in-lab environment of the study may also circumvent typical smartphone use, which would include casual smartphone use during a typical task. Forcing participants to ignore their smartphone while completing the CBS tests would therefore be analogous to an exam setting, which would be well-known to university students. Future studies should assess a wider age range and provide a more realistic experimental environment to truly assess if smartphones can affect our cognition.

3.4 Study 3: An Attempt to Reveal the Smartphone Effect with an Online Study

Similarly to Study 2, Study 3 investigated how smartphone presence affected a variety of cognitive measures, specifically, how one's smartphone location affects performance on the CBS test battery. Study 3 was therefore a conceptual replication of Study 1, where participants completed the exact same 12 CBS tests and nearly identical survey measures in an online platform. This was completed not only to investigate the replicability of Study 2's findings, but also to explore if an online platform was feasible for other similar paradigms.

Assessing online performance also allowed us to naturalize the environment in which participants completed the study. Internet usage, overall, is so wide-spread that completing a study on one's computer while in your own chosen environment provided the most "realistic" scenario to assess whether the mere presence of one's smartphone effects our cognition. It is important to note that although

Therefore, Study 3 used the 12 CBS tests to assess whether smartphone location effected cognitive performance. Due to the inherent constraints of online based studies, smartphone locations with the maximal physical and visual distance were chosen. Participants placed their smartphones either on their desk, in front of them (i.e., desk); or away from them, where they can not see it (i.e., away). Those in the desk condition would tend to have their smartphone besides them (low physical distance) and likely within their line-of sight (high visibility), while those in the away condition would have their smartphone outside of their immediate proximity (high physical distance) and outside of their line-of-sight (low visibility). Additionally, the demographic, smartphone use, and reliance measures from Study 2 were used with some modifications (e.g., adding measure to check for complicity to the instructions and attentiveness during the study).

Our predictions were based on our findings from Study 2. Namely, it was predicted that smartphone location would significantly affect verbal ability, where those with their smartphones on their desk would show the lowest performance. Based on the exploratory analysis of the verbal ability tests (i.e., Digit Span and Grammatical Reasoning), we also predicted that we would find the same effect on Digit Span, but not Grammatical Reasoning performance. It was also predicted that there would be significant strong positive correlations between the smartphone reliance measures (e.g., nomophobia, involvement, and attachment and dependency) and a similar pattern to typical smartphone use, location, and power as in Study 1 and Study 2.

3.4.1 Method

Participants

A total of 461 students were recruited from Western University's research pool. Of the total sample size, a total of 50 participants were flagged for either data collection related errors (e.g., technical issues, incomplete survey data) and 206 were flagged for having at least one invalid CBS test score as defined by Cambridge Brain Sciences (2019).

During the data cleaning phase, 61 outlying CBS scores were removed, where any test that was greater than three standard deviations from the mean was removed. This was completed for each CBS test. The primary analysis required that all participants completed the 12 CBS tests, so 45 participants were removed for having less than 12 tests completed. Any participants who either had an invalid CBS score, an outlying CBS score, or did not have 12 CBS tests scores was removed.

Since all data was collected online, participants who did not comply with their instructions were removed from the final analysis. For the desk condition, only participants who reported having their smartphone within their line-of-sight during the CBS tests were included. For the away condition, only participants who reported having their smartphone outside of their line-of-sight during the CBS test were included. Therefore, the conditions in the final analysis reflected (1) participants who had their smartphone on their desk and within their line-of-sight (i.e., the "*desk-IN"* condition), and (2) participants who had their smartphone away from them and outside of their line-of-sight (i.e., the "*away-OUT*" condition. Three attention check items were also used to determine complicity. Each item was presented during the survey component of the study, after each questionnaire. Thirteen, ten, and six participants did not correctly respond to the three attention check items correctly, respectively. Participants were included in the final analysis if they responded to all three attention check items correctly. Overall, 286 participants were removed from the analysis, where a participant may have been removed due to multiple criteria.

Therefore, a total of 175 students (105 females and 70 males) were used in the analyses. All participants consented as university students (i.e., 17 years old or older) and were required to have normal or corrected-to-normal vision (i.e., glasses and contacts were acceptable). The ages ranged from 18-43 years old (M = 19.29, SD = 2.79). Participants were also required to have English as their first language or be fluent in English as a second language. The majority of the final sample reported English as their first language 76 %, followed by Other (12 %, e.g., Farsi, Turkish, Bengali) and Mandarin (9.71 %). Most reported high (86.29 %), followed by moderate (13.71 %) English proficiency and none reported low proficiency (see Table 3.27 for more details). No participants were excluded based on language proficiency. Most participants reported currently living in North America (88.57 %) with a high school or equivalent education (61.14 %). Aside from being students, many reported being employed part-time (16 %; see Table 3.28 for more details).

Table 3.27: Descriptive statistics for demographic measures in Study 3.

Demographic measures as descriptive statistics or frequency counts by smartphone location and overall.

	Measure	Desk-IN (85)	Away-OUT (90)	Overall (175)
Age				
	M	19.39	19.20	19.29
	SD	3.18	2.39	2.79
	Min.	18	18	18
	Max.	43	36	43
Gender*				
	Male	33	37	70
	Female	52	53	105
First Language*				
	English	65	68	133
	Spanish	1	0	1
	Mandarin	9	8	17
	Arabic	1	1	2
	Other	8	13	21
	Prefer not to say	1	0	1
English Proficiency*				
	Moderate	11	13	24
	High	74	77	151
Current Location*				
	North America	75	80	155
	Europe	0	1	1
	Africa	0	0	0
	Asia	10	7	17
	Other	0	2	2

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Sample size is shown for each group in parentheses.
* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Self-Identify" and "Prefer not to say" for Gender; "Portuguese", and "French" for First Language; "Low" for English Proficiency. ; "Central America", "South America", "Africa", "Australia", "Pacific Islander", "Caribbean Islands", and "Prefer not to say" for Current Location.

Materials

Battery of Cognitive Tests: The Cambridge Brain Sciences (CBS) Tests The same 12 CBS tests from Study 2 were used in the same order. See Figure 3.5 in Study 2 for an example of a single trial for each CBS test.

General Demographic Questions The demographic items (i.e., eight items in total) asked participants to report their age (in years), gender (i.e., male, female, self-identified, or prefer not to say), first language (e.g., English, Spanish, Mandarin, Arabic), and English proficiency (i.e., low, moderate, or high). Additionally, participants were asked to state their current region

Table 3.28: Descriptive statistics for exploratory demographic measures in Study 3.

Exploratory demographic measures as frequency counts by smartphone location and overall.

Measure	Desk-IN	Away-OUT	Overall
Education*			
Some high school	5	7	12
High school or equivalent	56	51	107
Some college, no degree	14	25	39
Associate degree	1	1	2
Bachelor's degree	9	4	13
Prefer not to say	0	2	2
Employment* +			
Selection: 1	63	74	137
Selection: 2	21	16	37
Selection: 4	1	0	1
Employed full-time	2	0	2
Employed part-time	18	10	28
Self-employed	1	1	2
Unemployed	14	18	32
Student	74	76	150
Unable to work	0	1	1
Industry* +			
Selection: 1	68	79	147
Selection: 2	11	9	20
Selection: 3	6	2	8
Student	74	84	158
Construction	2	1	3
Services-producing sector	5	6	11
Finance, insurance, real estate, rental, and leasing	3	0	3
Professional, scientific, and technical services	0	1	1
Business, building and other support services	2	1	3
Educational services	1	2	3
Health care and social assistance	9	0	14
Information, culture, and recreation	2	0	2
Accommodation and food services	6	1	7
Other	3	0	3
Does not apply to me	1	2	3

* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Master's degree", "Professional degree", and "Doctorate or higher" for Education; "Retired" and "Prefer not to say" for Employment; "Goods-producing sector", "Utilities", "Manufacturing", and "Public administration" for Industry.

+ Multiple selections were allowed across measure. Top depicts the number of selections made. Bottom depicts frequency for given selection.

N = 175

of residence (e.g., North America, Asia), their education level (e.g., high school, Master's), their employment status (e.g., full-time, part-time), and the industry of their profession (e.g., construction, educational services; see Appendix H). This information was collected in order to provide a brief description of the sample.

The Smartphone Use Questionnaire-Revised This measure was revised from Study 1 and Study 2. Mainly, changes were made to have a manipulation check since participants were collected online and completed all task and survey measures with out guidance from a researcher. As in Study 1 and Study 2, some items were forced-choice and some were on a 7-point Likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). In total, there were 63 items and seven types of items (see Appendix I). The following describes the modified or additional items added to the measure. All other items were the same as in Study 1 and Study 2.

Manipulation Check Items There were three sections in the manipulation check items, which reviewed participation complicity with respect to their smartphone's location (one item), settings (four items), and the presence of additional tabs or applications on their computer while completing the study (seventeen items). The location item asked participants where they placed their smartphone during the study, regardless of their assigned location condition. The settings items asked participants if they complied to the specifics of their instructions, namely whether they placed their smartphone faced-down, on "silent", powered on, and within their line-of-sight[8]. Additionally, participants were asked whether they had any other tabs or applications open during their study in general (e.g., "*How many other browser tab(s)/other applications(s) did you have open during this study (e.g., 5)?*"), and with respect to the specific device (e.g., computer, phone, iPad/Tablet; e.g., "*If you did receive a notification on your computer during the study and noticed, was this distracting?*").

Smartphone Use An additional option (i.e., "Business/Productivity") was added to the items about participants most used application for both overall and iPhone specific items. For the iPhone specific items, one items was added to confirm whether participants had the Screen Time application activated on their iPhone prior to the study. Only those who confirmed prior activation were asked the remainder of the Screen Time items. The three main Screen Time measures (e.g., total Screen Time, total pickups, and notifications per day) were open-ended questions requesting a numerical input rather than a forced-choice selection. This was done to address the ceiling effect found in Study 1 and Study 2 for these measures. All other items were the same as in Study 1 and Study 2.

Smartphone Distraction and Comfort The distraction and comfort items were exactly the same as in Study 1 and Study 2.

[8]This item was the primary item used to assess complicity during Study 3.

Smartphone Location and Power Additional items were added to both the smartphone location and power items. The items added non-student specific situations such as "when I am working" and "when I am in a meeting". Additionally, only those who indicated they were a student in the employment and or industry items in the demographic questionnaire were asked the student-specific items for both the location (e.g., "*When I study, I keep my phone*") and power (e.g., "*When I am in a lecture, I tend to keep my phone on.*") items.

Exploratory Items Two additional exploratory items replaced the communication and type of use items from Study 1 and Study 2. These items asked participants (1) whether they required their smartphone for work purposes and (2) if they required any company-specific applications for their work.

Measures of Smartphone Reliance The exact same smartphone reliance measures from Study 1 and Study 2 were used: the NMPQ (Yildirim and Correia, 2015), which measured nomophobia; the MPIQ (Walsh et al., 2010), which measured involvement, self-identity, and validation from others; and the smartphone attachment and dependency inventory-modified (Ruiz Pardo and Minda, 2021), which measured dependency, emotional attachment, accessibility, and distractibility.

Attention Check Items Three attention check items were used to measure whether a participant was paying attention throughout the survey component of the study. Each item asked participants to transform a word from lower-case to upper-case (e.g., "*This is an attention check, please type in the word "time" in all CAPS (i.e., the word "want" in all CAPS is: "WANT").*"; see Appendix J for more details).

Procedure

Participants were recruited via an online study pool. They completed the study through an online platform on Qualtrics and a custom CBS link. Once they provided implied consent, participants were randomly assigned to one of two smartphone location conditions: on their desk (i.e., "*desk*") or away from them (i.e., "*away*"). All participants were instructed to keep their smartphones face-down, powered on, and set to "silent" (i.e., no noise or vibration notifications). Additionally, participants were told to close any other browser tabs or other applications while completing the study. For more details, see Appendix K.

After participants have placed their phone in their respective locations, they completed the 12 CBS tasks in the same order from Study 2. These tasks were preceded by the following instructions, which reminded participants about their assigned smartphone location and gave them a brief description of the tests:

> *Reminder: Please ensure your phone is in the designated location given in the previous portion of the study. Your phone should be turned ON and on silent (i.e., with notifications, including vibrations, turned off).*
>
> *In this phase of the experiment, we want to collect information about various aspects of your cognition. Please complete the following tasks on your device. There are 12 tasks, and each will be explained with a short tutorial on the screen before it begins. You may repeat the tutorial if needed. Once you have started a task, please complete it to the best of your ability without stopping. Try your best to complete all tasks without a break, but if you require one, please do so during the tutorial portion of a task. You are not allowed to restart, pause, or repeat any task. Please try to respond as quickly as you can, however, not at the expense of your performance.*

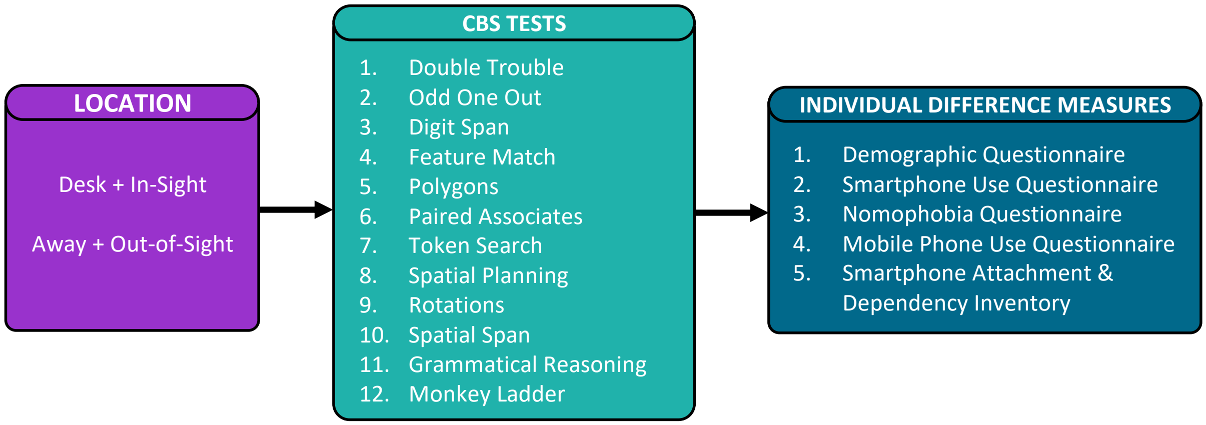
After completing the tasks, participants completed the survey component of the study, starting with the Demographic Questionnaire (modified for Study 3) and Smartphone Use Questionnaire (modified for Study 3). Then, all smartphone reliance measures were completed: the NMPQ (Yildirim and Correia, 2015), the MPIQ (Walsh et al., 2010), and the modified smartphone attachment and dependency inventory. The three attention check items were presented in the following order: Demographic and Smartphone Use Questionnaire, attention check (item 1), NMPQ, attention check (item 2), MPIQ, attention check (item 3), Smartphone Attachment and Dependency Inventory. Once they finished the questionnaires, participants were shown a downloadable debriefing form. The study took approximately 60 minutes to complete. Participants received credit for their participation. As shown in Figure 3.13, the final paradigm of for Study 3 used the "sight" items in the manipulation check to determine complicity with participants' assigned smartphone location.

3.4.2 Results

Since Study 3 was meant to be a conceptual replication of Study 2, the following results describe Study 3 results and how they compared to Study 2. The present study's analyses, including and exploratory analyses can be found on OSF (osf.io/n3vrz).

The present study asked participants to place their smartphone either on their desk or away from them during the CBS tests. After completing the tests, participants were asked manipulation check questions, which assessed their complicity with the instructions. The following

Figure 3.13: *Study 3 paradigm.*



Note. Schematic depicts the final paradigm for Study 3. Each participant was first randomly assigned to one of two location conditions: on your desk (i.e., desk) or away from you (i.e., away). Then, participants completed the 12 Cambridge Brain Sciences (CBS) tests in the same randomized order. Finally, participants completed the five individual difference measures in the same order. All participants completed Study 3 online over a single 60-minute session.

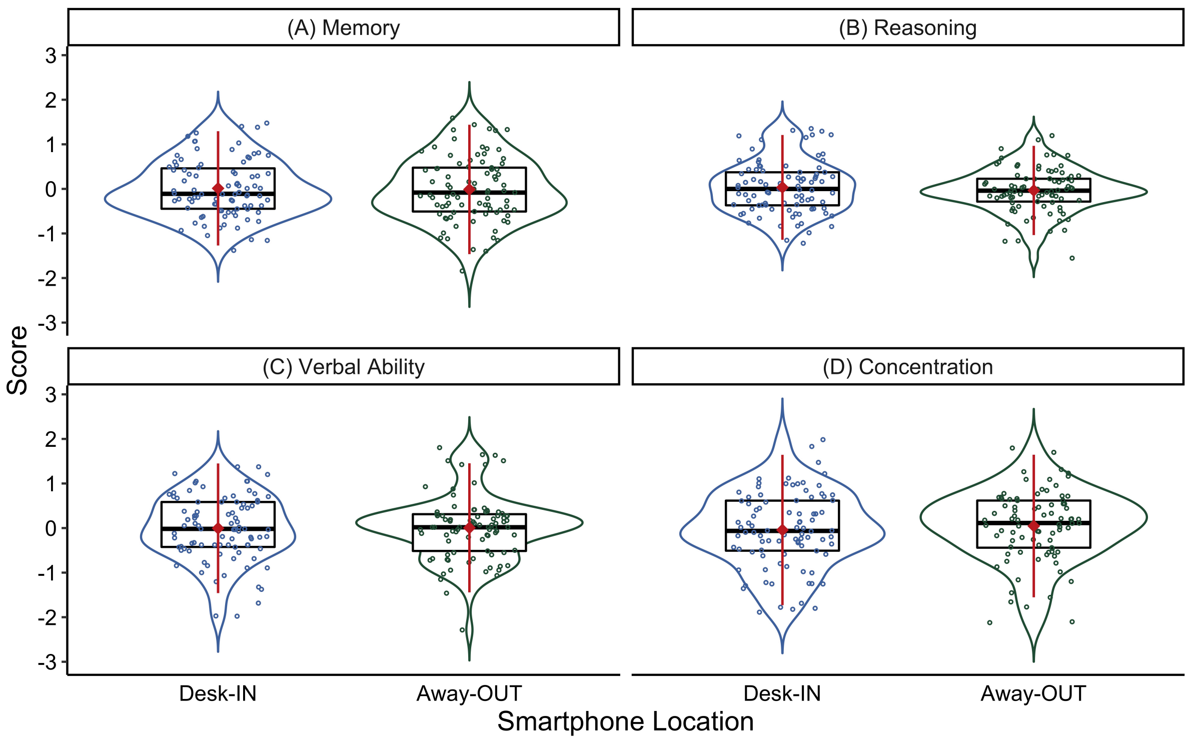
analyses only included participants who reported their smartphone was in-sight for the desk condition and out-of-sight for the away condition. These final smartphone locations conditions will be referred to as "desk-IN" and "away-OUT", respectively.

Battery of Cognitive Tests

Cambridge Brain Sciences Composite Scores The CBS composite scores were calculated exactly as in Study 2. Therefore, the memory composite score included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. The reasoning composite score included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. The verbal ability composite score included performance on Grammatical Reasoning and Digit Span. The concentration or attention composite score included performance on Feature Match and Double Trouble.

Assessing the Effect of Smartphone Location The effect of smartphone location on performance was assessed using an independent samples t-test for each composite score. Therefore, four t-tests with the independent variable of smartphone location (i.e., desk-In and away-IN) and dependent variable of CBS composite score were completed. For all t-test, the assumptions of normality and homogeneity were met. Since multiple t-tests were completed on the same data, a Holm-Bonferroni adjustment was used to account for multiple comparisons. Smartphone location did not significantly effect performance on memory, $t(173) = 0.24$, $p = .812$, $p_{adj.} = 1.000$, $d = .04$, reasoning, $t(173) = 0.83$, $p = .406$, $p_{adj.} = 1.000$, $d = .13$, verbal ability, $t(173) = -0.09$, $p = .927$, $p_{adj.} = 1.000$, $d = .01$, and concentration or attention, $t(173) = -0.72$, $p = .475$, $p_{adj.} = 1.000$, $d = .11$ (see Table 3.29. Therefore, there were no performance differences between placing one's smartphone on your desk, within your line-of-sight, and away from you, outside of your line-of-sight across all cognitive areas (see Figure 3.14).

Figure 3.14: *Comparing performance on the four CBS composite scores between smartphone location conditions in Study 2: Visual depiction of ANOVA tests.*



Note. For each composite score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Cambridge Brain Sciences (CBS) composite scores were calculated by averaging the standardized score for the included CBS tests for each participant. Panel A depicts the memory composite score, which included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. Panel B depicts the reasoning composite score, which included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. Panel C depicts the verbal ability composite score, which included performance on Grammatical Reasoning and Digit Span. Panel D depicts the concentration or attention composite score, which included performance on Feature Match and Double Trouble. $N = 175$.

Given the predictions made based on Study 2, two independent samples t-tests were completed for the verbal ability CBS tests: digit span and grammatical reasoning. This was done to assess if the findings from Study 2 were replicated. The assumptions of normality and homogeneity were met for both t-tests. There was no significant effect of smartphone location on

Table 3.29: Descriptive statistics for CBS composite scores by smartphone location and overall in Study 3.

Composite CBS scores as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Memory				
	M	0.02	0.04	0.03
	SD	0.72	0.64	0.68
	Min.	-1.79	-1.35	-1.79
	Max.	1.62	1.49	1.62
Reasoning				
	M	0.00	0.07	0.03
	SD	0.51	0.59	0.55
	Min.	-1.54	-1.20	-1.54
	Max.	1.24	1.39	1.39
Verbal Ability				
	M	0.04	0.03	0.03
	SD	0.70	0.70	0.70
	Min.	-2.16	-1.88	-2.16
	Max.	1.77	1.36	1.77
Concentration/Attention				
	M	0.08	0.00	0.04
	SD	0.79	0.82	0.80
	Min.	-2.03	-1.80	-2.03
	Max.	1.81	1.99	1.99

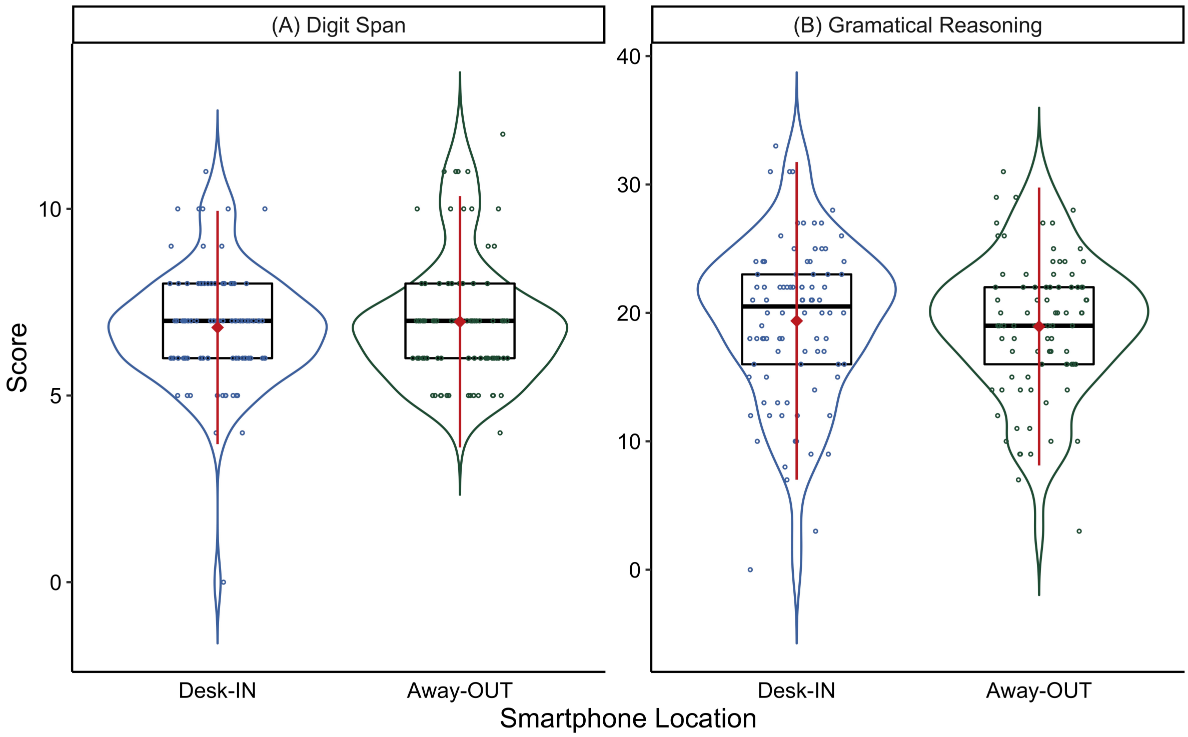
Note. Cambridge Brain Science (CBS) composite scores were calculated by averaging the standardized score for the included CBS tests for each participant. Memory included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. Reasoning included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. Verbal Ability included performance on Grammatical Reasoning and Digit Span. Concentration/Attention included performance on Feature Match and Double Trouble.
$N = 175$

digit span, $t(173) = -0.63$, $p = .530$, $p_{adj.} = 1.000$, $d = .10$, and grammatical reasoning, $t(173) = 0.50$, $p = .621$, $p_{adj.} = 1.000$, $d = .07$ (see Table 3.30 for descriptive statistics). Therefore, there were no performance differences between placing one's smartphone on your desk (within your line-of-sight) and away from you (outside of your line-of-sight) for either verbal ability measure (see Figure 3.15).[9]

Correlation Analysis A Pearson correlation analysis was completed to explore the relationship between all 12 CBS scores and the four composite scores. As shown in Figure 3.16, most CBS tests were positively and significantly correlated with all four composite scores. Similar to Study 2, the odd one out test was the only CBS test that was only significantly correlated to reasoning (i.e., the composite score it belongs to), $r(173) = .44$, $p < .001$. The digit span test was significantly correlated to all CBS composite scores except for reasoning, $r(173) = .08$, $p = .315$. The spatial span test was significantly correlated to all CBS composite scores except for verbal ability, $r(173) = .13$, $p = .090$. All other individual CBS tests were significantly cor-

[9] A supplementary analysis completed individual t-tests for all Cambridge Brain Sciences tests and found no effect of smartphone location on any test. See Appendix L for more details.

Figure 3.15: *Comparing performance on digit span and grammatical reasoning scores between smartphone location conditions in Study 2: Visual depiction of ANOVA tests.*



Note. For each Cambridge Brain Sciences (CBS) test score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Test were assessed for a secondary analysis exploring the driving force behind the effect of smartphone location on the verbal ability composite score. Panel A depicts performance on the digit span test. Panel B depicts performance on the grammatical reasoning test. $N = 175$.

related to all other composite scores, regardless of which composite score they were associated with, $r(173) = .16$ to $.82$, $p < .041$.

Additionally, most CBS tests were inter-correlated, with some exceptions. For the memory tests, all except the monkey ladder and paired associates tests, $r(173) = .14$, $p = .059$, were significantly correlated with each other, $r(173) = .25$ to $.39$, $p < .001$ (see Table 3.31 for descriptive statistics). For the reasoning composite tests, there were only two significant correlations between the related tests: spatial planning and polygons, $r(173) = .16$, $p = .033$, and rotations, $r(173) = .16$, $p = .039$. All other test correlations included in the reasoning composite score were not significantly related, $r(173) = -.05$ to $.11$, $p > .158$ (see Table 3.32 for descriptive statistics). For the verbal ability composite score, digit span and grammatical reasoning had a non-significant correlation, $r(173) = .05$, $p = .536$ (see Table 3.30 for descriptive statistics). Lastly, for the concentration or attention composite score, the feature match and

Table 3.30: Descriptive statistics for digit span and grammatical reasoning by smartphone location and overall in Study 2.

Raw CBS scores for verbal ability tests as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Grammatical Reasoning				
	M	18.94	19.38	19.17
	SD	5.41	6.19	5.81
	Min.	3	0	0
	Max.	31	33	33
Digit Span				
	M	6.98	6.82	6.90
	SD	1.68	1.56	1.62
	Min.	4	0	0
	Max.	12	11	12

Note. Cambridge Brain Science (CBS) score was the overall score (Grammatical Reasoning), or maximal level completed (Digit Span).
$N = 175$

double trouble test scores were significantly correlated, $r(173) = .35$, $p < .001$ (see Table 3.33 for descriptive statistics). All composite scores had a significant positive correlation with each other, $r(173) = .27$ to $.41$, $p < .001$. For more details about the correlation results, see Table 3.34.

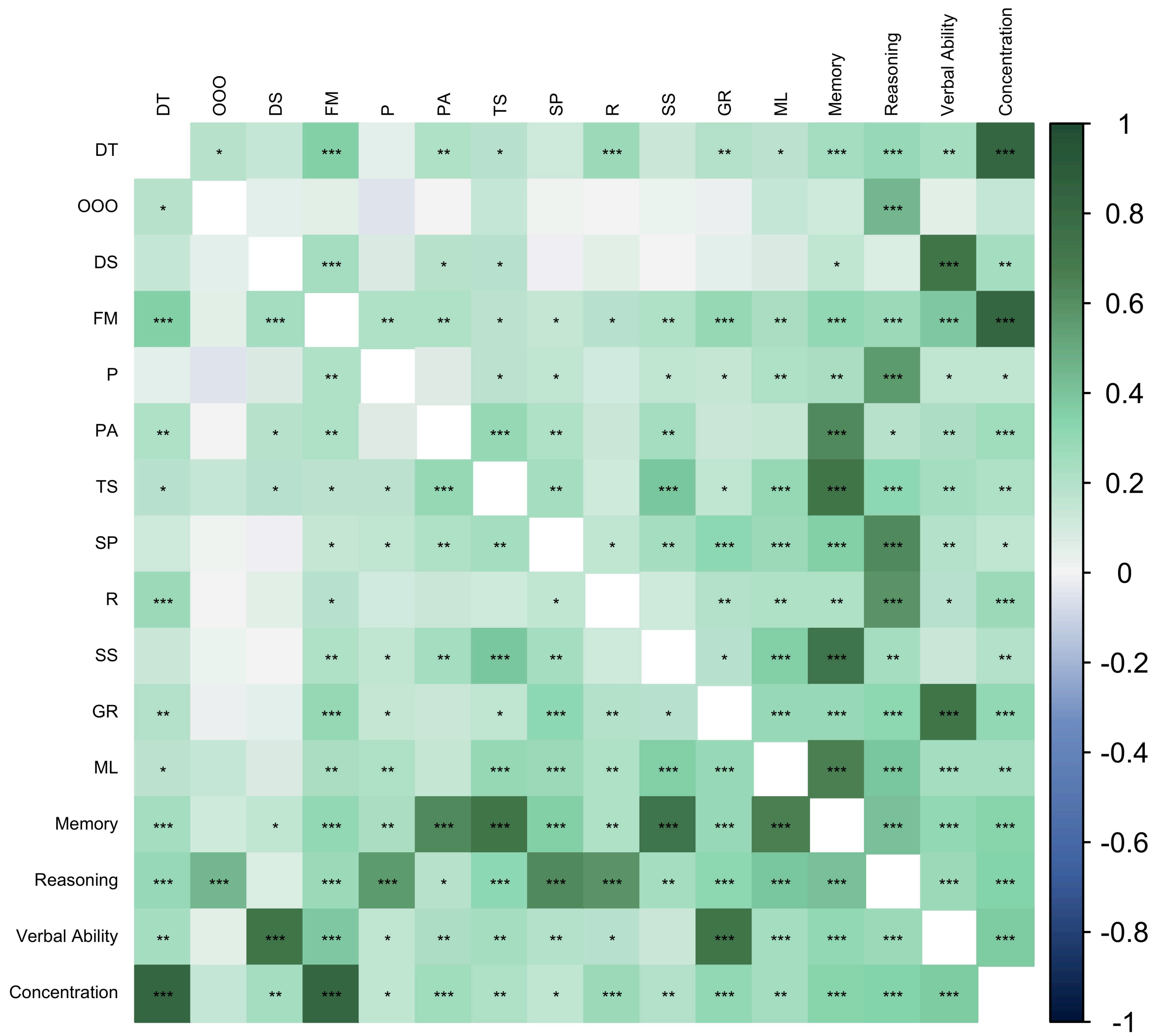
Table 3.31: Descriptive statistics for the memory CBS tests by smartphone location and overall for Study 3.

Raw CBS scores for memory tests as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Monkey Ladder				
	M	7.86	8.12	7.99
	SD	1.19	1.06	1.13
	Min.	5	4	4
	Max.	11	11	11
Spatial Span				
	M	6.27	6.20	6.23
	SD	1.08	1.00	1.04
	Min.	4	4	4
	Max.	9	9	9
Token Search				
	M	8.34	8.26	8.30
	SD	1.84	1.51	1.68
	Min.	4	5	4
	Max.	13	11	13
Paired Associates				
	M	5.08	5.07	5.07
	SD	0.95	0.98	0.97
	Min.	3	3	3
	Max.	7	7	7

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
$N = 175$

Figure 3.16: *Correlation matrix of the 12 CBS test scores and composite scores in Study 3.*



Note. Correlation matrix for the 12 Cambridge Brain Sciences (CBS) tests and composite scores (calculated by averaging the standardized score for the included CBS tests for each participant). The memory composite score included performance on Monkey Ladder (ML), Spatial Span (SS), Token Search (TS), and Paired Associates (PA). The reasoning composite score included performance on Rotations (R), Polygons (P), Odd One Out (OOO), and Spatial Planning (SP). The verbal ability composite score included performance on Grammatical Reasoning (GR) and Digit Span (DS). The concentration or attention composite score included performance on Feature Match (FM) and Double Trouble (DT). $N = 237$.
**p* < .05. ***p* < .01. ****p* < .001.

The Smartphone Use Questionnaire

Since Study 3 collected the same smartphone use measures, the following results describe not only how the data described the sample, but also how this compared to Study 1 and Study 2. This comparison was explored to ensure that the samples were comparable across studies and

Table 3.32: Descriptive statistics for the reasoning CBS tests by smartphone location and overall for Study 3.

Raw CBS scores for reasoning tests as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Rotations				
	M	92.14	88.74	90.39
	SD	35.25	42.23	38.92
	Min.	-7	-2	-7
	Max.	171	198	198
Polygons				
	M	47.93	51.50	49.77
	SD	21.81	23.50	22.70
	Min.	-4	2	-4
	Max.	107	107	107
Odd One Out				
	M	8.56	9.21	8.90
	SD	3.99	3.96	3.98
	Min.	-2	-1	-2
	Max.	16	20	20
Spatial Planning				
	M	23.36	23.76	23.57
	SD	8.28	9.85	9.09
	Min.	5	0	0
	Max.	41	50	50

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
N = 175

Table 3.33: Descriptive statistics for the concentration or attention CBS tests by smartphone location and overall for Study 3.

Raw CBS scores for concentration/attention tests as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Feature Match				
	M	136.18	134.23	135.18
	SD	33.66	30.82	32.15
	Min.	70	55	55
	Max.	210	210	210
Double Trouble				
	M	30.00	28.43	29.19
	SD	12.48	14.05	13.30
	Min.	-4	-6	-6
	Max.	55	51	55

Note. Cambridge Brain Science (CBS) score was the overall score for each test.
N = 175

to explore consistent or fluctuating patterns with respect to smartphone use across studies.

Typical Smartphone Use Participants reported getting their first smartphone at a similar age to our previous studies (M = 13.12, SD = 2.74, range = 5-37). Smartphone users (76.00 %) and iPhone users (71.77 %) reported their most used application was a social media application,

Table 3.34: Correlation matrix of the 12 CBS test scores and composite scores in Study 3.

CBS tests and composite scores as Pearson r correlations for study 3.

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Individual CBS Tests																
1. Double Trouble	–															
2. Odd One Out	.19*	–														
3. Digit Span	.14	.05	–													
4. Feature Match	.35***	.05	.25***	–												
5. Polygons	.05	-.05	.08	.21**	–											
6. Paired Associates	.21**	.00	.18*	.22**	.07	–										
7. Token Search	.18*	.14	.19*	.17*	.18*	.29***	–									
8. Spatial Planning	.12	.02	-.01	.15*	.16*	.21**	.24**	–								
9. Rotations	.27***	.00	.05	.19*	.11	.12	.11	.16*	–							
10. Spatial Span	.12	.02	.00	.21**	.16*	.25**	.39***	.23**	.12	–						
11. Grammatical Reasoning	.20**	.02	.05	.30***	.15*	.14	.16*	.31***	.20**	.19*	–					
12. Monkey Ladder	.17*	.14	.08*	.23**	.22**	.14***	.29***	.28***	.21**	.36***	.28***	–				
CBS Composite Scores																
13. Memory	.25***	.11	.16	.30***	.23**	.61***	.72***	.35***	.21**	.74***	.28***	.65***	–			
14. Reasoning	.28***	.44***	.08	.28***	.56***	.18*	.31***	.60***	.58***	.24**	.31***	.39***	.41***	–		
15. Verbal Ability	.24**	.05	.73***	.38***	.16*	.22**	.24**	.20**	.18*	.13	.72***	.25***	.30***	.27***	–	
16. Concentration / Attention	.81***	.14	.24***	.83***	.16*	.26***	.21**	.17*	.28***	.20**	.30***	.25**	.34***	.34***	.38***	–

Note. Pearson correlations between the 12 Cambridge Brain Science (CBS) individual tests and four composite scores. Four tests were included in the memory composite score (i.e., Monkey Ladder, Spatial Span, Token Search, and Paired Associates). Four tests were included in the reasoning composite score (i.e., Rotations, Polygons, Odd One Out, and Spatial Planning). Two tests were included in the verbal ability composite score (i.e., Grammatical Reasoning and Digit Span). Two tests were included in the concentration or attention composite score (i.e., Feature Match and Double Trouble).
$N = 175$
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

which was comparable to our previous studies. New smartphone use questions showed that 36.57 % of participants used their smartphone for work and 38.29 % used company-specific applications. Similar to our previous studies, subjective value for one's phone was the lowest presented option of $0-$20 (32.00 %). Most participants experienced phantom vibrations (81.14 %), which was similar to our previous studies; see Table 3.35 for a more detailed breakdown by smartphone location).

The Screen Time measures depicted a downwards trend from our first studies compared to Study 2 (M = 18.90, SD = 19.25, range = 2-96.5) in total hours. The number of pickups per day was in between the ranges form our previous studies (M = 121.69, SD = 128.01, range = 1-969). Notifications per day was comparable to our previous studies (M = 188.39, SD = 152.33, range = 3-909; see Table 3.36 for more details).

Distraction and Comfort Levels In line with Study 1 and 2, and with increased proportions, participants reported their phone as the most distracting device in general (92.57 %), while studying or working (90.29 %), and in a social context (97.17 %). Participants reported being somewhat distracted by their smartphone during daily activities (M = 5.83, SD = 1.21), but disagreed with being distracted by their smartphone during the study (M = 2.49, SD = 1.61), which aligned with Study 2. With respect to comfort levels of being without one's smartphone, participants reported being neutral to leave their phones with others or unattended, and tended to report leaving their phone locked while out of their possession. Participants reported being neutral to almost in agreement when asked if they would feel comfortable leaving their phone

Table 3.35: Descriptive statistics and frequency counts for smartphone use questionnaire measures for all smartphone users in Study 3.

Smartphone use questionnaire responses as descriptive statistics and frequency counts for all smartphone users by smartphone location and overall for study 3.

Measure	Desk-IN	Away-OUT	Overall
Age of first smartphone			
M	13.32	12.93	13.12
SD	3.18	2.24	2.74
Min.	8	5	5
Max.	37	21	37
Most used application			
Games	3	2	5
Social Networking	65	68	133
Entertainment	15	19	34
Business/Productivity	0	0	0
Other	1	1	2
Subjective value			
\$0-\$20	22	34	56
\$21-\$40	15	16	31
\$41-\$60	26	19	45
>\$60	22	21	43
Phantom vibrations			
Yes	69	73	142
No	16	17	33
Smartphone for work			
Yes	36	28	64
No	24	23	47
Does not apply	25	39	64
Company-specific application			
Yes	36	31	67
No	23	20	43
Does not apply	26	39	65

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
$N = 175$

in another room during a task (see Table 3.37 and Table 3.38 for more details). These findings were in agreement with results from Study 1 and 2.

Smartphone Power and Location Participants reported a tendency to keep their smartphone powered on when they are not using it, with notifications turned on, and on vibrate. They tended to have their smartphone powered on while studying and in a lecture. But were less likely to do so while sleeping or during a meeting. During an exam, participants reported being more likely to turn their phone off. These patterns were the same as in Study 1 and 2 (see Table 3.39 for more details).

Across the same situations presented in Study 1 and 2 (i.e., study, exam, lecture typical, and social context), the same trends form our previous studies were seen with respect to smartphone location: 56.37 % participants reported leaving their smartphone in their pocket or bag across

Table 3.36: Descriptive statistics and frequency counts for smartphone use questionnaire measures for iPhone user in Study 3.

Smartphone use questionnaire responses as frequency counts for all iPhone users for study 3.

Measure	Desk-IN (60)	Away-OUT (64)	Overall (124)
Screen Time (hours)			
M	18.27	19.50	18.90
SD	18.14	20.36	19.25
Min.	2	2	2
Max.	70	96.5	96.5
Pickups (per day)			
M	134.20	109.95	121.69
SD	94.16	152.97	128.01
Min.	1	4	1
Max.	492	969	969
Notifications (per day)			
M	216.60	161.94	188.39
SD	160.43	140.47	152.33
Min.	6	3	3
Max.	783	909	909
Most used application			
Games	1	1	2
Social Networking	43	46	89
Entertainment	12	16	28
Business/Productivity	0	0	0
Other	4	1	5
Most used application was text/messenger			
Yes	20	18	38
No	40	46	86

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Only those who reported having an iPhone (n = 153) and reported having their Screen Time application activated prior to the study (n = 124) completed the measures. All measures self-reported from participant's Screen Time application on their iPhone, which tracks their device use (i.e., the type and duration of use). Sample size for each device shown in parentheses.

situations (followed by on their desk, 44.60 %; and in another room, 10.52 %). However, when looking across the new situations added for Study 3 (i.e., work and meeting), the trend dissipated with most participants placing their smartphone on their desk (45.18 %), followed by in their pocket or bag (43.01 %), and in another room (9.74 %; see Table 3.40). This trend was explored further by looking at which location represented more than half of the participants for each situation (i.e., more than 88 participants) across the assigned conditions. Over half of participants reported keeping their smartphone on their desk for two situations (i.e., while studying, and typically), in their pocket or bag for two situations (i.e., in a social setting and during a meeting), and in another room for no situations. Therefore, the most frequent phone placement was between on one's desk and in one's pocket or bag.

Table 3.37: Descriptive statistics and frequency counts for distraction measures in Study 2.

Smartphone use questionnaire responses for distraction measures as frequency counts for study 3.

Measure	Desk-IN	Away-OUT	Overall
Distracted during daily activities			
M	5.75	5.90	5.83
SD	1.28	1.15	1.21
Min.	1	2	1
Max.	7	7	7
Distracted during study			
M	2.71	2.28	2.49
SD	1.66	1.54	1.61
Min.	1	1	1
Max.	7	7	7
Most distracting device: General*			
Computer	4	8	12
Phone	80	82	162
iPad / Tablet	1	0	1
Most distracting device: Studying/Working*			
Computer	7	9	16
Phone	77	81	158
Smartwatch	1	0	1
Most distracting device: Social Context			
Computer	0	0	0
Phone	83	87	170
iPad / Tablet	0	1	1
Smartwatch	1	0	1
Other	1	2	3

* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Smartwatch" and "Other" for Most distracting device: General; "iPad / Tablet" and "Other" for Most distracting device: Studying/Working.
N = 175

Table 3.38: Descriptive statistics and frequency counts for comfort measures in Study 2.

Smartphone use questionnaire responses for the comfort level measures as descriptive statistics for study 3.

Measure	Desk-IN	Away-OUT	Overall
I am comfortable with letting others use my phone.			
M	4.33	4.47	4.40
SD	1.75	1.84	1.79
I leave my phone unattended.			
M	4.55	4.83	4.70
SD	1.78	1.63	1.71
I leave my phone with other people.			
M	3.99	4.30	4.15
SD	1.84	1.68	1.76
I make sure my phone is locked when it is not in my hands.			
M	5.12	5.36	5.24
SD	1.57	1.38	1.48
I would feel comfortable leaving my phone in another room while completing a task.			
M	5.32	5.46	5.39
SD	1.56	1.64	1.60

Note. Minimum value (1) and maximum value (7) for each measure was identical.
N = 175

Table 3.39: Descriptive statistics and frequency counts for smartphone power measures in Study 3.

Smartphone use questionnaire responses for the power paradigm decision measures as descriptive statistics for study 3.

Measure		Desk-IN	Away-OUT	Overall
I tend to turn my phone off when I am not using it.				
	M	3.81	3.19	3.49
	SD	2.20	2.01	2.12
I tend to have my notifications turned on.				
	M	4.65	4.60	4.62
	SD	1.94	1.90	1.92
I tend to have my phone on vibrate.				
	M	4.81	5.01	4.91
	SD	2.17	2.11	2.14
Phone is on: Study*				
	M	5.34	5.29	5.31
	SD	1.46	1.49	1.47
Phone is on: Exam*				
	M	2.89	2.47	2.68
	SD	1.91	1.60	1.77
Phone is on: Lecture*				
	M	5.08	4.95	5.01
	SD	1.56	1.51	1.53
Phone is on: Work				
	M	5.02	5.11	5.07
	SD	1.63	1.36	1.50
Phone is on: Meeting				
	M	3.78	3.82	3.80
	SD	2.01	1.77	1.88
Phone is on: Sleep				
	M	4.36	4.52	4.45
	SD	2.15	2.02	2.08

Note. Measures used to determine typical smartphone use with respect to smartphone power. These results were compared to previous studies. Minimum value (1) and maximum value (7) for each measure was identical.
* Only participants who reported being a student responded (n = 150).
N = 175

Measures of Smartphone Reliance

Since Study 3 collected the same smartphone use measures, the following results describe not only how the data described the sample, but also how this compared to Study 1 and Study 2. This comparison was explored to ensure that the samples were comparable across studies and to explore consistent or fluctuating patterns with respect to smartphone use across studies.

As shown in Figure 3.17, all reliance measures were significantly and positively correlated, $r(173) = .15$ to .76, $p < .042$. Although some correlations were weaker, these results aligned with Study 2. The strongest correlations were between dependency and self-identity, $r(173) = .76$, $p < .001$, dependency and nomophobia, $r(173) = .72$, $p < .001$, and nomophobia and involvement, $r(173) = .71$, $p < .001$, respectively. This was similar to our previous studies, where nomophobia and involvement was the strongest correlation (see Table 3.41 and Table

Table 3.40: Descriptive statistics and frequency counts for smartphone location measures in Study 3.

Smartphone use questionnaire responses for the location paradigm decision measures as frequency counts for study 3.

Measure	Desk-IN	Away-OUT	Overall
Location: Typical			
On Desk	47	52	99
Pocket / Bag	37	37	74
Another room	1	1	2
Location: Working			
On Desk	40	44	84
Pocket / Bag	36	31	67
Another room	4	11	15
Does not apply	5	4	9
Location: Meeting			
On Desk	27	21	48
Pocket / Bag	49	52	101
Another room	3	6	9
Does not apply	6	11	17
Location: Social Setting			
On Desk	14	11	25
Pocket / Bag	70	77	147
Another room	1	2	3
Location: Study*			
On Desk	59	62	121
Pocket / Bag	9	9	18
Another room	6	5	11
Does not apply	11	14	25
Location: Exam*			
On Desk	19	16	35
Pocket / Bag	36	24	60
Another room	18	36	54
Does not apply	1	0	1
Location: Lecture*			
On Desk	40	46	86
Pocket / Bag	33	26	59
Another room	0	4	4
Does not apply	1	0	1

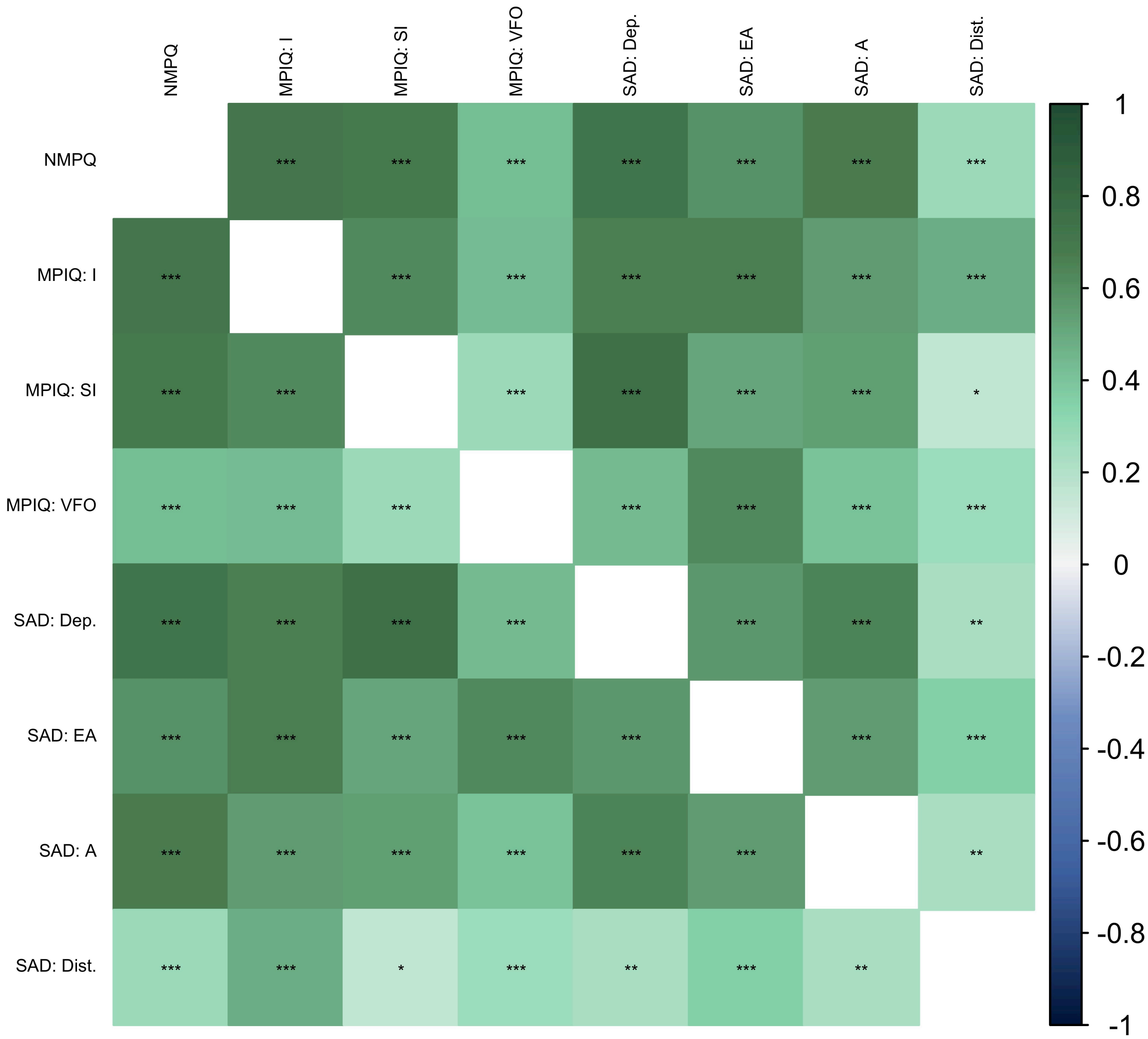
* Only participants who reported being a student responded (n = 150).
N = 175

3.42 for more details on the correlations, and descriptive statistics, respectively)[10].

In order to compare the level of reliance for each measure, each was split into levels: low, moderate, and high. This was done exactly as in Study 1 and 2. Across all reliance measures, 51.64 % of participants were in the moderate level of a reliance measure, followed by 32.22 % in high level, and 16.14 % in the low level. These proportions were similar to Study 1 and 2. As shown in Figure 3.18, four measures had over half of their proportion in the moderate

[10]Our measures in Study 3 generally displayed adequate levels of internal consistency (i.e., standardized Cronbach's $\alpha \geq .70$; $\alpha_{Nomophobia} = .94$, $\alpha_{Involvement} = .85$, $\alpha_{Self-Identity} = .80$, $\alpha_{ValidationfromOthers} = .82$, $\alpha_{Dependency} = .86$, $\alpha_{EmotionalAttachment} = .73$, $\alpha_{Accessibility} = .73$, $\alpha_{Distractibility} = .66$). It should be noted that, as in Study 1 and Study 2 the Distractibility subscale of the Smartphone Attachment and Dependency Questionnaire (Ward et al., 2017) was below the cut-off and our findings regarding this measure should be interpreted with caution.

Figure 3.17: *Correlation matrix of smartphone reliance measures in Study 3.*



Note. Correlation matrix for smartphone reliance measures for the three questionnaires: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). $N = 237$.
* $p < .05$. ** $p < .01$. *** $p < .001$.

level: nomophobia, involvement, emotional attachment, and accessibility. Distractibility was the only measure that had over half of participants in the high level. These findings are similar to our previous studies. For further details, please see Table 3.43.

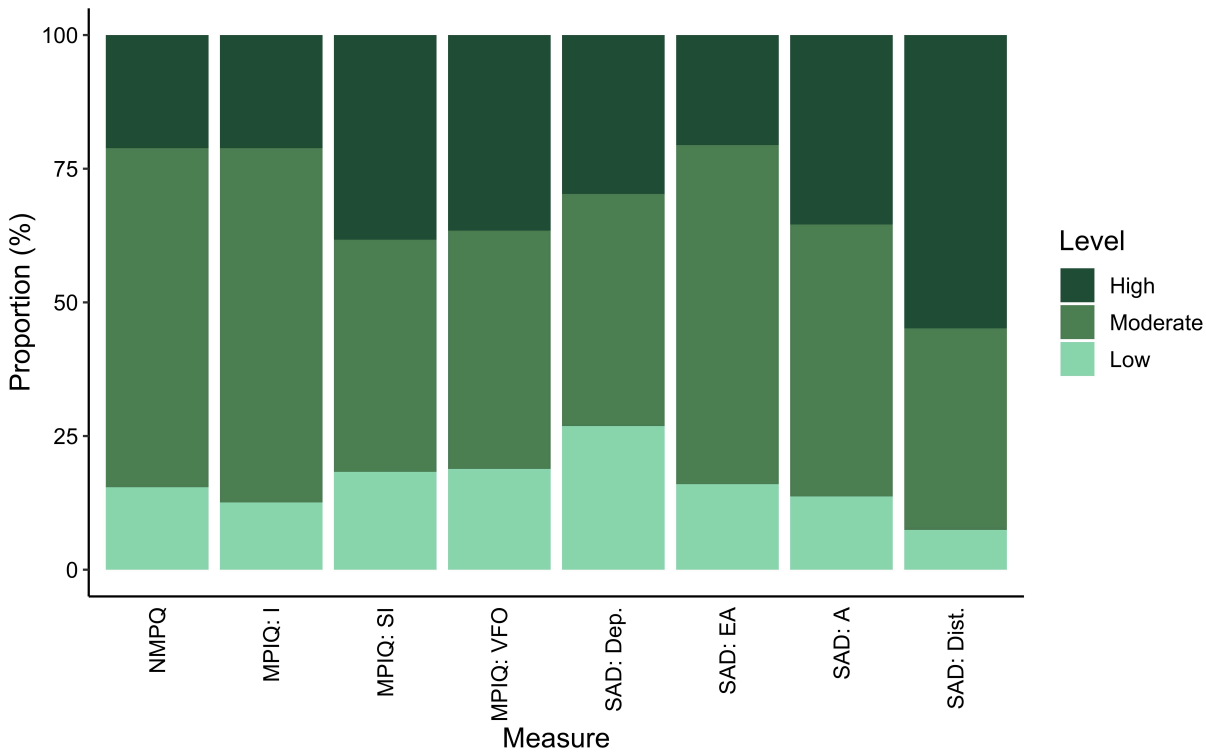
Table 3.41: Correlation results for smartphone reliance measures in Study 3.

Smartphone reliance measures as Pearson r correlations for study 3.

Measure	1	2	3	4	5	6	7	8
1. Nomophobia Questionnaire	–							
Mobile Phone Involvement Questionnaire								
2. Involvement	.71***	–						
3. Self-Identity	.69***	.62***	–					
4. Validation from Others	.42***	.43***	.27***	–				
Smartphone Attachment and Dependency Inventory								
5. Dependency	.72***	.66***	.76***	.43***	–			
6.Emotional Attachment	.59***	.67***	.51***	.62***	.56***	–		
7. Accessibility	.67***	.55***	.54***	.41***	.64***	.55***	–	
8. Distractibility	.28***	.48***	.15*	.27***	.23**	.36***	.23**	–

N = 175
*p < .05. **p < .01. ***p < .001.

Figure 3.18: *Smartphone reliance measures as proportion of participants in the low, moderate, or high level in Study 3.*



Note. Stacked bar graph for smartphone reliance measures by levels as proportions. Each level was decided by splitting up the range of possible scores for each each measure into three levels: low, moderate, and high. Each reliance measure is shown as an acronym for visualization purposes: Nomophobia (NMPQ); the three Mobile Phone Involvement subscales, Involvement (MPIQ: I), Self-Identity (MPIQ: SI), and Validation from Others (MPIQ: VFO); and the four Smartphone Attachment and Dependency subscales, Dependency (SAD: Dep.), Emotional Attachment (SAD: EA), Accessibility (SAD: A), and Distractibility (SAD: Dist.). *N* = 122.

Table 3.42: Descriptive statistics for smartphone reliance measures in Study 3.

Smartphone reliance measures as descriptive statistics by smartphone location and overall for study 3.

	Measure	Desk-IN	Away-OUT	Overall
Nomophobia				
	M	85.01	79.47	82.16
	SD	21.37	22.63	22.14
	Min.	36	30	30
	Max.	132	140	140
Mobile Phone Involvement Questionnaire				
Involvement				
	M	33.29	32.09	32.67
	SD	7.99	7.76	7.87
	Min.	14	13	13
	Max.	53	49	53
Self-Identity				
	M	13.47	12.19	12.81
	SD	4.10	4.16	4.17
	Min.	5	4	4
	Max.	21	21	21
Validation from Others				
	M	13.56	12.12	12.82
	SD	3.88	3.95	3.98
	Min.	3	3	3
	Max.	21	20	21
Smartphone Attachment and Dependency Inventory				
Dependency				
	M	12.35	10.89	11.60
	SD	4.54	4.87	4.75
	Min.	3	3	3
	Max.	20	21	21
Emotional Attachment				
	M	16.98	15.42	16.18
	SD	4.51	4.44	4.53
	Min.	4	5	4
	Max.	26	26	26
Accessibility				
	M	13.62	12.53	13.06
	SD	3.78	3.93	3.88
	Min.	4	3	3
	Max.	21	21	21
Distractibility				
	M	9.33	9.41	9.37
	SD	2.81	2.60	2.70
	Min.	2	2	2
	Max.	14	14	14

$N = 175$

3.4.3 Interim Discussion

Study 3 investigated the effect of smartphone location on different aspects of cognition using a battery of cognitive tests in an online platform. Based on Study 2, we predicted that smartphone location would affect performance on the verbal ability CBS composite score and on the digit span test. That is, that those who placed their smartphone on their desk would have the worst performance. This primary analysis sought to replicate our findings from Study 2.

Table 3.43: Frequency counts for smartphone reliance measures by level in Study 3.

Smartphone reliance measures as frequency counts by levels for study 3.

Measure	# Items	Likert Range	Possible Score	Levels Low	Moderate	High
Nomophobia Questionnaire						
Nomophobia	20	1-7	20-140	27	111	37
				(20-59)	(60-99)	(100-140)
Mobile Phone Involvement Questionnaire						
Involvement	8	1-7	8-56	22	116	37
				(8-23)	(24-39)	(40-56)
Self-Identity	3	1-7	3-21	32	76	67
				(3-8)	(9-14)	(15-21)
Validation from Others	3	1-7	3-21	33	78	64
				(3-8)	(9-14)	(15-21)
Smartphone Attachment and Dependency Inventory						
Dependency	3	1-7	3-21	47	76	52
				(3-8)	(9-14)	(15-21)
Emotional Attachment	3	1-7	3-21	28	111	36
				(3-8)	(9-14)	(15-21)
Accessibility	4	1-7	4-28	24	89	62
				(4-11)	(12-19)	(20-28)
Distractibility	2	1-7	2-14	13	66	96
				(2-5)	(6-9)	(10-14)

Note. Score value ranges for each respective level shown in parentheses.
$N = 175$

However, we did not replicate the smartphone location effect. There was no performance differences between those who placed their smartphone on their desk and in their line-of-sight and those who placed their smartphone away from them and out of their line-of-sight for any CBS measures. A secondary analysis of the verbal ability tests (i.e., digit span and grammatical reasoning) showed no effect on either test. Although Study 3 replicated the null effects found in Study 2 (i.e., no effect on memory, reasoning, or concentration or attention composite scores, and grammatical reasoning), Study 3 failed to replicate any effect of smartphone presence on cognition. This expands the current literature which states that smartphone presence does not impact our cognition in intrinsically, but rather active smartphone use or underlying smartphone reliance are the important factors (Courtright and Caplan, 2020; Liebherr et al., 2020). These factors were assessed in our study with our smartphone reliance measures.

Our correlation analysis between the CBS composite scores and themselves, and the individual CBS tests in Study 3 aligned with our previous studies. For the memory and concentration or attention composite scores, the findings supported that each test was related to the other test(s) in the same cognitive area. As in Study 2, the verbal ability tests (i.e., digit span and grammatical reasoning) were not significantly related to each other. This poor relationship between the two tests provided evidence against the task selection guide's (Cambridge Brain Sciences, 2018c) cognitive areas and suggested that digit span may belong with the memory area and grammatical reasoning with the reasoning area. In contrast to Study 2, Study 3 found that most correlations for the reasoning composite score tests were not significantly related. This again suggested that the cognitive areas defined by the CBS task selection guide (Cambridge Brain Sciences, 2018c) are outdated or in need of revision.

As in our previous studies, all smartphone reliance measures (e.g., nomophobia, involvement, dependency) were at least weak-to-moderately related. Therefore, those who had higher levels of one reliance measure tended to have higher levels in the other measures. This replicated the findings from Study 2. In contrast to Study 2, the strongest correlation was between dependency and self-identity (rather than nomophobia and involvement, which was third-strongest). Comparing low, moderate, and high levels of each reliance measure confirmed that, as in Study 1 and 2, most participants have moderate reliance.

Smartphone use patterns depicted that most participants tend to use their smartphones for social media applications, keep their smartphone powered on, and keep their smartphone either on their desk or in their pocket or bag in most situations. The most distracting device was still identified as one's phone. Participants did not report feeling distracted by their smartphone during daily activities or during the study. For iPhone users, more specifically their Screen Time, participants showed less total screen time and daily pickups, but had similar notifications per day as Study 1 and 2.

There are several limitations to the findings in Study 3. Similar to Study 2, our sample was primarily university-aged students from one university. This meant that our participants were likely very familiar with their smartphone and were accustomed to its daily use during their regularly demanding tasks (e.g., course work). This is especially true considering the time in which the data were collected: during their second semester of a fully online year due to the COVID-19 pandemic. During this time students who had already been accustomed to their devices had a greater need to use these devices to stay connected with family, friends, and keep up with their course work. Therefore, it is likely that their frequency and type of smartphone use (and other devices) was increased from their normal typical nature. By this point, our participants may have been accustomed to their increased device presence and may even have developed better strategies to avoid being distracted by their smartphone. Future studies should consider the attrition and compliance rate for their desired final sample size. The present study asked participants to place their smartphone in two location conditions rather than the three from Study 2. This was done in order to provide the most discernible and clearly instructed conditions since participants were not in a lab setting. However, as shown in the data cleaning process, our participants might have struggled to follow the directions and showed an abundance of invalid test performance (according to the Cambridge Brain Sciences, 2019). From our total collected participants, 44.69 % showed at least one invalid test score and were removed. These two data cleaning instances drastically reduced our final analysis's sample and were counter productive to a benefit of online testing (i.e., larger sample sizes; Eyal et al., 2021; Woods et al., 2015).

Overall, it seems like smartphone presence on its own may not be enough to impact our cognition consistently. Future studies should investigate a wider age range and include a non-student population. Additionally, other individual difference measures that related to people's smartphone reliance should be explored to clarify which type of person may be more susceptible to developing a reliance on their smartphone.

3.5 General Discussion

Our general discussion elaborates on the trends we found across our three studies, how the trends expand the smartphone literature, the limitations of the findings, and future studies to continue exploring the smartphone phenomenon.

Three studies were completed to gauge people's typical smartphone use and frequency of use, the prevalence of smartphone reliance, and to determine whether smartphone presence affects our cognition. Study 1 was an online-based survey study where we obtained a baseline for typical smartphone tendencies (e.g., type and frequency of use, smartphone reliance measures) and determined which smartphone power and location tendencies should be explored in further studies. We found that, as predicted, most people tend to have their smartphone powered on and in their pocket or bag, followed by on their desk and very few in another room. Most of the smartphone reliance measures (e.g., nomophobia, involvement, dependency) were moderately or strongly related and suggested that those with higher levels of one measure tended to have higher levels of the other reliance measures. In Study 2, we completed an experiment to evaluate whether placing one's smartphone in one of three locations (i.e., on your desk, in your pocket or bag, or outside of the testing room) affected performance on a battery of cognitive tests (i.e., the 12 CBS tests; Hampshire et al., 2012). To do this, we first assessed each of the four cognitive areas defined by the CBS task selection guide (Cambridge Brain Sciences, 2018c): memory, reasoning, verbal ability, and concentration or attention. We predicted that smartphone location would affect the memory and attention-based areas, but found that only the verbal ability composite score was affected by smartphone location. There was lower performance for those who placed their smartphone on their desk compared to in their pocket or bag. This same effect was found for one of the two verbal ability tests (i.e., digit span). In order to explore whether our findings in Study 2 were stable and to see if a smartphone paradigm could be completed fully online, Study 3 completed a conceptual replication of Study 2. Using the same 12 CBS tests in an online experiment, we assessed if placing one's smartphone in one of two smartphone locations (i.e., on your desk and within your line-of-sight or away from you and out of your line-of-sight) would affect cognitive performance. We found that the effect found in Study 2 on verbal ability and digit span were not replicated. Smartphone location did not affect any of our CBS measures.

The correlations between the 12 CBS tests and their respective composite scores also showed that the CBS task selection guide (Cambridge Brain Sciences, 2018c) may be outdated. Although most tests were significantly correlated to others within the same cognitive area across our studies, the reasoning and verbal ability cognitive areas showed mixed results. The tests in the reasoning cognitive area were either weakly related or not related across our studies. In both Study 2 and Study 3, the verbal ability tests (i.e., digit span and grammatical reasoning) were not related to each other. These findings shows that there is a need to re-evaluate the cognitive areas defined in the CBS task selection guide (Cambridge Brain Sciences, 2018c). This guide was chosen since the battery of tests is marketed to a clinical population and future studies would benefit from this potential platform (e.g., ease of use, distribution, analysis). However, future studies with similar smartphone manipulations should consider using individual tests and being selective on how many tests participants complete. This would give not only more time to collect other potential covariating variables, but also allow for quicker participant turn-over and less test fatigue.

These findings add to the ever-growing and conflicting research on the effect of smartphone presence on cognition (Courtright and Caplan, 2020; Liebherr et al., 2020). It seems that smartphone presence, specifically placing your smartphone on your desk, can impact verbal ability (i.e., more specifically, verbal short-term memory) as seen in Study 2. The findings in Study 2 support some previous research which found an effect of smartphone presence on a different computerized working memory task (e.g., Tanil and Yong, 2020; Ward et al., 2017). These suggest that people who place their smartphone on their desk could face detrimental effects on their short-term memory. However, this effect not only had a small effect size, but also was not seen in the memory composite score or other individual memory CBS tests in Study 2. Moreover, this effect was not replicated in Study 3. These conflicting accounts to the effect of smartphone presence align with other research that has found no effect of smartphone presence (e.g., Hartmann et al., 2020; Ruiz Pardo and Minda, 2021). Although these findings partially support the notion that smartphone presence can impact our cognition, our studies suggests that the impact is localized or very small and may benefit from assessing other covariates such as smartphone reliance and other individual difference measures.

3.5.1 Smartphone Reliance Measures

All three studies measured the same smartphone reliance measures, using three scales: the NMPQ (Yildirim and Correia, 2015), the MPIQ (Walsh et al., 2010), and the modified smartphone attachment and dependency inventory (Ruiz Pardo and Minda, 2021). In total, these scales gave us eight reliance measures. The NMPQ measured nomophobia, which was the fear of being with out your phone or the internet (Yildirim and Correia, 2015). The MPIQ had three measures: involvement (i.e., how involved one is with one's phone), self-identity (i.e., using one's phone as an extension of one's identity), and validation from others (i.e., using one's phone to feel a sense of validation form others). Finally, the modified smartphone attachment and dependency inventory had four measures: dependency (i.e., degree of dependence on one's smartphone), emotional attachment (i.e., using one's smartphone for emotional support), accessibility (i.e., the need to have access to one's smartphone and it's uses), and distractibility (i.e., how distracted one feels due to one's smartphone). Across the three studies, most reliance measures were related to each other, which showed that they are all measuring the same overall concept. This coincides with Harris et al.'s 2020 account that many measures of problematic smartphone use can measure very similar traits and tendencies. The similarity between the measures not only supports the idea that there is a reliance or tendency for problematic use, but also shows how many of the measures are redundant and require further research to narrow down which traits are truly unique and worth exploring. For now, it seems like using any of the measures would be sufficient.

To further explore the prevalence of smartphone reliance in our samples, we split each measure into a low, moderate, or high level by dividing the total possible range of scores into three for each respective measure. Across all three studies, most participants reported a moderate level across all reliance measures, and close to or over half of participants were in the moderate level for nomophobia, involvement, and emotional attachment. The distractibility measure was the only reliance measure with a large proportion (i.e., greater than half) in the high level for Study 1 (53.28 %) and Study 3 (54.86 %), and comparably in Study 3 (40.51 %). The dependence measure consistently had the highest proportion of participants in the low levels compared to the other measures (17.21 % in Study 1, 32.07 % in Study 2, and 26.86 % in Study 3). Our results depict that, overall, the prevalence of smartphone reliance is less of an epidemic than the literature and media would like to admit. Future research should aim to find the breaking point at which smartphone reliance may lead to problematic smartphone use and whether reliance is a result of the smartphone use itself or of other individual differences (e.g., impulsiveness, personality differences, emotional intelligence).

Smartphone Use Tendencies

Our three studies measured people's smartphone tendencies to explore the trends in typical smartphone use and frequency of use. The measures included an exploratory set of questions that asked iPhone users to report their smartphone use based on their Screen Time application, which provided a potential objective measure. Although the average age for people's first smartphone was comparable across our three studies, the range for Study 3 (5-37 years old) was larger than Study 1 (9-18 years old) and Study 2 (8-19 years old). This showed a potential shift in the cohort of our population and emphasizes that the average age is not as important as the age cohort or age range. Inline with Browne et al.'s (2019) systematic review, our participants reported that their primary reason for their smartphone use was for social media. This was not surprising with the prevalence and communicative abilities that extend from people's social media use. Rather, our results add to the notion that social media use and smartphone use are more related and should be considered jointly rather than distinct.

Typical Smartphone Location Typical location across our three studies showed that there is a general trend where people tend to keep their smartphone in their pocket or bag. However, it should be noted that Study 3 showed a shift in the trend, where the proportions of people keeping their smartphone on their desk increased. This was especially apparent when considering the shift in the "typical" situation. Our first two studies showed a clear preference for keeping your smartphone in your pocket or bag with 56.56 % and 66.67 % reporting this preference in Study 1 and 2, respectively. However, only 42.29 % in Study 3 showed this, and rather preferred keeping their smartphone on their desk (56.57 %). This depicts a potential shift in where people tend to keep their smartphone and could be due to the changes in smartphone use seen during and after the COVID-19 pandemic (e.g., Hodes and Thomas, 2021). These findings support the need for further research into how typical smartphone use has shifted or changed due to the vastly different environment and social climate we now live in.

iPhone's Screen Time Application Screen Time application measures were collected for all three studies. This allowed to collect an objective measure of iPhone user's total screen time in hours, total pickups per day, and total notifications per day. Although the Screen Time application is only available for iPhone users, using these measures provided a realistic measure of smartphone frequency and type of use across our samples. This measure was meant to provide an alternative to existing scales, which provide a more subjective and experience-based perspective of people's smartphone use tendencies (Liebherr et al., 2020). Our studies show that there seems to be a relatively stable proportion of people that own a smartphone. For example, Jay (2020) reported that Canada and the United States have the largest proportion of iPhone users (56 %) and least number of android users (46 %). Our studies found that iPhone users made up an even larger proportion of our sample (i.e., 79.51 % in Study 1, 66.67 % in Study 2, and 70.86 % in Study 3), which may indicate a growth in iPhone ownership.

In contrast to our previous studies, Study 3 asked participants to report the exact number for each of the frequency of use Screen Time measure. The trend across the three studies showed that there is an instability across samples for the total Screen Time and pickups per day. Participants in Study 1 reported over twice as many Screen Time hours than the subsequent studies. The typical notifications per day was consistent across the three studies. Our results confirmed that smartphone frequency is a dynamic measure, which can be somewhat stable if measured as a range, but that using an open-answer rather than a forced-choice answer was more advantageous as this gave a more specific depiction of our sample's typical smartphone frequency of use.

Our Screen time measures were used to assess if a self-reported measure could represent an objective representation of people's smartphone use and to ease the data analysis process. However, having a self-reported measure still allowed the potential for human error (e.g., misunderstanding the instructions, reporting the wrong measure, reporting a made-up measure). An alternative method is Gower and Moreno's (2018) Battery Use Screen Shot, where participants submitted a screen capture of their battery usage application on their smartphone. Gower and Moreno (2018) showed that more than half of their sample was able to follow the instructions. Similarly, Hodes and Thomas (2021) recently extended this screen capture method to the Screen Time applications. Hodes and Thomas (2021) found that, overall, using something like the Screen Time application provided a great objective measure of type of smartphone use or frequency of use. In future studies, it seems like using a screen capture method may allow for more reliable measure even considering the higher processing time with the raw data.

3.5.2 Conclusions

It should be noted that it seems apparent that our first two studies were completed within the same school year (i.e., September 2018 to April 2019), whereas Study 3 was completed later (i.e., September 2020 to April 2021) and during unprecedented times (i.e., during COVID-19). Although smartphones are still very prevalent in our society, smartphone reliance and smartphone use results suggest that the patterns may not be as problematic as once thought. The specific type and frequency of use across participants (e.g., social media, communicating with family) did not coincide with exceptionally high levels of smartphone reliance. The vast majority of participants were moderately reliant on their smartphone, which is an unavoidable state of being with the prevalence of technology for every-day life use like studying, working, and keeping up with the news. Therefore, policy makers should consider this expanded view of smartphone presence rather than generalizing based on older research which used a now older cohort. Results from Study 2 suggest that smartphone presence may impact our cognition, but this effect is localized and may not be as alarming as previously thought. Further research is needed to explore if these findings are replicable, and potential smartphone reliance covariates.

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Chapter 4

It's Not My Phone, It's Me: Individual Differences Predict Smartphone Reliance

Our smartphones provide a constant state of connectedness that is so enticing and useful in our globalized world that some of us have become reliant on them. In two studies, we explored which individual difference measures (e.g., personality traits, well-being measures, age) can predict smartphone reliance (i.e., nomophobia and smartphone attachment and dependency). Both studies collected the same measures using an online platform in different populations: a university sample (Study 1) and a global population (Study 2). For each study, we completed a multiple regression analyses which predicted smartphone reliance with 13 predictors: age, impulsivity, the five-facet personality traits (i.e., openness, conscientiousness, extraversion, agreeableness, and neuroticism), self-esteem, self-regulation, emotional intelligence, and depression, anxiety, and stress. Results highlighted both neuroticism and emotional intelligence as the best predictors of smartphone reliance. Our findings suggest that there may be a personality profile that makes people more susceptible to smartphone reliance. This is an important addition to the smartphone literature as it expands on the notion that our smartphones are not innately the issue, but rather that some of us may be more prone to the negative effects of smartphone use. These findings can be used in future studies to build a personality profile and assess whether this moderates cognitive performance differences during a smartphone manipulation experiment.

Keywords: Smartphone reliance, smartphone dependency, nomophobia, personality, well-being, emotional intelligence

4.1 Introduction

4.1.1 Problematic Smartphone Use: The Modern Dilemma

Smartphones are an inevitability in our society. Eighty-five percent of people report owning a smartphone in America (Pew Research Center, 2021), which is part of an upwards trend over the years. This hand-held computer gives the user constant access to endless functions such as communicating with others, using social media, and playing games. This constant state of connectedness is useful in a globalized world, but also has an inherent downfall: the cost or inability to disconnect. Although some research has focused on the cognitive effects of both smartphone presence (e.g.., Courtright and Caplan, 2020) and smartphone use (e.g., Stothart et al., 2015), there is a relatively recent increase in research investigating the psychological factors that make someone more susceptible to smartphone's potentially negative effects. The increase of online presence both on and off our smartphones since the internet age has sparked specialized fields.

One such field is the study of smartphone reliance or problematic smartphone use. Overall, smartphone reliance is the tendency to need uninterrupted access to one's smartphone to fulfil an emotional, social, or cognitive need (Harris et al., 2020). This field has seen an increase in published papers regarding problematic smartphone use and mental health issues. A review by Thomée (2018) found there were almost as many papers published in just two years (i.e., 2016-2017) as there was across the previous 15 years (i.e., 2001-2015). Of those papers, the majority (70 %) specifically looked at problematic or excessive phone use and psychological factors. Some of the typical outcome measures that have been explored for their relation to high problematic smartphone use were depression, anxiety, personality traits (e.g., extraversion, neuroticism), sleep problems, low mental well-being, and other behavioural addictions (Marengo et al., 2020; Thomée, 2018). This growing field aims to expand the mindset of smartphone literature from how you smartphone can affect you, to considering what individual differences can cause one person to be more susceptible to smartphone reliance, and therefore more prone to the potential cognitive deficits.

4.1.2 Measuring Problematic Smartphone Use and Smartphone Reliance

Problematic smartphone use, smartphone addiction, and smartphone reliance are all commonly used terms which refer to an inherently toxic, damaging, or dependent relationship with one's smartphone. A systematic review of problematic smartphone use measures found that, over the last 13 years, there are 78 existing validated scales measuring differing aspects of this phenomenon (Harris et al., 2020). These scales explored measures such as internet involvement

(Young Cyberpsychology & behavior and 1998, 1998), mobile phone involvement (Walsh et al., 2010), smartphone attachment and dependency (Ward et al., 2017), nomophobia (i.e., the fear of being with out one's phone or the internet; Yildirim and Correia, 2015, and smartphone addiction (Kwon et al., 2013). Nomophobia is a neologism for "No Mobile Phobia", which was coined in England (King et al., 2014) and is operationally defined as the modern fear of being without your phone or access to the internet which causes anxiety-related symptoms or behaviours (Yildirim and Correia, 2015). In 2015, Yildirim and Correia found over half of mobile phone users experienced this phenomenon for a variety of reasons such as social communication and a social anxiety buffer. This supported the relevance of investigating nomophobia when considering smartphone reliance and lead to the development of the Nomophobia Questionnaire (NMPQ; Yildirim and Correia, 2015). The NMPQ measures the severity of nomophobia a person experiences and can be worsened by phone separation. It is related to the need for communication and staying connected even at the cost of convenience. The Smartphone Attachment and Dependency Inventory measures the tendency to feel attached and or dependent on your smartphone (Ward et al., 2017). This measure has been found to relate to people's cognitive performance and moderate the effect of one's smartphone presence on a working memory task (Ward et al., 2017). However, this finding is not always seen (see Ruiz Pardo and Minda, 2021). Since everyone is unique in their feelings towards and interactions with their phone, research investigating the impact that smartphones have on cognition should consider these measures of problematic smartphone tendencies.

4.1.3 Individual Differences as Predictors of Smartphone Reliance

Across the general research topic of smartphone use and tendencies there is a branch focusing on the relationship between our smartphone reliance and our personality, well-being, and other individual difference measures. Some of the most commonly investigated psychological factors that have been found to be associated with smartphone reliance are: extraversion, neuroticism, low self-esteem, loneliness, low conscientiousness, low agreeableness, high anxiety, low openness, high impulsivity, low self-control (Augner et al., 2021; Horwood and Anglim, 2021; Marengo et al., 2020; Thomée, 2018). Although the following is not an extensive list, we discuss these measures across the spectrum, how they have been measured, and their relationship to smartphone reliance and problematic smartphone use.

Younger Individuals Tend to Experience More Smartphone Reliance

Age as an individual difference measure has been extensively covered both in the media and in empirical research. In general, previous findings support the notion that younger individuals (e.g., 35 years old and younger) have higher smartphone reliance tendencies compared to their older counterparts (Anshari et al., 2016; Gezgin et al., 2018). Anshari et al. (2016) found that younger participants (i.e., those younger than 30 years old) exhibited more smartphone dependency and addictive smartphone behaviour. Younger participants reported their typical smartphone use was across all hours of the day, whereas the older participants reported less than six hours of typical smartphone use. Additionally, younger participants reported a willingness to sacrifice a meal in order to have access to their phone. This was the opposite for older participants. Interestingly, studies such as in Gezgin et al. (2018) found that observing a small age range did not show age differences among high school student's internet addiction tendencies. This supports the need for studies which assess a wider age range and a more diverse sample (e.g., education level, current residence).

Psychological Measures as Predictors of Smartphone Reliance

An abundance of previous studies have explored how different personality traits are related to problematic smartphone use (Ehrenberg et al., 2008; Horwood and Anglim, 2021; Marengo et al., 2020; Takao, 2014; Thomée, 2018). Many of these studies specifically assessed the five-facet model personality traits: openness, conscientiousness, extraversion, agreeableness, and neuroticism. Each of these traits exists on a spectrum: openness to closedness, conscientiousness to disinhibition, extraversion to introversion, agreeableness to antagonism, and neuroticism to emotional stability (Costa and McCrae, 2009). These traits have a multitude of associated measures, which vary widely in length (e.g., 300 items versus 60 items) and are commonly referred to as the NEO inventories. Across the studies, there is some relative consistency for some NEO measures such as neuroticism and extraversion, but less so for openness, conscientiousness, and agreeableness.

Takao (2014) investigated if the NEO measures could predict problematic smartphone use. They found that gender, extraversion, neuroticism, and openness all predicted problematic smartphone use, but found no significant predictors for agreeableness and conscientiousness. In contrast, Bianchi and Phillips (2005) found no relationship for neuroticism. Ehrenberg et al. (2008) found more disagreeable people tended to have stronger addictive tendencies towards their instant messaging. Marengo et al. (2020) completed a meta analysis on studies that investigated the NEO measures and their relationship to problematic smartphone use. They found the most consistency for neuroticism, where higher neuroticism was associated with higher problematic smartphone use. With respect to conscientiousness and agreeableness, the results were mixed but mainly showed a negative relationship. So, higher problematic smartphone use was associated with less conscientiousness and less agreeableness. Extraversion did show a positive relationship with problematic smartphone use, but the sample sizes were too small for any conclusive interpretations.

In addition to the NEO personality measures, other studies looked at measures such as self-regulation and emotional regulation. Horwood and Anglim (2021) investigated these two measures along with the NEO personality traits and found that worse emotional regulation leads to problematic smartphone use. This association was specifically related to impulse control when in a negative mood due to a lack of emotional intelligence. Mascia et al. (2020) looked at self-regulation and emotional regulation with respect to student quality of life (i.e., satisfaction with their life and well-being). They found a negative relationship between self-regulation and smartphone addiction, where those who are not able to self-regulate showed higher levels of smartphone addiction. Similar patterns were seen for the emotional regulation measure, which was related to a general ability to monitor one's emotions and act appropriately in emotionally high situations (Mascia et al., 2020). That is, emotional regulation was seen as a relative measure of the larger idea of emotional intelligence. A systematic review of emotional intelligence and physical and mental health was completed by Kun and Demetrovics (2010) and found that lower emotional intelligence was associated with higher intensities of addictive behaviors such as alcohol and drug use. Emotional intelligence played a role in addictive behaviour in that higher emotional intelligence allowed one to interpret one's emotions and regulate one's emotions better (Kun and Demetrovics, 2010). Impulsivity as a psychological factor associated with smartphone use tends to relate negatively Thomée (2018). Similarly a large-scale study completed by Kim et al. (2016) found that smartphone addiction proneness was associated with greater impulsivity and lower self-control.

The link between problematic smartphone use and well-being measures was also a common theme in the existing literature. This included measures such as self-esteem, depression, anxiety, and stress. Augner et al. (2021) found that problematic smartphone use was associated with higher depression and anxiety in a meta analysis. Similarly, Yang et al. (2020) found that problematic smartphone use was associated with anxiety and depression. Gao et al. (2018) investigated predictors of mobile phone addiction and found that depression, anxiety, and stress all predicted the three mobile phone addiction measures (i.e., inability to control craving, feeling anxious and lost, withdrawal escape, and productivity loss). Romero-Rodríguez et al. (2020) completed an online cross-sectional study which investigated typical smartphone use, problematic smartphone use, and social media use and how they can impact self-esteem. They found that higher problematic smartphone use predicted lower self-esteem. Interestingly, this same relationship was not seen for the social media measure (i.e., Instagram use intensity). Similarly, Yang et al. (2010) found a positive association between problematic phone use and aggression, insomnia, and low self-esteem. Overall, a multitude of studies have explored different psychological measures (e.g., personality traits, well-being measures) and how they are related to problematic smartphone use. However, more than two or three of these measures are rarely considered jointly in one study.

Online Data Collection

Online data collection in the age of wider internet accessibility has benefits such as larger and diverse samples (Chandler et al., 2019; Eyal et al., 2021; van Steenbergen and Bocanegra, 2016; Woods et al., 2015). Increasing numbers of behavioural studies are being conducted through platform such as Amazon's Mechanical Turk and Prolific (Eyal et al., 2021), where researchers can strive to collect not only a diverse population, but also a specific subsection of the available population as well. These relatively new platforms have grown in popularity (Chandler et al., 2019; Eyal et al., 2021) and can have data with comparable quality to traditional in-person studies (Eyal et al., 2021; Woods et al., 2015). There are still considerations when collecting behavioural data from participants given the lessened control over the equipment calibration and complicity with respect to experimental instructions (Eyal et al., 2021; van Steenbergen and Bocanegra, 2016). However, this online platform still provides an abundance of opportunity to explore research questions on a global scale.

4.1.4 Overview of the Studies

Some previous studies have explored multiple individual difference measures (e.g., Horwood and Anglim, 2021; Kim et al., 2016; Mascia et al., 2020), however, to our knowledge no previous studies have explored all of the most commonly used measures in a single study. Previous research has explored how psychological factors such as personality traits (e.g., neuroticism, extraversion) and well-being measures (e.g., self-esteem, anxiety) are related to our smartphone tendencies and problematic smartphone use. However, no study has explored how all the commonly measures factors play a role in a larger model and how these can predict smartphone reliance. Although there are some overall consistencies in the literature (e.g., neuroticism, extraversion; Marengo et al., 2020; Thomée, 2018), no previous study has examined how all traits may predict our smartphone reliance. Therefore, the present study implements a similar methodology to previous studies (e.g., Augner et al., 2021; Horwood and Anglim, 2021; Marengo et al., 2020) to determine which measures predict smartphone reliance.

We used two studies to explore the relationship between smartphone reliance and individual difference measures for university students (Study 1) and a global sample (Study 2). Both studies used a multiple regression model to predict smartphone reliance using the individual difference measures and participant age. Two smartphone reliance measures were used in both studies: nomophobia, and smartphone attachment and dependency. A total of 13 predictors were used in each regression model predicting each of our smartphone reliance measures. These predictors were: age, impulsivity, openness, conscientiousness, extraversion, agreeableness, neuroticism, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress.

Therefore, each study had two regression models, one for each smartphone reliance measure, and used all 13 predictors. Additionally, we collected smartphone use tendencies with a smartphone use questionnaire deigned for the studies. We predicted that those who were younger; more impulsive, extraverted, neurotic, depressed, stressed, and anxious; and less openness, conscientiousness, agreeableness, self-esteem, self-regulation, and emotional intelligence would have higher smartphone reliance (see Table 4.1 for more details). Our exploratory individual difference measure was emotional intelligence. This measure was related to emotional regulation, which has been linked to smartphone addiction tendencies (Kun and Demetrovics, 2010; Mascia et al., 2020; van Deursen et al., 2015). Therefore, we hypothesized that higher emotional intelligence would predict lower smartphone reliance. All studies can be found on Open Science Framework (OSF; osf.io/jhecy). This includes all materials used in the present studies. The present studies were approved through the WREM Ethics Board at Western University (see Appendix M).

Table 4.1: Hypotheses for regression models predicting smartphone reliance in Study 1 and Study 2.

Hypotheses for regression models predicting smartphone reliance in Study 1 and Study 2.

Predictor	Hypothesis
Age	–
Impulsivity	+
Openness	–
Conscientiousness	–
Extraversion	+
Agreeableness	–
Neuroticism	+
Self-Esteem	–
Self-Regulation	–
Emotional Intelligence	–
Depression	+
Anxiety	+
Stress	+

Note. Hypothesis for each measure is depicted with respect to the relationship between the measure and the smartphone reliance measure (i.e., "–" for negative and "+" for positive). Smartphone reliance measures were: Nomophobia and Smartphone Attachment and Dependency.

4.2 Study 1: Predicting Smartphone Reliance in University Students

Study 1 was designed to investigate which individual difference measures can predict smartphone reliance in a university sample. Typical smartphone use included questions which asked participants about where they typically place (e.g., on their desk, in their pocket or bag, outside of the room) their smartphone during different situations (e.g., during a lecture, while they study, during a social setting). Additionally, smartphone power tendencies (i.e., powered on or off) during different situations (e.g., in an exam, in a lecture) were measured. We predicted that most participants would report placing their smartphone either in their pocket or bag, or on their desk, with very few reporting keeping their smartphone in another room. The main analysis used a multiple regression analysis predicting each of the smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency) with all the measures predictors (i.e., age, impulsivity, openness, contentiousness, extraversion, agreeableness, neuroticism, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress). A correlation analysis for all measures was also completed. It was hypothesized that each predictor measure would relate to the smartphone reliance measures as described in Table 4.1 for the regression and correlation analyses. Additionally, we predicted that the smartphone measures would have a strong, positive significant correlation. Typical smartphone use (e.g., total "screen time", most used application) was also explored.

4.2.1 Method

Participants

A total of 258 students at Western University were collected from an online research pool. Of the total sample size, a total of 18 participants were flagged for missing, corrupt, or incomplete data. Therefore, a total of 240 participants (126 females and 114 males) were used in the analyses. All participants consented as university students (i.e., 17 years old or older) and were required to have normal or corrected-to-normal vision (i.e., glasses and contacts were acceptable). The ages ranged from 17-42 years old (M = 19.29, SD = 2.20). Participants were also required to have English as their first language or be fluent in English as a second language. The final sample had 79.17 % who reported English as their first language (20.83 % other; e.g., Mandarin, Korean, Spanish) and 91.25 % reported high English proficiency (8.75 % moderate; 0 % low). No participants were excluded based on language proficiency. The majority of participants were currently living in North America (98.33 %; see Table 4.2 for more details). For those who chose to disclose, 23.40 % of participants reported being employed part-time and 6.47 % reported working in the services-producing sector (e.g., retail, transportation; see Table 4.3 for more details).

Table 4.2: Descriptive statistics for demographic measures in Study 1.

Demographic measures as descriptive statistics or frequency counts for Study 1.

	Measure	Statistic / Frequency
Age		
	M	19.29
	SD	2.20
	Min.	17
	Max.	42
Gender*		
	Male	114
	Female	126
First Language		
	English	190
	Other	50
English Proficiency*		
	Moderate	21
	High	219
Current Location*		
	North America	236
	Asia	3
	Other	1

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Other" and "Prefer not to say" for Gender; "Low" for English Proficiency; "Central America", "South America", "Europe", "Africa", "Australia", "Pacific Islander", "Caribbean Islands", and "Prefer not to say" for Current location.
$N = 240$

Materials

General Demographic Questions The demographic items (i.e., eight items in total) asked participants to report their age (in years), gender (i.e., male, female, other, or prefer not to say), first language (i.e., English or other), and English proficiency (i.e., low, moderate, or high). Additionally, participants were asked to state their current region of residence (e.g., North America, Asia), their education level (e.g., high school, Master's), their employment status (e.g., full-time, part-time), and the industry of their profession (e.g., construction, educational services; see Appendix N). This information was collected in order to provide a brief description of the sample.

The Smartphone Use Questionnaire This measure was created for the present study and consisted of modified items from Ruiz Pardo and Minda (2021). Some items were forced-

Table 4.3: Descriptive statistics for additional demographic measures in Study 1.

Exploratory demographic measures as frequency counts for Study 1.

Measure	Statistic / Frequency
Education*	
Some high school	12
High school or equivalent	127
Some college, no degree	79
Associate degree	1
Bachelor's degree	14
Master's degree	1
Prefer not to say	6
Employment* +	
Selection: 1	188
Selection: 2	50
Selection: 4	2
Employed full-time	3
Employed part-time	44
Self-employed	9
Unemployed	37
Student	198
Unable to work	2
Prefer not to say	1
Industry* +	
Selection: 1	201
Selection: 2	30
Selection: 3	9
Student	219
Goods-producing sector	2
Utilities	1
Construction	2
Services-producing sector	13
Finance, insurance, real estate, rental, & leasing	6
Professional, scientific, & technical services	3
Business, building and other support services	8
Educational services	4
Health care & social assistance	8
Information, culture, & recreation	4
Accommodation & food services	9
Other	6
Does not apply to me	3

* Options with a count of zero were removed from the table for succinctness. The removed options are as follows: "Professional degree" and "Doctorate or higher" for Education; "Retired" for Employment; "Manufacturing" and "Public administration" for Industry.

+ Multiple selections were allowed across measure. Top depicts the number of selections made. Bottom depicts frequency for given selection.

$N = 240$

choice and some were on a 7-point Likert scale ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). In total, there were 47 items and seven types of items (see Appendix O).

Smartphone Use One item measured general smartphone information (e.g., "*At what age did you first get a smartphone?*"). Ten items measured frequency of smartphone use and typical smartphone use for all smartphone users (two items; e.g., "*What is your most used app* *on your smartphone (excluding text message/messenger apps)?*") and for iPhone users only (eight items). Items for iPhone users asked participants to report their smartphone use based on the Screen Time application available on Apple devices (e.g., "*What is your weekly total screen time in hours (e.g., 5)?*"). This application is for Apple products only and records how much time you spend on your device, including: time spent on specific applications; how many times you pick up your phone, regardless of using it; number of notifications received, etc.

Privacy Items Five items measured participants tendency for privacy on their smartphone (e.g., "*Do you have a passcode to access your smartphone?*").

Smartphone Distraction and Comfort Items A total of ten items assessed participant's self-perceived distraction with respect to their smartphone, and comfort level with respect to their smartphone given different situations. Two items asked participants whether they found their smartphone distracting either during their daily activities (e.g., "*I find my phone can distract me from my daily activities (e.g., work, school, social interactions).*") or during their study. Three items asked participants to select the most distracting electronic device (e.g., computer, phone) in different situations such as while studying or working or in a social context (e.g., "*I find the following the most distracting when I am studying/working*"). Five items measured comfort level leaving their smartphone unattended (e.g., "*I would feel comfortable leaving my phone in another room while completing a task.*").

Smartphone Location and Power Items Sixteen items were used to gauge participant's typical smartphone use with respect to (1) whether they typically have their smartphone turned on or off in different situations (nine items; e.g., "*When I sleep, I typically keep my phone on.*"), and (2) their typical smartphone location (i.e., on their desk, in their pocket or bag, or in another room) in various situations (seven items; e.g., "*When I study, I keep my phone...*"). These items were collected to describe people's typical smartphone use with respect to where they keep their smartphone and whether they tend to have it powered on or off.

Other Items There were six additional items. One item measured the subjective value placed on one's smartphone by asking participants a forced-choice question: "*How much money would it take for you to give up your phone for a full day?*". This measure was explored to compare to previous research which found there was no "set" threshold on the value people place on their smartphone. One item measured participant's subjective experience of "phantom vibrations" or "phantom ringing", first coined by Laramie (2007), is a phenomenon where people feel a notification (e.g., text, call, social media) on their smartphone without an actual notification occurring (Deb, 2015; e.g.,"*Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?*"). This measure was explored to compare to previous research which found that most people do experience phantom vibrations (Deb, 2015; Laramie, 2007). There were two items that asked what participants tend to use their smartphones for (e.g., "*Who do you mostly communicate with on your phone?*"). Lastly, there were two items that asked what participants work-related questions (e.g., "*Does your profession require the use of a smartphone for work purposes?*").

Smartphone Reliance Measures The following were used as the criterion for the main analyses in the Study 1. These measures are relatively brief and do not inherit the behavioural component of smartphone addiction measures. Rather, the following measures assess the tendency to rely on your smartphone regardless of whether this reliance is problematic in nature or clinically addictive. Each measure asked participants to respond to statements honestly regarding how they use, interact with, and feel about their smartphone on a 7-point Likert scale from 1 ("strongly disagree") to 7 ("strongly agree"). A total sum-score was calculated for each measure, where higher scores corresponded with higher levels of each respective measure.

Nomophobia Questionnaire (NMPQ) The NMPQ consisted of 20 items that measured participant's nomophobia, which is the modern fear of being away from one's smartphone and or the internet (King et al., 2014; Yildirim and Correia, 2015). This included items such as: "*I would feel uncomfortable without constant access to information through my smartphone.*" and "*If I did not have a data signal or could not connect to Wi-Fi, then I would constantly check to see if I had a signal or could find a Wi-Fi Network.*". The total score for the NMPQ can range from 20 to 140, with higher scores depicting greater nomophobia. See Yildirim and Correia (2015) for item details.

Smartphone Attachment and Dependency Inventory (SAD) The SAD consisted of 13 items that measured participant's tendency to feel attached and or dependent on their smartphone (Ward et al., 2017).This included items such as: "*I would have trouble getting through a normal day without my smartphone.*" and "*I find it tough to focus whenever my smartphone is nearby.*". The total score for the SAD can range from 13 to 91, with higher scores depicting greater attachment and dependency. See Ward et al. (2017) for item details.

Individual Difference Measures The following were used as the predictors for the main analyses in the Study 1. Each measure asked participants to respond to statements measuring the respective individual difference measure using a Likert scale. These measures were chosen to assess the typically investigated measures in the smartphone literature (Marengo et al., 2020; Thomée, 2018). A total sum-score was calculated for each measure, where higher scores corresponded with higher levels of each respective measure.

Barratt Impulsiveness Scale-Brief (BIS) The BIS consisted of 8 items that measured impulsive tendencies (Steinberg et al., 2013). Participants were asked to indicate how much each statement applied to them on a 4-point Likert scale from 1 ("Rarely/Never") to 4 ("Almost Always/Always"). This included items such as "*I do things without thinking.*" and reverse items such as "*I am self controlled.*". The total score for the BIS can range from 8 to 32, with higher scores depicting more impulsive tendencies. See Steinberg et al. (2013) for item details.

International Personality Item Pool NEO (NEO) The NEO consisted of 60 items that measured the big five personality traits: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (Maples-Keller et al., 2019). Participants were asked to describe themselves in the present on a 5-point Likert scale from 1 ("Very Inaccurate") to 5 ("Very Accurate"). There were five subscales of 12 items, each measuring one of the five personality traits. The Openness subscale measured openness to new experiences (e.g., imagination, artistic interests, emotionality, adventurousness, intellect, liberalism) with items such as "*Have a vivid imagination.*" and reverse items such as "*Prefer to stick with things that I know.*". The Conscientiousness subscale measured a tendency for self-efficacy, orderliness, dutifulness, achievement striving, self-discipline, and cautiousness with items such as "*Carry out my plans.*" and reverse items such as "*Act without thinking.*". The Extraversion subscale measured a tendency for friendliness, gregariousness, assertiveness, activity level, excitement seeking, and cheerfulness with items such as "*Try to lead others.*" and a reverse item, "*Avoid crowds.*". The Agreeableness subscale measured a tendency for trust, morality, altruism, cooperation, modesty, and sympathy with items such as "*Believe that others have good intentions.*" and reverse items such as "*Believe that I am better than others.*". The Neuroticism subscale measured a tendency for anxiety, anger, depression, self-consciousness, immoderation, and vulnerability with items such as "*Find it difficult to approach others.*" and reverse items such as "*Rarely overindulge.*". Each subscale had a total score that can range from 12 to 60, with higher scores depicting higher levels of the respective personality trait. See Maples-Keller et al. (2019) for item details.

Rosenberg Self-Esteem Scale (RSES) The RSES consisted of 10 items that measured people's level of self-esteem (Rosenberg, 1965). Participants were asked to indicate how much they agreed to each statement on a 4-point Likert scale from 1 ("Strongly Agree") to

4 (“Strongly Disagree”). This included items such as “*I feel that I have a number of good qualities.*” and reverse items such as “*At times I think I am no good at all.*”. The total score for the RSES can range from 10 to 40, with higher scores depicting higher self-esteem. See Rosenberg (1965) for item details.

Self-Regulation Scale (SRS) The SRS consisted of 10 items that measured people’s tendency for self-regulation (Schwarzer et al., 1999). Participants were asked to indicate how much each item applied to them on a 4-point Likert scale from 1 (“Not at all true”) to 4 (“Completely true”). This included items such as “*I can concentrate on one activity for a long time, if necessary.*” and reverse items such as “*When I worry about something, I cannot concentrate on an activity.* ”. The total score for the SRS can range from 10 to 40, with higher scores depicting higher self-regulation capacity. See Schwarzer et al. (1999) for item details.

Schutte Self-Report Emotional Intelligence Test (SSEIT) The SSEIT consisted of 33 items that measured people’s emotional intelligence (Schutte et al., 1998). Participants were asked to indicate how much each item applied to them on a 5-point Likert scale from 1 (“Strongly Disagree”) to 4 (“Strongly Agree”). This included items such as “*I have control over my emotions.*” and reverse items such as “*It is difficult for me to understand why people feel the way they do.*”. The total score for the SSEIT can range from 33 to 165, with higher scores depicting higher emotional intelligence capacity. See Schutte et al. (1998) for item details.

Depression, Anxiety, and Stress Scale (DASS) The DASS consisted of 21 items that measured depression, anxiety and stress over the past week (Lovibond and Lovibond, 1995). Participants were asked to indicate how much a statement applied to them over the past week on a 4-point Likert scale from 0 (“Did not apply to me at all - NEVER”) to 3 (“Applied to me very much, or most of the time - ALMOST ALWAYS”). Depression, Anxiety and Stress were each measured in a separate subscale with 7 items. The Depression subscale measures how depressed people felt in the past week using items such as“*I felt down-hearted and blue.*”. The Anxiety subscale measures how anxious people felt in the past week using items such as“*I felt I was close to panic.*”. The Stress subscale measures how stressed people felt in the past week using items such as“*I found it hard to wind down.*”. Each subscale had a total score that can range from 0 to 42, with higher scores depicting higher levels of the respective measure. See Lovibond and Lovibond (1995) for item details.

Procedure

Participants were recruited via an online study pool at Western University (London, Ontario, Canada) and completed the study through an online platform on Qualtrics. Once they provided implied consent, participants were instructed to complete the study honestly. All participants completed the demographic questionnaire, followed by the smartphone use questionnaire, and then the rest of the measures in the following randomized order: NMPQ (Yildirim and Correia, 2015), SRS (Schwarzer et al., 1999), SAD (Ward et al., 2017), DASS (Lovibond and Lovibond, 1995), BIS (Steinberg et al., 2013), SSEIT (Schutte et al., 1998), RSES (Rosenberg, 1965), and NEO (Maples-Keller et al., 2019). Once they have completed all the measures, participants were shown a downloadable debriefing form. The study took approximately 40 minutes to complete. Participants received credit for their participation.

4.2.2 Results

The present study's analyses can be found on OSF (osf.io/jhecy) and include R scripts of the analyses.

Smartphone Use Tendencies

We measured smartphone use tendencies using the smartphone use questionnaire designed for this study. The measures are used to describe our sample.

Typical Smartphone Use On average, participants reported getting their first smartphone at 13.17 years old (*SD* = 2.04, range = 7-25). Smartphone users (75.42 %) and iPhone users (73.71 %) reported their most used application was a social media application. This coincided with most participants who reported that their most typical type of phone use was for social media (70.83 %), followed by calling or testing (22.92 %). Other questions showed that 40.42 % of participants used their smartphone for work and 31.67 % used company-specific applications. Participants reported that they mainly used their smartphone to communicate with their friends (91.25 %). For subjective value for one's phone, most people selected the lowest presented option of \$0-\$20 (32.50 %), which was closely followed by the highest option of ¿\$60 (30.83 %). Most participants experienced phantom vibrations (87.50 %), which was similar to previous studies (e.g., Deb, 2015; Ruiz Pardo and Minda, 2021); see Table 4.4 for more details).

Our Screen Time measures depicted large variance for total Screen Time (in hours; *M* = 19.52, *SD* = 19.24, range = 2-75), pickups per day (*M* = 126.28, *SD* = 161.06, range = 1-1306), and notifications per day (*M* = 222.55, *SD* = 219.55, range = 5-1931; see Table 4.5 for more details).

Table 4.4: Descriptive statistics and frequency counts for smartphone use questionnaire measures for all smartphone users in Study 1.

Smartphone use questionnaire responses as descriptive statistics and frequency counts for Study 1.

Measure	Statistic / Frequency
Age of first smartphone	
M	13.17
SD	2.04
Min.	7
Max.	25
Most used application	
Games	6
Social Networking	181
Entertainment	46
Business/Productivity	2
Other	5
Subjective value	
\$0-\$20	78
\$21-\$40	46
\$41-\$60	42
>\$60	74
Phantom vibrations	
Yes	210
No	30
Smartphone for work	
Yes	97
No	68
Does not apply	75
Company-specific application	
Yes	76
No	79
Does not apply	85
Main communication	
Family	17
Friends	219
Work	2
Other	2
Type of phone use	
Calling / Texting	55
Social media	170
Games	6
Email	1
Other	8

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
N = 240

Distraction and Comfort Levels Participants reported their phone as the most distracting device in general (85.42 %), while studying or working (81.67 %), and in a social context (94.58 %). Participants reported being distracted by their smartphone during daily activities (M = 5.88, SD = 1.36), but not during the study (M = 3.71, SD = 2.03). When asked about comfort levels when being without one's smartphone, participants reported being neutral to leaving their phones with others or unattended, and tended to report leaving their phone locked

Table 4.5: Descriptive statistics and frequency counts for smartphone use questionnaire measures for iPhone users in Study 1.

Smartphone use questionnaire responses as frequency counts for all iPhone users for Study 1.

	Measure	Statistic / Frequency
Screen Time (hours)		
	M	19.52
	SD	19.24
	Min.	2
	Max.	75
Pickups (per day)		
	M	126.28
	SD	161.06
	Min.	1
	Max.	1306
Notifications (per day)		
	M	222.55
	SD	219.55
	Min.	5
	Max.	1931
Most used application		
	Games	6
	Social Networking	129
	Entertainment	34
	Business/Productivity	1
	Other	4
	No Screen Time app	0
Most used application was text/messenger		
	Yes	53
	No	121
	No Screen Time app	1

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Only those who reported having an iPhone (n = 209) and reported having their Screen Time application activated prior to the study (n = 175) completed the measures. All measures self-reported from participant's Screen Time application on their iPhone, which tracks their device use (i.e., the type and duration of use).

while out of their possession. Interestingly, they reported being neutral when asked if they would feel comfortable leaving their phone in another room during a task (see Table 4.6 and Table 4.7 for more details).

Smartphone Location and Power Participants reported a tendency to keep their smartphone powered on when they are not using it, with notifications turned on, and on vibrate. Aside from during an exam, participants tended to keep their smartphone powered on in different situations (i.e., while studying, in a lecture, while sleeping; see Table 4.8 for more details).

With respect to smartphone location, 61.13 % participants reported leaving their smartphone in their pocket or bag across situations (followed by on their desk, 31.92 %; and in another room, 4.31 %; see Table 4.9). This trend was explored further by looking at which

Table 4.6: Descriptive statistics and frequency counts for distraction measures in Study 1.

Smartphone use questionnaire responses for distraction measures as descriptive statistics and frequency counts for Study 1.

Measure	Statistic / Frequency
Distracted during daily activities*	
M	5.88
SD	1.36
Distracted during study*	
M	3.71
SD	2.03
Most distracting device: General	
Computer	27
Phone	205
iPad / Tablet	6
Smartwatch	2
Other	0
Most distracting device: Studying/Working	
Computer	37
Phone	196
iPad / Tablet	4
Smartwatch	2
Other	1
Most distracting device: Social Context	
Computer	8
Phone	227
iPad / Tablet	1
Smartwatch	3
Other	1

* Minimum value (1) and maximum value (7) for each measure was identical.
N = 240

Table 4.7: Descriptive statistics and frequency counts for comfort measures in Study 1.

Smartphone use questionnaire responses for the comfort level measures as descriptive statistics for Study 1.

Measure	*M*	*SD*
I am comfortable with letting others use my phone.	3.81	1.80
I leave my phone unattended.	3.71	1.88
I leave my phone with other people.	3.58	1.85
I make sure my phone is locked when it is not in my hands.	5.45	1.60
I would feel comfortable leaving my phone in another room while completing a task.	4.76	1.77

Note. A total of 173 participants responded “Yes” to “*I would leave my phone in another room in the presence of another.*”. Minimum value (1) and maximum value (7) for each measure was identical.
N = 240

Table 4.8: Descriptive statistics and frequency counts for smartphone power measures in Study 1.

Smartphone use questionnaire responses for the power paradigm decision measures as descriptive statistics for Study 1.

Measure	*M*	*SD*
I tend to turn my phone off when I am not using it.	3.34	2.14
I tend to have my notifications turned on.	5.03	1.82
I tend to have my phone on vibrate.	5.26	1.89
Phone is on: Study*	5.24	1.64
Phone is on: Exam*	2.33	1.83
Phone is on: Lecture*	5.59	1.47
Phone is on: Working	5.47	1.45
Phone is on: Meeting	4.07	1.97
Phone is on: Sleep	5.31	1.85

Note. Minimum value (1) and maximum value (7) for each measure was identical.
* Only those who reported being a student (n = 198) were shown school-related situation (i.e., Studying, Exam, Lecture).
$N = 240$

location represented more than half of the participants for each situation (i.e., more than 120 participants) across the assigned conditions. As shown in Figure 4.3, over half of participants reported keeping their smartphone on their desk for one situation (i.e., while studying), in their pocket or bag for six situations (i.e., during an exam, a lecture, while working, during a meeting, typically, and in a social setting), and in another room for no situations. The most frequent phone placement was in one's pocket or bag, across most situations.

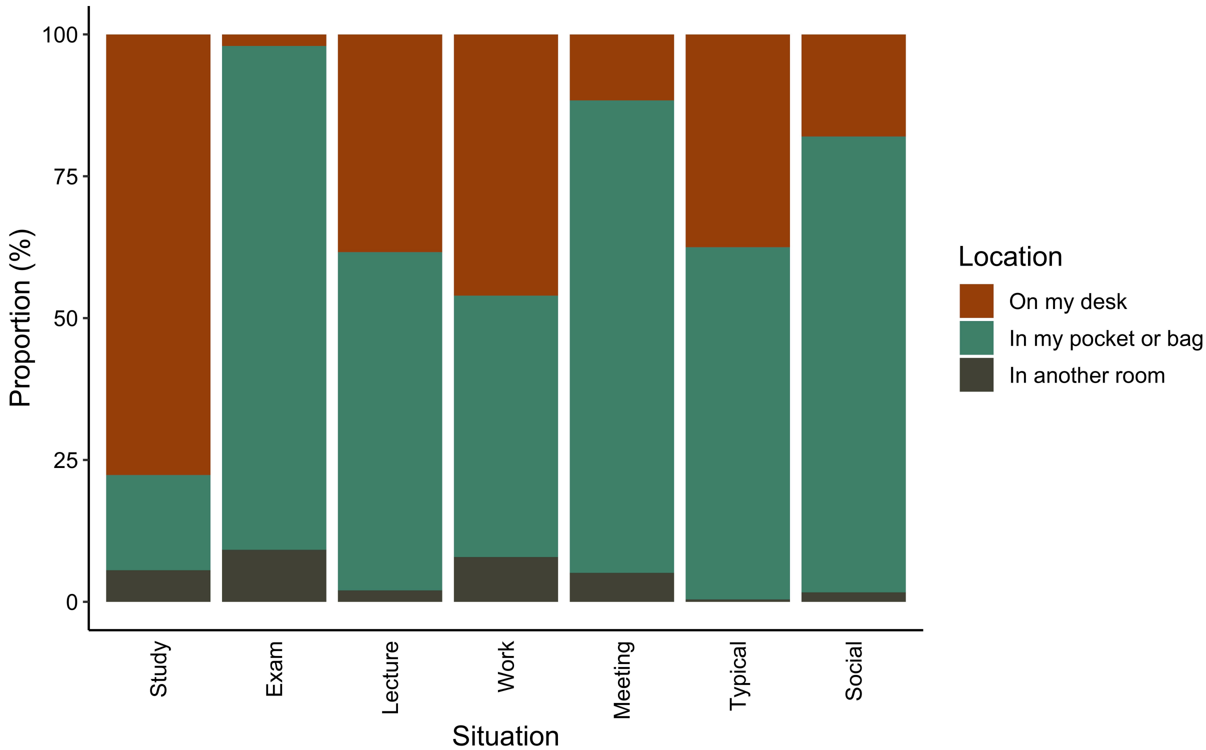
Table 4.9: Descriptive statistics and frequency counts for smartphone location measures in Study 1.

Smartphone use questionnaire responses for the location paradigm decision measures as frequency counts for Study 1.

Situation	On Desk	Pocket / Bag	Another Room	Not Applicable
Typical	90	149	1	0
Studying*	153	33	11	43
Exam*	4	174	18	44
Lecture*	76	118	4	42
Working	105	105	18	12
Meeting	25	179	11	25
Social setting	43	192	4	1

* Only those who reported being a student (n = 198) were shown school-related situation (i.e., Studying, Exam, Lecture).
$N = 240$

Figure 4.1: *Smartphone location by situations for Study 1.*



Note. Responses to smartphone location measures in the Smartphone Use Questionnaire for all participants in Study 1 (N = 240). Most participants showed a tendency to keep their smartphone in their pocket or bag across all situations, excluding the study situation, where most reported keeping their smartphone on their desk. Only those who reported being a student (n = 198) responded to the school-related situation (i.e., studying, exam, and lecture).

Analyses

Study 1 investigated predictors to smartphone reliance in university students. For each of our smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency) we completed one multiple regression model with all individual difference measures (i.e., impulsivity, openness, conscientiousness, extraversion, agreeableness, neuroticism, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress) and age. In order to do this, we first examined the correlations between all of our variables of interest (i.e., the criteria and predictors).

The Relationship between Smartphone Reliance and Individual Difference Measures A Pearson correlation analysis was completed on all our criteria and predictor variables. As shown in Figure 4.2, most correlations were significant, $r(238) = -.69$ to $.76$, $p = .041$ to $< .001$, with 36.19 % of the correlations being non-significant, $r(238) = -.14$ to $.15$, $p > .055$. The strongest correlation was between nomophobia and smartphone attachment and dependency, $r(238) = .76$, $p < .001$, which showed that our smartphone reliance measures were strongly and positively correlated. Between each criterion and the predictors, only two predictors were moderately, positively, and significantly correlated with nomophobia: neuroticism, $r(238) = .20$, $p = .008$, and stress, $r(238) = .20$, $p = .009$. Five predictors had a significant correlation with smartphone attachment and dependency, with weak to moderate strength: neuroticism, $r(238) = .22$, $p < .001$, self-regulation, $r(238) = -.16$, $p = .015$, emotional intelligence, $r(238) = .18$, $p = .003$, depression, $r(238) = .21$, $p = .041$, and stress, $r(238) = .27$, $p = .002$. It should be noted that age was not only non-significantly correlated with the smartphone reliance measures, but also most predictor measures, $r(238) = -.09$ to $.11$, $p = .012$ to $.885$. See Table 4.10 and Table 4.11 for more details[1].

Table 4.10: Correlation table of the criteria and predictors in Study 1.

Criterion and predictor measures as Pearson r correlations for Study 1.

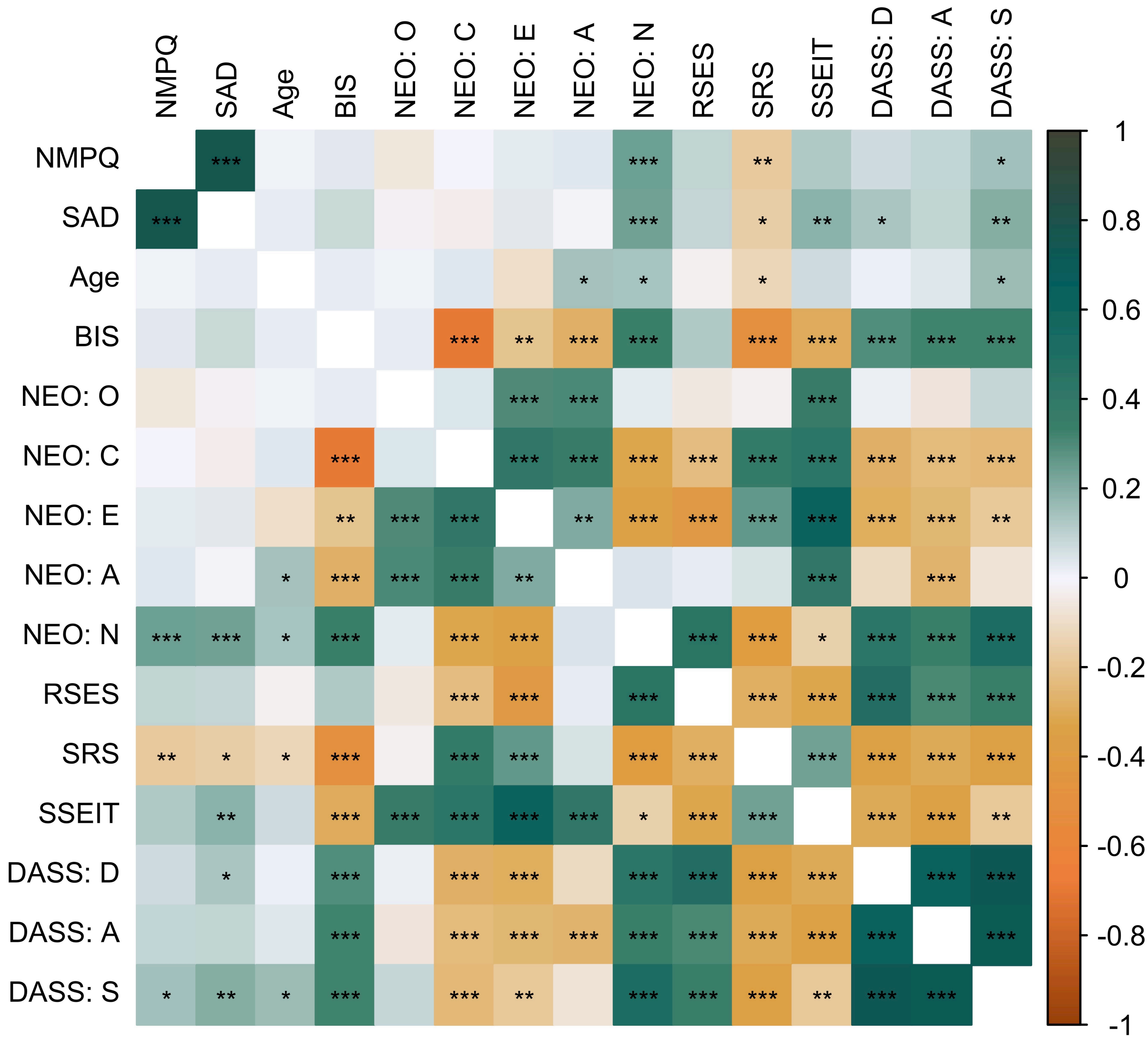
Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. NMPQ	–														
2. SAD	.76***	–													
3. Age	.05	-.06	–												
4. BIS	.07	.13	.06	–											
5. NEO: O	-.09	-.05	.07	.01***	–										
6. NEO: C	-.05	-.13	.01	-.69**	.08	–									
7. NEO: E	.08	.07	.05	-.16***	.39***	.36***	–								
8. NEO: A	-.01	-.12	.02*	-.27***	.23***	.38***	.29**	–							
9. NEO: N	.20***	.22***	.06*	.38	.00	-.34***	-.24***	-.03	–						
10. RSES	.02	.01	-.09	.08***	-.13	-.17***	-.38***	.01	.39***	–					
11. SRS	-.14**	-.10*	.01*	-.51***	.00	.40***	.26***	.14	-.36***	-.26***	–				
12. SSEIT	.15	.18**	.10	-.32***	.32***	.45***	.66***	.42***	-.16*	-.37***	.27***	–			
13. DASS: D	.15	.21*	-.09	.28***	.01	-.23***	-.17***	-.13	.37***	.47***	-.44***	-.26***	–		
14. DASS: A	.12	.16	.00	.36***	.01	-.24***	-.20***	-.25***	.33***	.29***	-.35***	-.25***	.60***	–	
15. DASS: S	.20*	.27**	.11*	.36***	.10	-.25***	-.10**	-.10	.49***	.29***	-.38***	-.16**	.72***	.72***	–

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
N = 240
*p < .05. **p < .01. ***p < .001.

In order to compare the level degree of smartphone reliance or individual difference across our measures, each measure was split into levels, which depicted an increase of the respective measure: low, mild, moderate, high, and very high. Each measure's range in total sum score was split into levels and the frequency of participants within each level was tallied, which resulted in five levels for each measure. There were five levels to coincide with the DASS subscales. The DASS subscales (i.e., depression, anxiety, and stress) had a pre-existing and clinically-based 5-level split, and therefore this was used for those measures. For example, nomophobia was split into low (i.e., score of 20-43), mild (i.e., 44-67), moderate (i.e., 68-91),

[1]Our measures in Study 1 displayed adequate levels of internal consistency (i.e., standardized Cronbach's $\alpha \geq .70$). See Table 4.11 for more details.

Figure 4.2: *Correlation matrix of the criteria and predictors in Study 1.*



Note. Correlation matrix for criteria (i.e., smartphone reliance measures), Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD); and predictors, Age, Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). $N = 240$. *$p < .05$. **$p < .01$. ***$p < .001$.

high (i.e., 92-115), and very high (i.e., 116-140). Across the smartphone reliance measures, 37.50 % of participants were in the moderate level, followed by 36.67 % in the high level. Very few participants were in the low level (i.e., 3.13 %. A similar pattern was present for the predictor measures, where most participants were in the moderate level (33.44 %), followed by the high level (26.01 %). In contrast with the reliance measures, the lowest proportion of the predictor measures was in the very high level (5.59 %). As shown in Figure 4.3, eight of

Table 4.11: Descriptive statistics for criteria and predictors in Study 1.

Criterion and predictor measures as descriptive statistics and internal consistencies for Study 1.

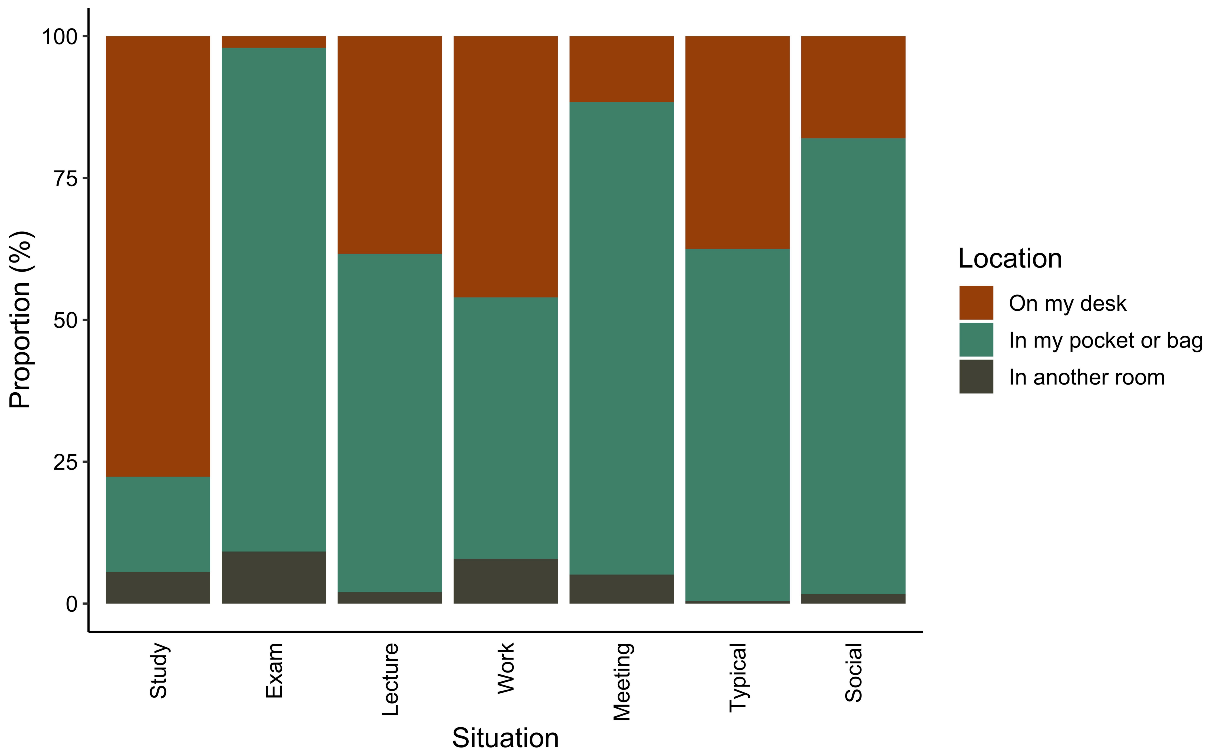
Measure	*M*	*SD*	Min.	Max.	Cronbach's α*
Criterion					
NMPQ	87.98	22.46	20	140	.94
SAD	59.29	13.79	13	91	.89
Predictors					
BIS	17.74	3.76	8	31	.74
NEO: O	41.95	6.42	26	60	.70
NEO: C	40.35	5.88	25	55	.72
NEO: E	42.78	7.53	17	60	.85
NEO: A	45.18	6.87	28	60	.81
NEO: N	35.79	7.29	16	57	.78
RSES	22.35	4.96	10	40	.85
SRS	26.37	4.40	10	39	.76
SSEIT	122.39	16.49	45	160	.93
DASS: D	6.60	4.64	0	21	.89
DASS: A	5.59	3.83	0	17	.78
DASS: S	7.36	4.07	0	18	.82

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S).
* Internal consistency for each measure is depicted using standardized Cronbach's alpha (α). Generally, the measures showed adequate consistency (i.e., α ≥ .70).
$N = 240$

our predictor measures had more than half of participants in one level. Conscientiousness, neuroticism, self-esteem, and self-regulation had over half of participants in the moderate level (50.42 %to51.67 %. Emotional intelligence had 67.92 % in the high level. Depression, anxiety, and stress were all primarily in the low level (67.92 % to 95.00 %). For further details, please see Table 4.12.

Predicting Smartphone Reliance A multiple regression analysis was completed for each of the smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency). The predictors were added in simultaneously and are presented in the following order: age (measured with our demographic questionnaire); impulsivity (measured with the BIS; Steinberg et al., 2013); the five personality traits measured by the NEO (Maples-Keller et al., 2019), which were openness, conscientiousness, extraversion, agreeableness, and neuroticism; self-esteem (measured by the RSES; Rosenberg, 1965); self-regulation (measure by the SRS; Schwarzer et al., 1999); emotional intelligence (measured by the SSEIT; Schutte et al., 1998); and the three DASS (Lovibond and Lovibond, 1995) measures, which were depression,

Figure 4.3: *Criterion and predictor measures as proportion of participants in the low, mild, moderate, high, or very high in Study 1.*



Note. Stacked bar graph for all measures by levels as proportions. Each level was decided by splitting up the range of possible scores for each each measure into five levels: low, mild, moderate, high, and very high. Each measure is shown as an acronym for visualization purposes: Nomophobia (NMPQ), Smartphone Attachment and Dependency (SAD), Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). N = 240.

anxiety, and stress. Both models are visualized in Figure 4.4.

The overall model regression predicting nomophobia (i.e., as measured with the NMPQ; Yildirim and Correia, 2015) using all predictor measures was significant, $F(13, 226) = 2.85$, $p < .001$, $R^2 = .14$, $R^2_{adj.} = .09$. Neuroticism, $\beta_{std} = .23$, $t(226) = 2.77$, $p = .006$, and emotional intelligence, $\beta_{std} = .23$, $t(226) = 2.57$, $p = .011$, significantly added to the model and were positively associated with nomophobia. Openness, $\beta_{std} = -.17$, $t(226) = -2.42$, $p = .016$, and self-regulation, $\beta_{std} = -.18$, $t(226) = -2.39$, $p = .018$, significantly added to the model and were negatively associated with nomophobia. For more details, see Table 4.13. Each significant predictor is further visualized as a scatter plot in Figure 4.5.

The overall model regression predicting smartphone attachment and dependency (i.e., as measured with the SAD; Ward et al., 2017) using all predictor measures was significant, $F(13, 226) = 3.58$, $p < .001$, $R^2 = .17$, $R^2_{adj.} = .12$. Neuroticism, $\beta_{std} = .16$, $t(226) = 2.03$, $p =$

Table 4.12: Frequency counts for criterion and predictor measures by level in Study 1.

Criterion and predictor measures as frequency counts by levels for Study 1.

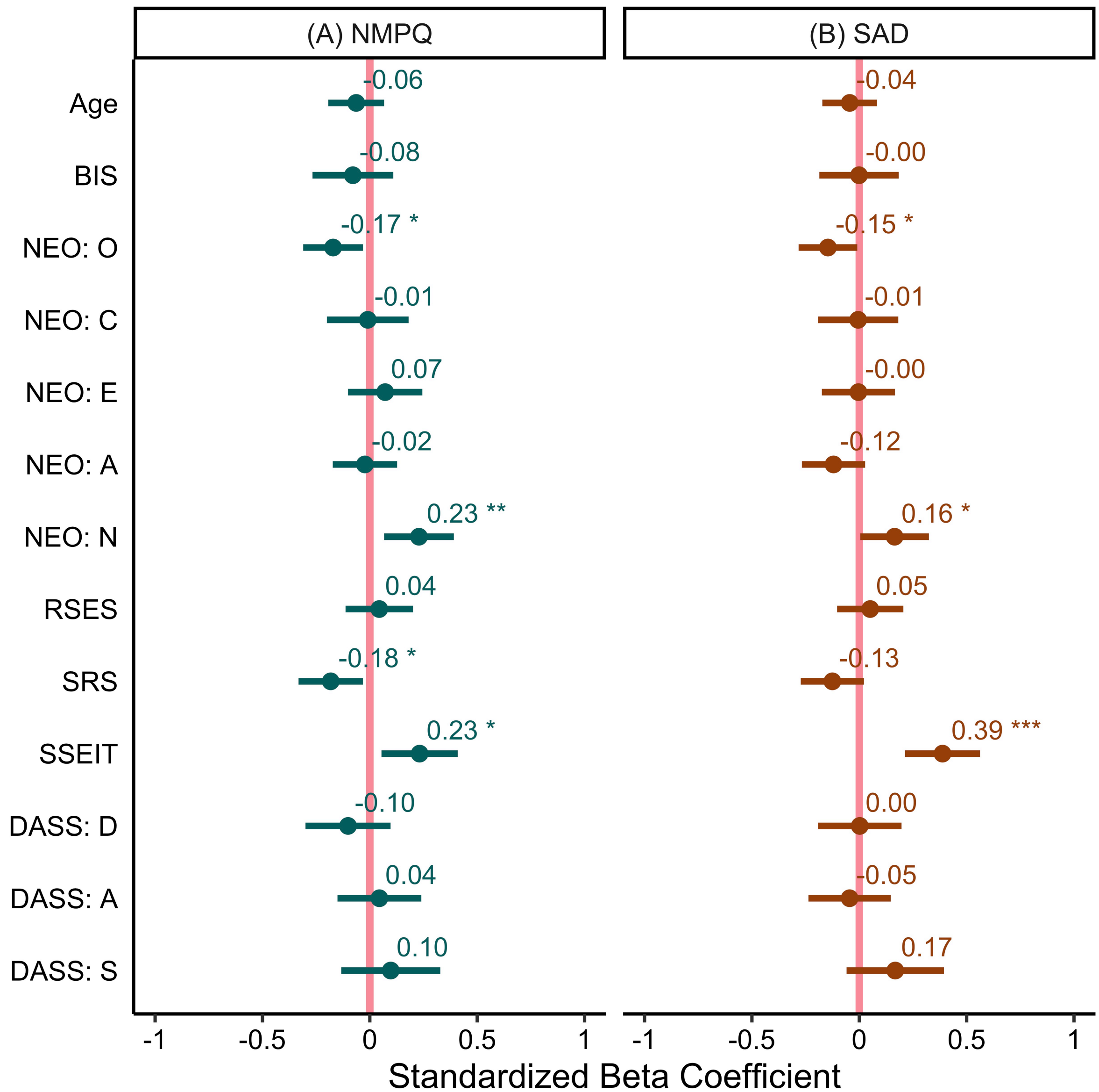
Measure	# Items	Likert Range	Possible Score	Levels: Low	Mild	Moderate	High	Very High
Criterion								
NMPQ	20	1-7	20-140	7 (20-43)	36 (44-67)	86 (68-91)	84 (92-115)	27 (116-140)
SAD	13	1-7	13-91	8 (13-28)	21 (29-44)	94 (45-60)	92 (61-76)	25 (77-91)
Predictors								
BIS	8	1-4	8-32	18 (8-12)	100 (13-17)	96 (18-22)	24 (23-27)	2 (28-32)
NEO: O	12	1-5	12-60	0 (12-21)	9 (22-31)	106 (32-41)	106 (42-51)	19 (52-60)
NEO: C	12	1-5	12-60	0 (12-21)	17 (22-31)	123 (32-41)	93 (42-51)	7 (52-60)
NEO: E	12	1-5	12-60	1 (12-21)	15 (22-31)	89 (32-41)	101 (42-51)	34 (52-60)
NEO: A	12	1-5	12-60	0 (12-21)	5 (22-31)	71 (32-41)	110 (42-51)	54 (52-60)
NEO: N	12	1-5	12-60	7 (12-21)	57 (22-31)	124 (32-41)	48 (42-51)	4 (52-60)
RSES	10	1-4	10-40	28 (10-15)	61 (16-21)	121 (22-27)	26 (28-33)	4 (34-40)
SRS	10	1-4	10-40	4 (10-15)	24 (16-21)	124 (22-27)	74 (28-33)	14 (34-40)
SSEIT	33	1-5	33-165	1 (33-59)	5 (60-86)	48 (87-113)	163 (114-140)	23 (141-165)
DASS: D	7	0-3	0-42	186 (0-9)	31 (10-13)	21 (14-20)	2 (21-27)	0 (28-42)
DASS: A	7	0-3	0-42	163 (0-7)	35 (8-9)	40 (10-14)	2 (15-19)	0 (20-42)
DASS: S	7	0-3	0-42	228 (0-14)	12 (15-18)	0 (19-25)	0 (26-33)	0 (34-42)

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
N = 240

.043, and emotional intelligence, β_{std} = .39, $t(226) = 4.38$, $p < .001$, significantly added to the model and were positively associated with smartphone attachment and dependency. Openness significantly added to the model, β_{std} = -.15, $t(226) = -2.10$, p = .036, and was negatively associated with smartphone attachment and dependency. For more details, see Table 4.14. Each significant predictor is further visualized as a scatter plot in Figure 4.6[2].

[2]Supplementary analyses for Study 1 were completed using multiple regression analyses which added gender as a dichotomous (i.e., male and female) predictor to the same models used in the main analyses. These analyses explored the potential relationship between gender and our smartphone reliance measures. It should be noted that

Figure 4.4: *Standardized beta coefficients for multiple regression models predicting smartphone reliance measures in Study 1.*



Note. Forest plot for the two multiple regression models. Panel A depicts the model predicting Nomophobia (NMPQ) and panel B depicts the model predicting Smartphone Attachment and Dependency (SAD). Standardized beta coefficients (dots) and the 95 % confidence interval (whiskers) are shown for each model. Vertical line represents the neutral point or no relationship between the predictor and the criterion. Predictors were identical for both models and are shown across the y-axis: Age, Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). N = 240.

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these analyses were explored as supplementary analyses since gender was unbalanced (i.e., more females). See Appendix P for more details.

Table 4.13: Multiple regression model results predicting nomophobia in Study 1.

Multiple regression results predicting nomophobia in Study 1.

Predictor	β	SE_β	Std. β	Std. SE_β	$t(226)$	p
Age	-0.65	0.67	-.06	0.07	-0.96	.34
BIS	-0.47	0.57	-.08	0.10	-0.83	.41
NEO: O	-0.60	0.25	-.17	0.07	-2.42	.02
NEO: C	-0.04	0.37	-.01	0.10	-0.10	.92
NEO: E	0.21	0.26	.07	0.09	0.81	.42
NEO: A	-0.07	0.25	-.02	0.08	-0.30	.76
NEO: N	0.70	0.25	.23	0.08	2.77	.01
RSES	0.20	0.36	.04	0.08	0.55	.58
SRS	-0.93	0.39	-.18	0.08	-2.39	.02
SSEIT	0.32	0.12	.23	0.09	2.57	.01
DASS: D	-0.49	0.49	-.10	0.10	-1.01	.31
DASS: A	0.26	0.58	.04	0.10	0.45	.65
DASS: S	0.54	0.65	.10	0.12	0.83	.41

Note. Overall model was significant, $F(13, 226) = 2.85$, $p < .001$, $R^2 = .14$, $R^2_{adj} = .09$. Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 240$

Table 4.14: Multiple regression model results predicting smartphone attachment and dependency in Study 1.

Multiple regression results predicting smartphone attachment and dependency in Study 1.

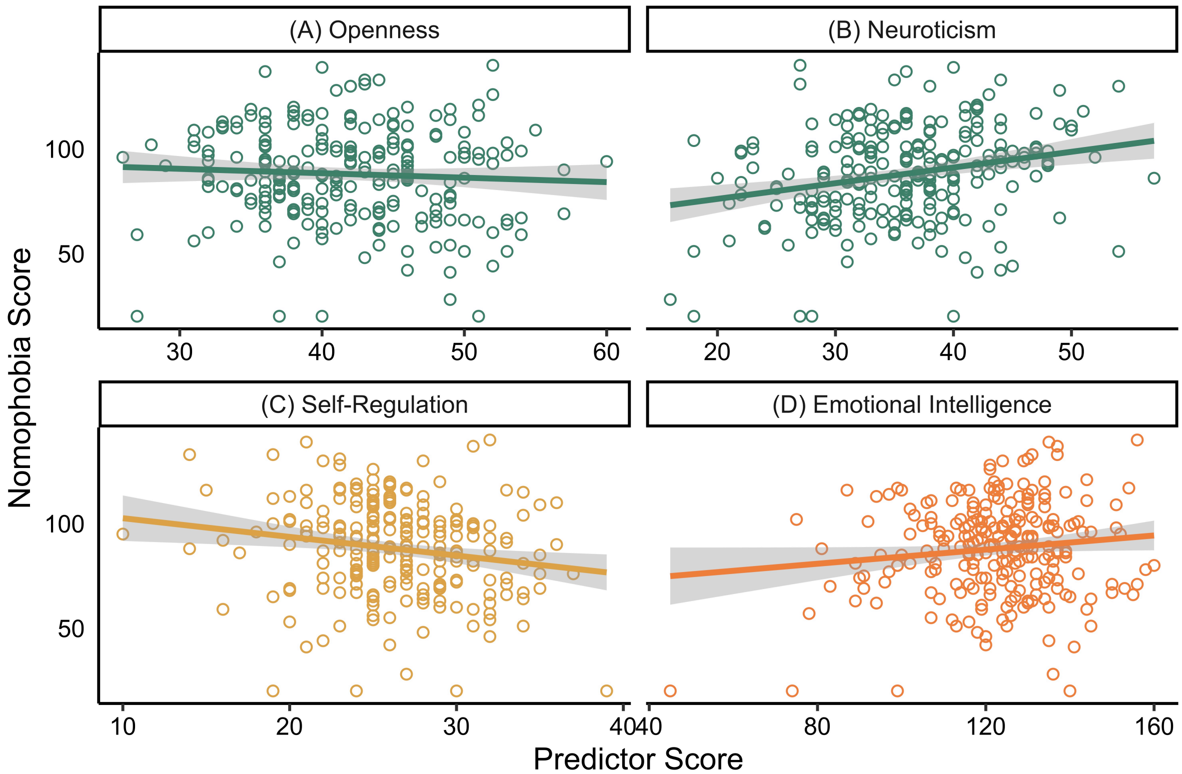
Predictor	β	SE_β	Std. β	Std. SE_β	$t(226)$	p
Age	-0.28	0.41	-.04	0.06	-0.69	.49
BIS	0.00	0.34	.00	0.09	-0.01	.99
NEO: O	-0.31	0.15	-.15	0.07	-2.10	.04
NEO: C	-0.01	0.22	-.01	0.09	-0.06	.95
NEO: E	-0.01	0.16	.00	0.09	-0.05	.96
NEO: A	-0.24	0.15	-.12	0.07	-1.60	.11
NEO: N	0.31	0.15	.16	0.08	2.03	.04
RSES	0.14	0.22	.05	0.08	0.65	.52
SRS	-0.39	0.23	-.13	0.07	-1.68	.10
SSEIT	0.32	0.07	.39	0.09	4.38	< .001
DASS: D	0.01	0.29	.00	0.10	0.02	.98
DASS: A	-0.16	0.35	-.05	0.10	-0.46	.64
DASS: S	0.57	0.39	.17	0.12	1.46	.15

Note. Overall model was significant, $F(13, 226) = 3.58$, $p < .001$, $R^2 = .17$, $R^2_{adj} = .12$. Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 240$

4.2.3 Interim Discussion

Findings for typical smartphone use were in line with previous studies (e.g., Ruiz Pardo and Minda, 2021). Average age of getting your first smartphone was similar to previous studies.

Figure 4.5: *Scatter plot depicting each significant predictor of nomophobia in Study 1.*

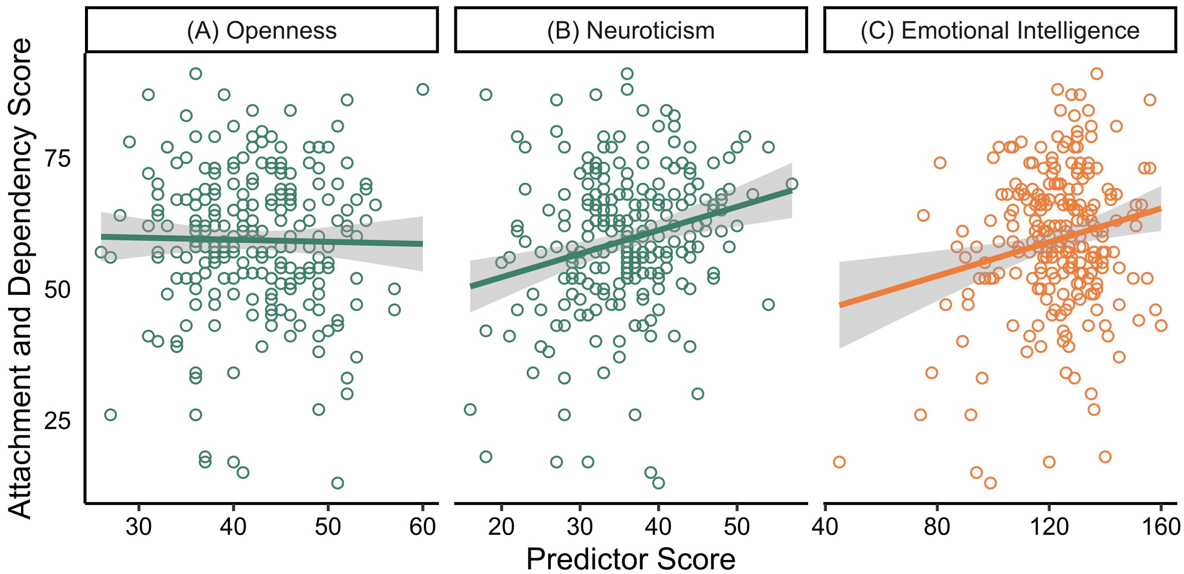


Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Openness, β_{std} = -.17, $t(226)$ = -2.42, p = .016. Panel B depicts Neuroticism, β_{std} = .23, $t(226)$ = 2.77, p = .006. Panel C depicts Self-regulation, β_{std} = -.18, $t(226)$ = -2.39, p = .018. Panel D depicts Emotional Intelligence, β_{std} = .23, $t(226)$ = 2.57, p = .011. N = 240.

The most used application was social media. The lowest and highest subjective value options represented almost equal proportions of responses. This was contrary to previous findings. Phantom vibrations were very prevalent, which was expected given previous studies. Screen time measures showed not only a large number for total screen time, pickups per day, and notification per day; but also a large range in scores. This showed how variable each participant's frequency of use can be. It should be noted, however, that the notification measure can be skewed if a participant tends to keep their notifications turned off. Participants reported that their phone is the most distracting device across situations. Additionally, they reported feeling very distracted by their smartphone during their daily activities, but not during the study.

A correlation analysis confirmed that the smartphone reliance measures were strongly related to each other. Higher nomophobia was associated with being more neurotic and stressed.

Figure 4.6: *Scatter plot depicting each significant predictor of smartphone attachment and dependency in Study 1.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Openness, β_{std} = -.15, $t(226) = -2.10$, $p = .036$. Panel B depicts Neuroticism, β_{std} = .16, $t(226) = 2.03$, $p = .043$. Panel C depicts Emotional Intelligence, β_{std} = .39, $t(226) = 4.38$, $p < .001$. $N = 240$.

Higher smartphone attachment and dependency was associated with being more neurotic, emotionally intelligent, depressed, anxious, and stressed. Age was not related to either reliance measure. Future studies should expand their participation recruitment to include a wider age range and more participants of age ranges outside of the typical university student. These results depict that there was relative stability in the predictors, however, it was not entirely unexpected with our limited sample size and demographic.

We explored the smartphone reliance and predictor variables as levels (i.e., low, mild, moderate, high, and very high). Our results in depicted an overall trend of large proportion of participants in the moderate and high levels, with two main exceptions: emotional intelligence was primarily in the high level and the DASS measures were primarily in the low level. Greater details are given in the general discussion.

Overall, our regression models were able to predict both smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency). Significant predictors of nomophobia were less openness, more neuroticism, less self-regulation, and more emotional intelligence. Significant predictors of smartphone attachment and dependency were less openness, more neuroticism, and more emotional intelligence. Therefore, there was some agreement in the predictors that were adding significantly to both of our regression models. These findings suggest that there are some individual differences that predict our tendency to be reliant on our smartphone, but had a limited sample by only using university students. Therefore, we explored the same predictors in a larger and non-university sample in Study 2.

4.3 Study 2: Predicting Smartphone Reliance on a Global Scale

Study 2 was designed to investigate which individual difference measures can predict smartphone reliance on a global scale. Typical smartphone use included questions which asked participants about where they typically place (e.g., on their desk, in their pocket or bag, outside of the room) their smartphone during different situations (e.g., during a lecture, while they study, during a social setting). Additionally, smartphone power tendencies (i.e., powered on or off) during different situations (e.g., in an exam, in a lecture) were measured. We predicted that most participants would report placing their smartphone either in their pocket or bag, or on their desk, with very few reporting keeping their smartphone in another room. The main analysis used a multiple regression analysis predicting each of the smartphone reliance measures (i.e., nomophobia, and smartphone attachment and dependency) with all the measures predictors (i.e., age, impulsivity, openness, contentiousness, extraversion, agreeableness, neuroticism, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress). A correlation analysis for all measures was also completed. It was hypothesized that each predictor measure would relate to the smartphone reliance measures as described in Table 4.1 for the regression and correlation analyses. These predictions were based on previous literature on larger and more diverse samples rather than our results from Study 1. Additionally, we predicted that the smartphone measures would have a strong, positive significant correlation. Typical smartphone use (e.g., total "screen time", most used application) was also explored.

4.3.1 Method

Participants

A total of 595 participants were collected using Mturk. Of the total sample size, a total of 90 participants were flagged for missing, corrupt, or incomplete data. Therefore, a total of 505 participants (190 females, 311 males, 2 Other, and 2 Prefer not to say) were used in the analyses. All participants consented as adults (i.e., 18 years old or older) and were required to have normal or corrected-to-normal vision (i.e., glasses and contacts were acceptable). The ages ranged from 18-69 years old (*M* = 34.18, *SD* = 10.00). Participants were also required to have English as their first language or be fluent in English as a second language. The final sample had 95.84 % who reported English as their first language (4.16 % other; e.g., Tamil, Portuguese, Italian) and 81.19 % reported high English proficiency (17.23 % moderate; 1.58 % low). No participants were excluded based on language proficiency. The majority of participants were currently living in North America (60.00 %, followed by Asia with 22.78 %; see Table 4.15 for more details). Most participants reported their highest level of school completed as a Bachelor's Degree (55.64 %), followed by some college with no degree (14.65 %), a Master's degree (11.68 %), and high school or equivalent (8.12 %). For those who chose to disclose, 81.57 % of participants reported being employed full-time and 22.47 % reported working in the professional, scientific, and technical services (see Table 4.16 for more details).

Table 4.15: Descriptive statistics for demographic measures in Study 2.

Demographic measures as descriptive statistics or frequency counts for Study 2.

	Measure	Statistic / Frequency
Age		
	M	34.18
	SD	10.00
	Min.	18
	Max.	69
Gender*		
	Male	311
	Female	190
	Other	2
	Prefer not to say	2
First Language		
	English	484
	Other	21
English Proficiency		
	Low	8
	Moderate	87
	High	410
Current Location		
	North America	303
	Central America	23
	South America	34
	Europe	16
	Africa	1
	Asia	115
	Australia	3
	Pacific Islander	3
	Caribbean Islands	0
	Other	4
	Prefer not to say	3

Note. Top shows descriptive statistics for responses to continuous measures.
Bottom shows frequency counts for responses to nominal measures.
N = 505

Table 4.16: Descriptive statistics for additional demographic measures in Study 2.

Exploratory demographic measures as frequency counts for Study 2.

Measure	Statistic / Frequency
Education*	
Some high school	1
High school or equivalent	41
Some college, no degree	74
Associate degree	37
Bachelor's degree	281
Master's degree	59
Professional degree	8
Doctorate or higher	2
Prefer not to say	2
Employment* +	
Selection: 1	472
Selection: 2	26
Selection: 3	1
Selection: 4	1
Selection: 7	2
Selection: 8	3
Employed full-time	385
Employed part-time	34
Self-employed	85
Unemployed	23
Student	19
Retired	9
Unable to work	9
Prefer not to say	5
Industry* +	
Selection: 1	445
Selection: 2	40
Selection: 3	9
Selection: 4	4
Selection: 5	3
Selection: 10	1
Selection: 14	2
Selection: 15	1
Student	28
Goods-producing sector	21
Utilities	14
Construction	32
Manufacturing	83
Services-producing sector	58
Finance, insurance, real estate, rental, & leasing	66
Professional, scientific, & technical services	100
Business, building and other support services	22
Educational services	41
Health care & social assistance	36
Information, culture, & recreation	59
Accommodation & food services	18
Public administration	18
Other	25
Does not apply to me	15

+ Multiple selections were allowed across measure. Top depicts the number of selections made. Bottom depicts frequency for given selection.
N = 505

Materials and Procedure

Materials were identical to Study 1. Participants were recruited via an online study pool on Amazon's Mechanical Turk (no specific population selected) and completed the study through an online platform on Qualtrics. The procedure was identical to Study 1.

Once they provided implied consent, participants were instructed to complete the study honestly. All participants completed the demographic questionnaire, followed by the smartphone use questionnaire, and then the rest of the measures in the following randomized order: NMPQ (Yildirim and Correia, 2015), SRS (Schwarzer et al., 1999), SAD (Ward et al., 2017), DASS (Lovibond and Lovibond, 1995), BIS (Steinberg et al., 2013), SSEIT (Schutte et al., 1998), RSES (Rosenberg, 1965), and NEO (Maples-Keller et al., 2019). Once they have completed all the measures, participants were shown a downloadable debriefing form. The study took approximately 40 minutes to complete. Participants received credit for their participation.

4.3.2 Results

The present study's analyses can be found on OSF (osf.io/jhecy) and include R scripts of the analyses.

Smartphone Use Tendencies

We measured smartphone use tendencies using the smartphone use questionnaire designed for this study. The measures are used to describe our sample.

Typical Smartphone Use On average, participants reported getting their first smartphone at 23.25 years old (*SD* = 10.09, range = 2-64). Smartphone users (55.25 %) and iPhone users (59.26 %) reported their most used application was a social media application, followed by an entertainment application (21.19 % smartphone users; 20.99 % iPhone users). This coincided with most participants who reported that their most typical type of phone use was for social media (44.16 %), followed closely by calling or testing (42.97 %). Other questions showed that 70.50 % of participants used their smartphone for work and 31.67 % used company-specific applications. Participants reported that they mainly used their smartphone to communicate with their friends (46.14 %) and family (43.37 %). The largest proportion for the subjective value measure was the second-lowest option (i.e., \$21-\$40; 34.65 %), and was closely followed by both the lowest (i.e., \$0-\$20;25.74 %) and highest options (i.e., >\$60; 24.36 %). Similar to previous studies (e.g., Deb, 2015; Ruiz Pardo and Minda, 2021) and Study 1, most participants experienced phantom vibrations (71.88 %); see Table 4.17 for more details).

Table 4.17: Descriptive statistics and frequency counts for smartphone use questionnaire measures for all smartphone users in Study 2.

Smartphone use questionnaire responses as descriptive statistics and frequency counts for Study 2.

Measure	Statistic / Frequency
Age of first smartphone	
M	23.25
SD	10.09
Min.	2
Max.	64
Most used application	
Games	40
Social Networking	279
Entertainment	107
Business/Productivity	51
Other	28
Subjective value	
$0-$20	130
$21-$40	175
$41-$60	77
>$60	123
Phantom vibrations	
Yes	363
No	142
Smartphone for work	
Yes	356
No	130
Does not apply	19
Company-specific application	
Yes	291
No	190
Does not apply	24
Main communication	
Family	219
Friends	233
Work	49
Other	4
Type of phone use	
Calling / Texting	217
Social media	223
Games	27
Email	25
Other	13

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures.
$N = 240$

Our Screen Time measures depicted large variance for total Screen Time (in hours; M = 12.09, SD = 15.90, range = 1-145), pickups per day (M = 44.75, SD = 102.32, range = 2-1107), and notifications per day (M = 160.37, SD = 148.39, range = 2.5-757; see Table 4.18 for more details).

Table 4.18: Descriptive statistics and frequency counts for smartphone use questionnaire measures for iPhone users in Study 2.

Smartphone use questionnaire responses as frequency counts for all iPhone users for Study 2.

	Measure	Statistic / Frequency
Screen Time (hours)		
	M	12.09
	SD	15.90
	Min.	1
	Max.	145
Pickups (per day)		
	M	44.75
	SD	102.32
	Min.	2
	Max.	1107
Notifications (per day)		
	M	160.37
	SD	148.39
	Min.	2.5
	Max.	757
Most used application		
	Games	14
	Social Networking	96
	Entertainment	34
	Business/Productivity	11
	Other	6
	No Screen Time app	0
Most used application was text/messenger		
	Yes	111
	No	51
	No ST	0

Note. Top shows descriptive statistics for responses to continuous measures. Bottom shows frequency counts for responses to nominal measures. Only those who reported having an iPhone (n = 248) and reported having their Screen Time application activated prior to the study (n = 162) completed the measures. All measures self-reported from participant's Screen Time application on their iPhone, which tracks their device use (i.e., the type and duration of use). Sample size for each device shown in parentheses.

Distraction and Comfort Levels Participants reported their phone as the most distracting device in general (62.38 %), while studying or working (59.60 %), and in a social context (76.83 %). Participants reported being distracted by their smartphone during daily activities (M = 4.50, SD = 1.75), but not during the study (M = 3.32, SD = 2.19). When asked about comfort levels when being without one's smartphone, participants reported being neutral to almost in agreement to leaving their phones with others or unattended, and tended to report leaving their phone locked while out of their possession. Interestingly, they reported being comfortable when asked if they would feel comfortable leaving their phone in another room during a task (see Table 4.19 and Table 4.20 for more details).

Table 4.19: Descriptive statistics and frequency counts for distraction measures in Study 2.

Smartphone use questionnaire responses for distraction measures as descriptive statistics and frequency counts for Study 2.

Measure	Statistic / Frequency
Distracted during daily activities*	
M	4.50
SD	1.75
Distracted during study*	
M	3.32
SD	2.19
Most distracting device: General	
Computer	125
Phone	315
iPad / Tablet	32
Smartwatch	18
Other	15
Most distracting device: Studying/Working	
Computer	146
Phone	301
iPad / Tablet	28
Smartwatch	15
Other	15
Most distracting device: Social Context	
Computer	74
Phone	388
iPad / Tablet	19
Smartwatch	12
Other	12

* Minimum value (1) and maximum value (7) for each measure was identical.
N = 505

Table 4.20: Descriptive statistics and frequency counts for comfort measures in Study 2.

Smartphone use questionnaire responses for the comfort level measures as descriptive statistics for Study 2.

Measure	*M*	*SD*
I am comfortable with letting others use my phone.	4.05	1.98
I leave my phone unattended.	3.68	2.02
I leave my phone with other people.	3.51	2.01
I make sure my phone is locked when it is not in my hands.	5.34	1.65
I would feel comfortable leaving my phone in another room while completing a task.	4.56	1.83

Note. A total of 290 participants responded "Yes" to "*I would leave my phone in another room in the presence of another.*". Minimum value (1) and maximum value (7) for each measure was identical.
N = 505

Smartphone Location and Power Participants reported a tendency to keep their smartphone powered on when they are not using it, with notifications turned on, and on vibrate. Aside from during an exam, participants tended to keep their smartphone powered on in different situations (i.e., while studying, in a lecture, while sleeping; see Table 4.21 for more details).

Table 4.21: Descriptive statistics and frequency counts for smartphone power measures in Study 2.

Smartphone use questionnaire responses for the power paradigm decision measures as descriptive statistics for Study 2.

Measure	*M*	*SD*
I tend to turn my phone off when I am not using it.	3.46	2.09
I tend to have my notifications turned on.	5.19	1.63
I tend to have my phone on vibrate.	5.00	1.82
Phone is on: Study*	5.58	1.35
Phone is on: Exam*	4.63	1.92
Phone is on: Lecture*	5.26	1.85
Phone is on: Working	5.54	1.42
Phone is on: Meeting	4.90	1.79
Phone is on: Sleep	5.44	1.65

Note. Minimum value (1) and maximum value (7) for each measure was identical, except for "Phone is on: Study" (min. = 1, max. = 7).
* Only those who reported being a student (n = 19) were shown school-related situation (i.e., Studying, Exam, Lecture).
N = 505

With respect to smartphone location, 53.39 % participants reported leaving their smartphone in their pocket or bag across situations (followed by on their desk, 38.52 %; and in another room, 6.64 %; see Table 4.22). This trend was explored further by looking at which location represented more than half of the participants for each situation (i.e., more than 120 participants) across the assigned conditions. As shown in Figure 4.9, over half of participants reported keeping their smartphone on their desk for three situations (i.e., while studying, typically, and while working), in their pocket or bag for two situations (i.e., during a meeting and in a social setting), and in another room for no situations. The most frequent phone placement was in one's pocket or bag, across most situations.

Analyses

Study 2 investigated predictors to smartphone reliance on a global scale. For each of our smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency)

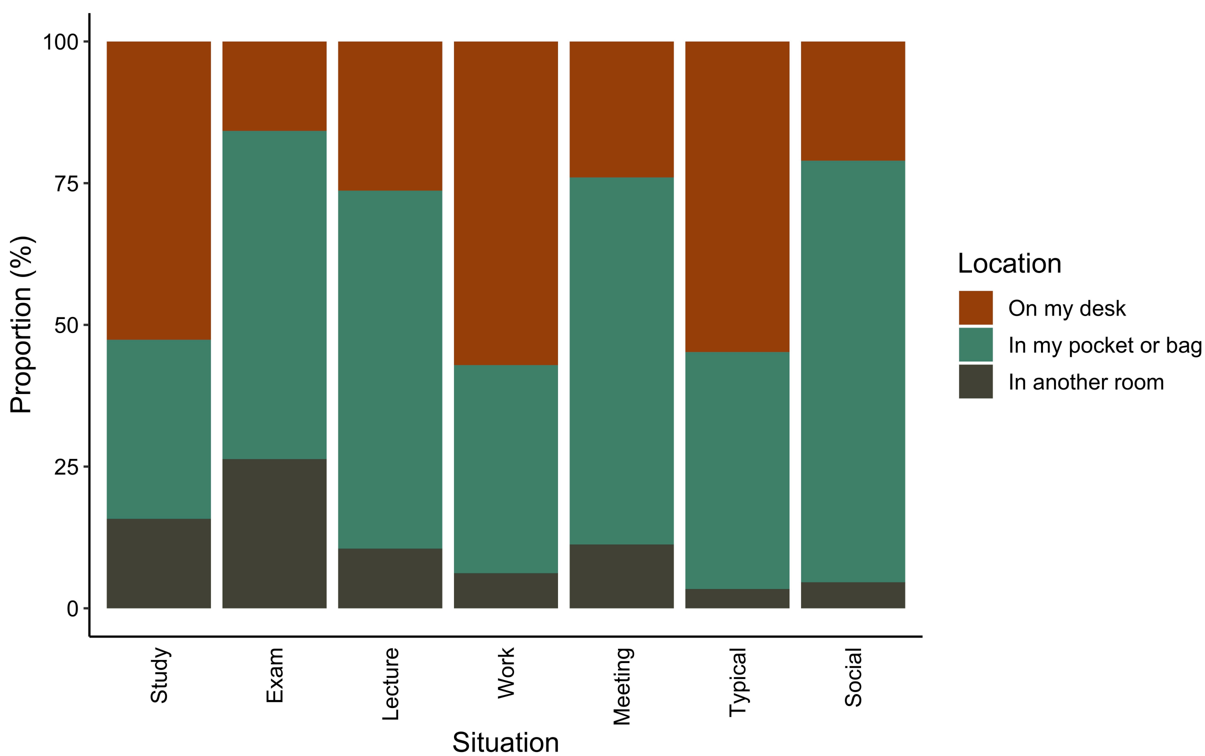
Table 4.22: Descriptive statistics and frequency counts for smartphone location measures in Study 2.

Smartphone use questionnaire responses for the location paradigm decision measures as frequency counts for Study 2.

Situation	On Desk	Pocket / Bag	Another Room	Not Applicable
Typical	274	209	17	5
Studying*	10	6	3	486
Exam*	3	11	5	486
Lecture*	5	12	2	486
Working	286	184	31	4
Meeting	117	316	55	17
Social setting	105	371	23	6

* Only those who reported being a student (n = 19) were shown school-related situation (i.e., Studying, Exam, Lecture).
N = 505

Figure 4.7: *Smartphone location by situations for Study 2.*



Note. Responses to smartphone location measures in the Smartphone Use Questionnaire for all participants in Study 1 (N = 505). Most participants showed a tendency to keep their smartphone in their pocket or bag across all situations, excluding the study situation, where most reported keeping their smartphone on their desk. Only those who reported being a student (n = 19) responded to the school-related situation (i.e., studying, exam, and lecture).

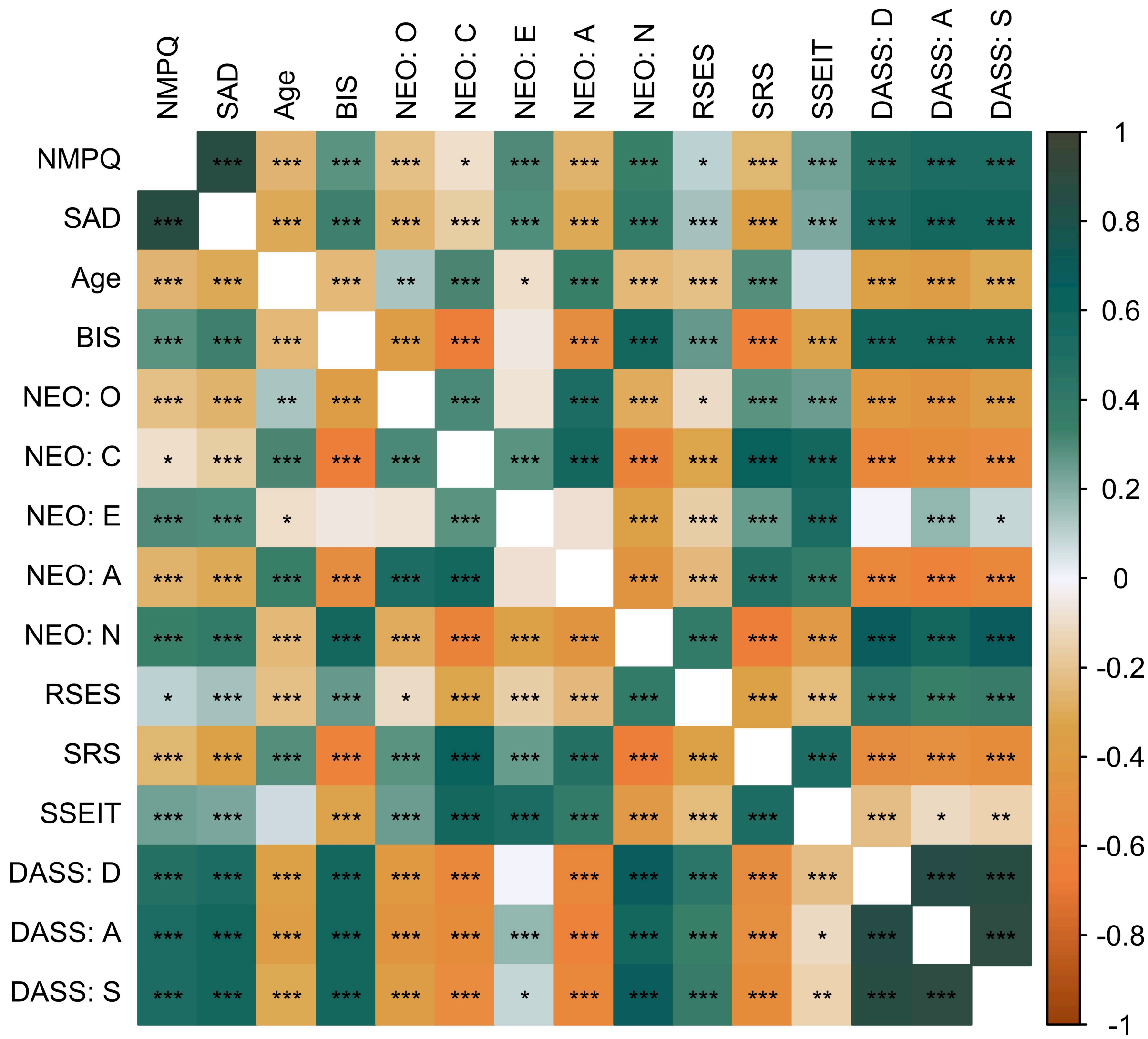
we completed one multiple regression model with all individual difference measures (i.e., impulsivity, openness, conscientiousness, extraversion, agreeableness, neuroticism, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress) and age. In order to do this, we first examined the correlations between all of our variables of interest (i.e., the criteria and predictors).

The Relationship between Smartphone Reliance and Individual Difference Measures A Pearson correlation analysis was completed on all our criterion and predictor variables. As shown in Figure 4.8, most correlations were significant, $r(503)$ = -.67 to .89, p = .045 to < .001, with only 3.81 % of the correlations being non-significant, $r(503)$ = -.08 to .09, p = .109 to .887. The strongest correlation was between anxiety and stress, $r(503) = .89$, $p < .001$. Although it was not the strongest, our reliance measures were still very strongly and positively correlated, $r(503) = .87$, $p < .001$. Between each criterion and the predictors, all predictors were significantly correlated with nomophobia, with the strongest positive correlations being anxiety, $r(503) = .53$, $p < .001$, stress, $r(503) = .52$, $p < .001$, and depression, $r(503) = .47$, $p < .001$. For nomophobia, the strongest negative correlations were agreeableness, $r(503) = -.26$, $p < .001$, self-regulation, $r(503) = -.25$, $p < .001$, and openness, $r(503) = -.21$, $p < .001$. All predictors were significantly correlated with smartphone attachment and dependency, with the strongest positive correlations being anxiety, $r(503) = .59$, $p < .001$, stress, $r(503) = .57$, $p < .001$, and depression, $r(503) = .52$, $p < .001$. The strongest negative correlations for smartphone attachment and dependency were self-regulation, $r(503) = -.35$, $p < .001$, agreeableness, $r(503) = -.30$, $p < .001$, and openness, $r(503) = -.26$, $p < .001$. In contrast to Study 1, age had a non-significant correlation with only one predictor: emotional intelligence, $r(503) = .07$, $p = .124$. All other measures were significantly correlated with age, $r(503)$ = -.37 to .35, p = .028 to < .001. See Table 4.23 and Table 4.24 for more details[3].

In order to compare the level degree of smartphone reliance or individual difference across our measures, each measure was split into levels, which depicted an increase of the respective measure: low, mild, moderate, high, and very high. This was done identical to Study 1. Across the smartphone reliance measures, 39.01 % of participants were in the high level, followed by 25.54 % in the moderate level. Very few participants were in the low level (i.e., 7.23 %. A similar pattern was present for the predictor measures, where most participants were in the moderate level (35.00 %), followed by the high level (22.67 %). It should be noted that the low level was a close third-highest (21.42 %) and the lowest proportion of the predictor measures was in the very high level (7.51 %). As shown in Figure 4.9, six of our predictor measures had more than half of participants in one level. Openness and agreeableness had over half of their participants in the moderate level (56.24 %, and 50.69 %, respectively). Emotional intelligence

[3]Our measures in Study 2 generally displayed adequate levels of internal consistency (i.e., standardized Cronbach's $\alpha \geq .70$). It should be noted that one measure, Openness, was below the cut-off and our findings regarding this measure should be interpreted with caution. See Table 4.11 for more details.

Figure 4.8: *Correlation matrix of the criteria and predictors in Study 2.*



Note. Correlation matrix for criteria (i.e., smartphone reliance measures), Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD); and predictors, Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). $N = 505$.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

had 58.42 % in the high level. Depression, anxiety, and stress were all primarily in the low level (51.09 % to 80.79 %). For further details, please see Table 4.25.

Predicting Smartphone Reliance As in Study 1, a multiple regression analysis was completed for each of the smartphone reliance measures (i.e., nomophobia and smartphone attach-

Table 4.23: Correlation table of the the criteria and predictors in Study 2.

Criterion and predictor measures as Pearson r correlations for Study 2.

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. NMPQ	–														
2. SAD	.87***	–													
3. Age	-.26***	-.30***	–												
4. BIS	.28***	.33***	-.24***	–											
5. NEO: O	-.21***	-.26***	.13**	-.37***	–										
6. NEO: C	-.09*	-.16***	.31***	-.67***	.30***	–									
7. NEO: E	.30***	.30***	-.10*	-.05***	-.07***	.28***	–								
8. NEO: A	-.26***	-.30***	.35***	-.54***	.52***	.58***	-.08	–							
9. NEO: N	.34***	.38***	-.24***	.58***	-.29***	-.61***	-.33***	-.45***	–						
10. RSES	.10*	.15***	-.22***	.26***	-.10*	-.32***	-.15***	-.24***	.39***	–					
11. SRS	-.25***	-.35***	.29***	-.61***	.28***	.65***	.25***	.48***	-.65***	-.35***	–				
12. SSEIT	.24***	.22***	.07	-.33***	.25***	.58***	.54***	.39***	-.41***	-.23***	.50***	–			
13. DASS: D	.47***	.52***	-.34***	.57***	-.41***	-.58***	.01	-.60***	.67***	.43***	-.54***	-.22***	–		
14. DASS: A	.53***	.59***	-.37***	.60***	-.45***	-.54***	.18***	-.62***	.58***	.34***	-.51***	-.11*	.86***	–	
15. DASS: S	.52***	.57***	-.31***	.58***	-.38***	-.53***	.09*	-.58***	.68***	.37***	-.54***	-.14**	.87***	.89***	–

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.

N = 505

*p < .05. **p < .01. ***p < .001.

ment and dependency). The predictors were added in simultaneously and are presented in the following order: age (measured with our demographic questionnaire); impulsivity (measured with the BIS; Steinberg et al., 2013); the five personality traits measured by the NEO (Maples-Keller et al., 2019), which were openness, conscientiousness, extraversion, agreeableness, and neuroticism; self-esteem (measured by the RSES; Rosenberg, 1965); self-regulation (measure by the SRS; Schwarzer et al., 1999); emotional intelligence (measured by the SSEIT; Schutte et al., 1998); and the three DASS (Lovibond and Lovibond, 1995) measures, which were depression, anxiety, and stress. Both models are visualized in Figure 4.10.

The overall model regression predicting nomophobia (i.e., as measured with the NMPQ; Yildirim and Correia, 2015) using all predictor measures was significant, $F(13, 491) = 32.11$, $p < .001$, $R^2 = .46$, $R^2_{adj.} = .45$. Four predictors significantly added to the model and were positively related to nomophobia: conscientiousness, $\beta_{std} = .21$, $t(491) = 3.65$, $p < .001$, extraversion, $\beta_{std} = .14$, $t(491) = 3.00$, $p < .001$, neuroticism, $\beta_{std} = .25$, $t(491) = 4.26$, $p < .001$, and emotional intelligence, $\beta_{std} = .29$, $t(491) = 5.55$, $p < .001$. Two predictors significantly added to the model and were negatively related to nomophobia: age, $\beta_{std} = -.09$, $t(491) = -2.27$, $p = .024$, and self-regulation, $\beta_{std} = -.17$, $t(491) = -3.31$, $p < .001$. It should be noted that self-esteem, $\beta_{std} = -.07$, $t(491) = -1.93$, $p = .054$, and anxiety, $\beta_{std} = .17$, $t(491) = 1.97$, $p = .050$, were approaching significance. For more details, see Table 4.26. Each significant predictor is further visualized as a scatter plot in Figure 4.11.

The overall model regression predicting smartphone attachment and dependency (i.e., as measured with the SAD; Ward et al., 2017) using all predictor measures was significant, F(13,

Table 4.24: Descriptive statistics for criteria and predictors in Study 2.

Criterion and predictor measures as descriptive statistics and internal consistencies for Study 2.

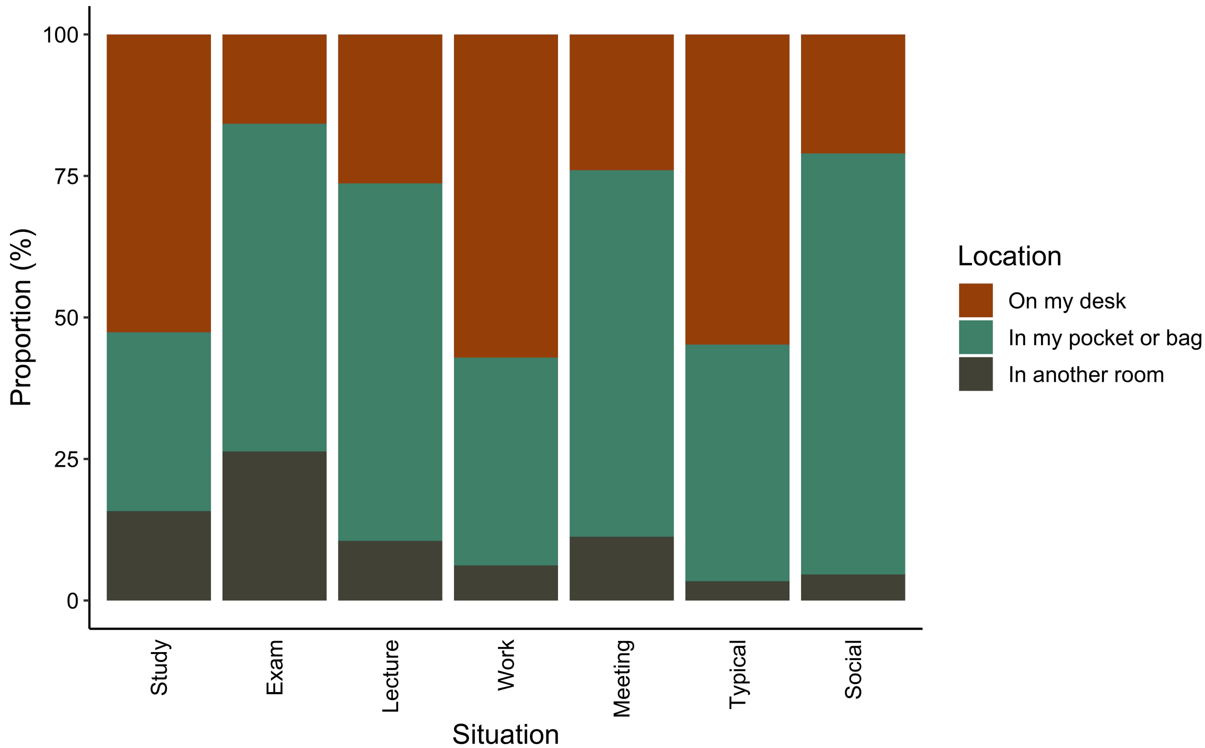
Measure	*M*	*SD*	Min.	Max.	Cronbach's α*
Criterion					
NMPQ	90.05	27.17	20	140	.96
SAD	58.55	17.32	13	91	.93
Predictors					
BIS	15.48	4.38	8	30	.75
NEO: O	39.68	6.90	24	59	.66
NEO: C	42.57	6.79	25	57	.74
NEO: E	39.75	9.14	12	60	.87
NEO: A	42.53	7.81	21	60	.77
NEO: N	32.13	9.68	12	59	.85
RSES	22.48	6.95	10	40	.88
SRS	29.44	5.30	14	40	.82
SSEIT	121.49	17.71	56	165	.93
DASS: D	7.80	6.59	0	21	.94
DASS: A	7.26	6.39	0	21	.94
DASS: S	8.20	6.18	0	21	.93

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S).
* Internal consistency for each measure is depicted using standardized Cronbach's alpha (α). Generally, the measures showed adequate consistency (i.e., $\alpha \geq .70$). Openness was below the cut-off and our findings regarding this measure should be interpreted with caution.
$N = 505$

491) = 43.61, $p < .001$, $R^2 = .54$, $R^2_{adj.} = .52$. Five predictors significantly added to the model and were positively related to smartphone attachment and dependency: conscientiousness, $\beta_{std} = .15$, $t(491) = 2.82$, $p < .001$, extraversion, $\beta_{std} = .14$, $t(491) = 3.13$, $p < .001$, neuroticism, $\beta_{std} = .22$, $t(491) = 4.09$, $p < .001$, emotional intelligence, $\beta_{std} = .35$, $t(491) = 7.09$, $p < .001$, and anxiety, $\beta_{std} = .25$, $t(491) = 3.10$, $p < .001$. Three predictors significantly added to the model and were negatively related to smartphone attachment and dependency: age, $\beta_{std} = -.09$, $t(491) = -2.55$, $p = .011$, openness, $\beta_{std} = -.08$, $t(491) = -2.03$, $p = .043$, and self-regulation, $\beta_{std} = -.29$, $t(491) = -6.12$, $p < .001$. For more details, see Table 4.27. Each significant predictor is further visualized as a scatter plot in Figure 4.12[4].

[4]Supplementary analyses for Study 2 were completed using multiple regression analyses which added gender as a dichotomous (i.e., male and female) predictor to the same models used in the main analyses. These analyses were explored the potential relationship between gender and our smartphone reliance measures. It should be noted that these analyses were explored as supplementary analyses since gender was unbalanced (i.e., more males). See Appendix P for more details.

Figure 4.9: *Criterion and predictor measures as proportion of participants in the low, mild, moderate, high, or very high in Study 1.*



Note. Stacked bar graph for all measures by levels as proportions. Each level was decided by splitting up the range of possible scores for each each measure into five levels: low, mild, moderate, high, and very high. Each measure is shown as an acronym for visualization purposes: Nomophobia (NMPQ), Smartphone Attachment and Dependency (SAD), Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). N = 505.

4.3.3 Interim Discussion

On average, participants were older when they got their first smartphone. Unlike Study 1, participant's most used application was either a social media or an entertainment application. For the subjective value measure, the two lowest and the highest options were all chosen with high frequency. This was inline with Study 1. A very large proportion of participants reported using their smartphone for work and a company-specific application. Participants reported using their smartphone to communicate mainly with friends and family. There was less total screen time (in hours), pickups per day, and notifications per day than in Study 1. One's smartphone was still the most distracting device and this distraction was reported during daily activities, but not during the study. With respect to comfort levels, participants in Study 2 showed no hesitation for leaving their smartphone unattended or in another room during a task.

Table 4.25: Frequency counts for criterion and predictor measures by level in Study 2.

Criterion and predictor measures as frequency counts by levels for Study 2.

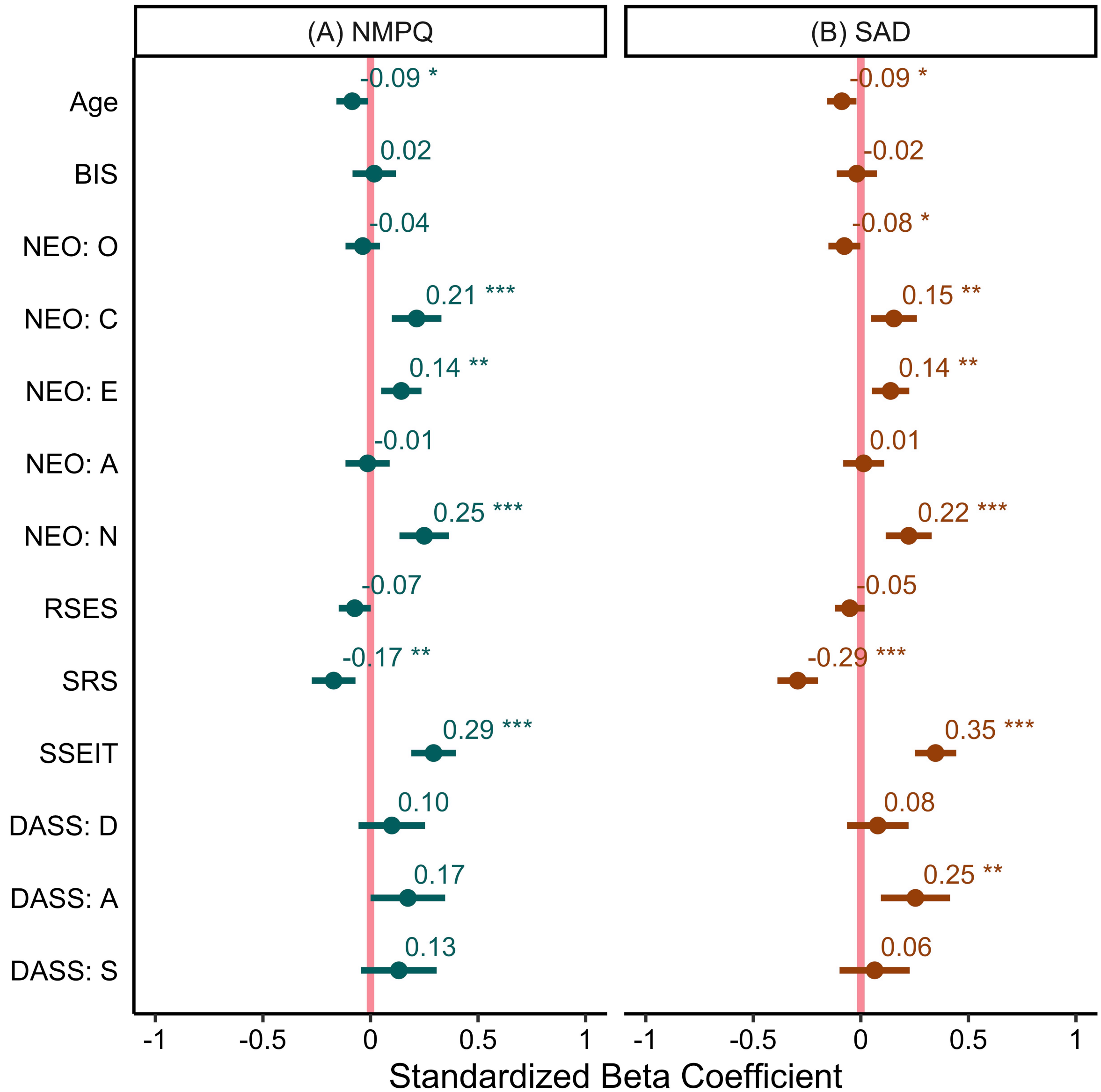
Measure	# Items	Likert Range	Possible Score	Levels: Low	Mild	Moderate	High	Very High
Criterion								
NMPQ	20	1-7	20-140	38	62	125	198	82
				(20-43)	(44-67)	(68-91)	(92-115)	(116-140)
SAD	13	1-7	13-91	35	75	133	196	66
				(13-28)	(29-44)	(45-60)	(61-76)	(77-91)
Predictors								
BIS	8	1-4	8-32	150	175	161	18	1
				(8-12)	(13-17)	(18-22)	(23-27)	(28-32)
NEO: O	12	1-5	12-60	0	42	284	141	38
				(12-21)	(22-31)	(32-41)	(42-51)	(52-60)
NEO: C	12	1-5	12-60	0	15	235	190	65
				(12-21)	(22-31)	(32-41)	(42-51)	(52-60)
NEO: E	12	1-5	12-60	16	76	172	205	36
				(12-21)	(22-31)	(32-41)	(42-51)	(52-60)
NEO: A	12	1-5	12-60	0	16	256	138	94
				(12-21)	(22-31)	(32-41)	(42-51)	(52-60)
NEO: N	12	1-5	12-60	94	113	228	64	6
				(12-21)	(22-31)	(32-41)	(42-51)	(52-60)
RSES	10	1-4	10-40	89	118	218	44	36
				(10-15)	(16-21)	(22-27)	(28-33)	(34-40)
SRS	10	1-4	10-40	3	22	183	183	114
				(10-15)	(16-21)	(22-27)	(28-33)	(34-40)
SSEIT	33	1-5	33-165	1	17	131	295	61
				(33-59)	(60-86)	(87-113)	(114-140)	(141-165)
DASS: D	7	0-3	0-42	278	100	119	8	0
				(0-9)	(10-13)	(14-20)	(21-27)	(28-42)
DASS: A	7	0-3	0-42	258	39	116	88	4
				(0-7)	(8-9)	(10-14)	(15-19)	(20-42)
DASS: S	7	0-3	0-42	408	79	18	0	0
				(0-14)	(15-18)	(19-25)	(26-33)	(34-42)

Note. Criterion measures shown on top: Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD). Predictor measures shown on bottom: Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
N = 505

A correlation analysis replicated and expanded the findings from Study 1. Not only were the same predictors related (e.g., neuroticism, stress, emotional intelligence), but all predictors were related to nomophobia and smartphone attachment and dependency. These results coincided with our predictions. In contrast to Study 1, Study 2 showed almost all measures were related to age (excluding emotional intelligence). The change in the relationship to age could be due to the larger age range in the sample.

When exploring the smartphone reliance and predictor variables as levels (i.e., low, mild,

Figure 4.10: *Standardized beta coefficients for multiple regression models predicting smartphone reliance measures in Study 2.*



Note. Forest plot for the two multiple regression models. Panel A depicts the model predicting Nomophobia (NMPQ) and panel B depicts the model predicting Smartphone Attachment and Dependency (SAD). Standardized beta coefficients (dots) and the 95 % confidence interval (whiskers) are shown for each model. Vertical line represents the neutral point or no relationship between the predictor and the criterion. Predictors were identical for both models and are shown across the y-axis: Age, Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). $N = 505$.

Table 4.26: Multiple regression model results predicting nomophobia in Study 2.

Multiple regression results predicting nomophobia in Study 2.

Predictor	β	$SE_β$	Std. β	Std. $SE_β$	t(491)	p
Age	-0.23	0.10	-.09	0.04	-2.27	.02
BIS	0.11	0.32	.02	0.05	0.34	.74
NEO: O	-0.14	0.16	-.04	0.04	-0.89	.38
NEO: C	0.86	0.24	.21	0.06	3.65	< .01
NEO: E	0.43	0.14	.14	0.05	3.00	< .01
NEO: A	-0.05	0.18	-.01	0.05	-0.26	.80
NEO: N	0.70	0.16	.25	0.06	4.26	< .01
RSES	-0.29	0.15	-.07	0.04	-1.93	.05
SRS	-0.88	0.27	-.17	0.05	-3.31	< .01
SSEIT	0.45	0.08	.29	0.05	5.55	< .01
DASS: D	0.41	0.32	.10	0.08	1.26	.21
DASS: A	0.74	0.38	.17	0.09	1.97	.05
DASS: S	0.58	0.39	.13	0.09	1.47	.14

Note. Overall model was significant, $F(13, 491) = 32.11$, $p < .001$, $R^2 = .46$, $R^2_{adj} = .45$. Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 505$

Table 4.27: Multiple regression model results predicting smartphone attachment and dependency in Study 2.

Multiple regression results predicting smartphone attachment and dependency in Study 2.

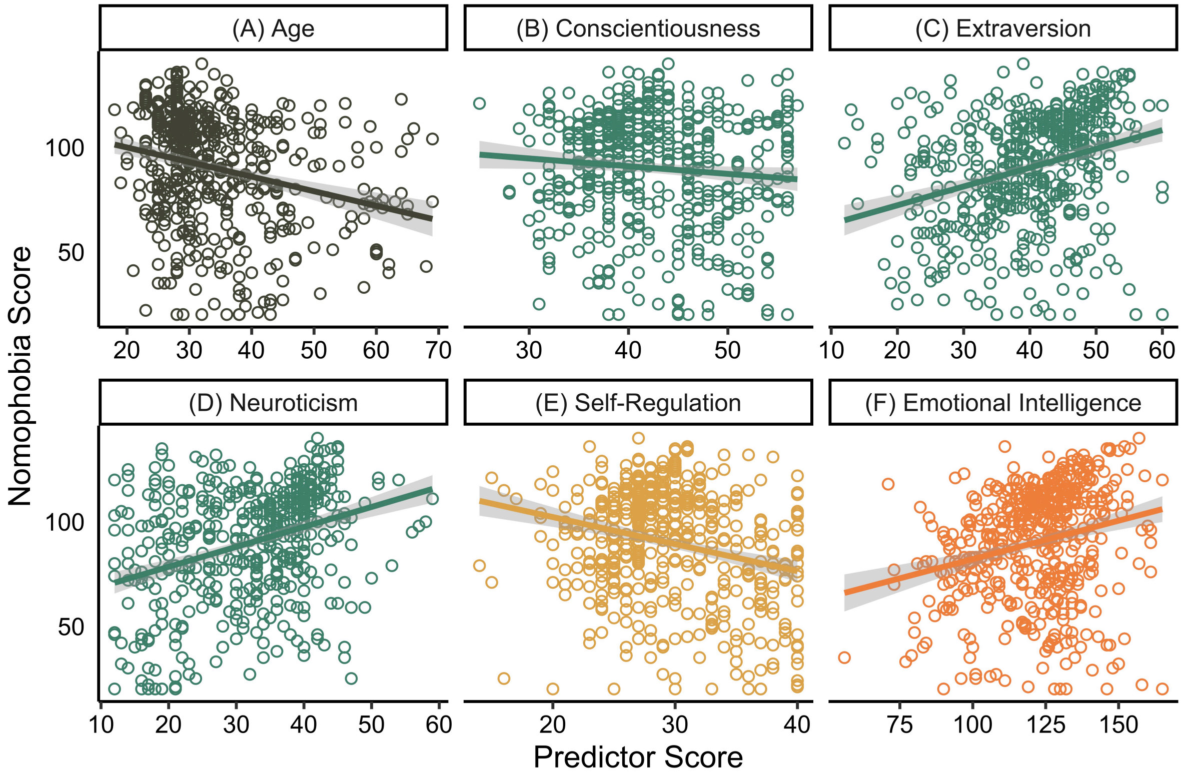
Predictor	β	$SE_β$	Std. β	Std. $SE_β$	t(491)	p
Age	-0.15	0.06	-.09	0.03	-2.55	.01
BIS	-0.07	0.19	-.02	0.05	-0.40	.69
NEO: O	-0.19	0.09	-.08	0.04	-2.03	.04
NEO: C	0.39	0.14	.15	0.05	2.82	< .01
NEO: E	0.26	0.08	.14	0.04	3.13	< .01
NEO: A	0.03	0.11	.01	0.05	0.27	.79
NEO: N	0.40	0.10	.22	0.05	4.09	< .01
RSES	-0.13	0.09	-.05	0.04	-1.46	.14
SRS	-0.96	0.16	-.29	0.05	-6.12	< .01
SSEIT	0.34	0.05	.35	0.05	7.09	< .01
DASS: D	0.21	0.19	.08	0.07	1.08	.28
DASS: A	0.69	0.22	.25	0.08	3.10	< .01
DASS: S	0.18	0.23	.06	0.08	0.77	.44

Note. Overall model was significant, $F(13, 491) = 43.61$, $p < .001$, $R^2 = .54$, $R^2_{adj} = .52$. Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 505$

moderate, high, and very high), results in Study 2 coincided with the trends in Study 1. Greater details are given in the general discussion.

As in Study 1, our regression models were able to predict both smartphone reliance mea-

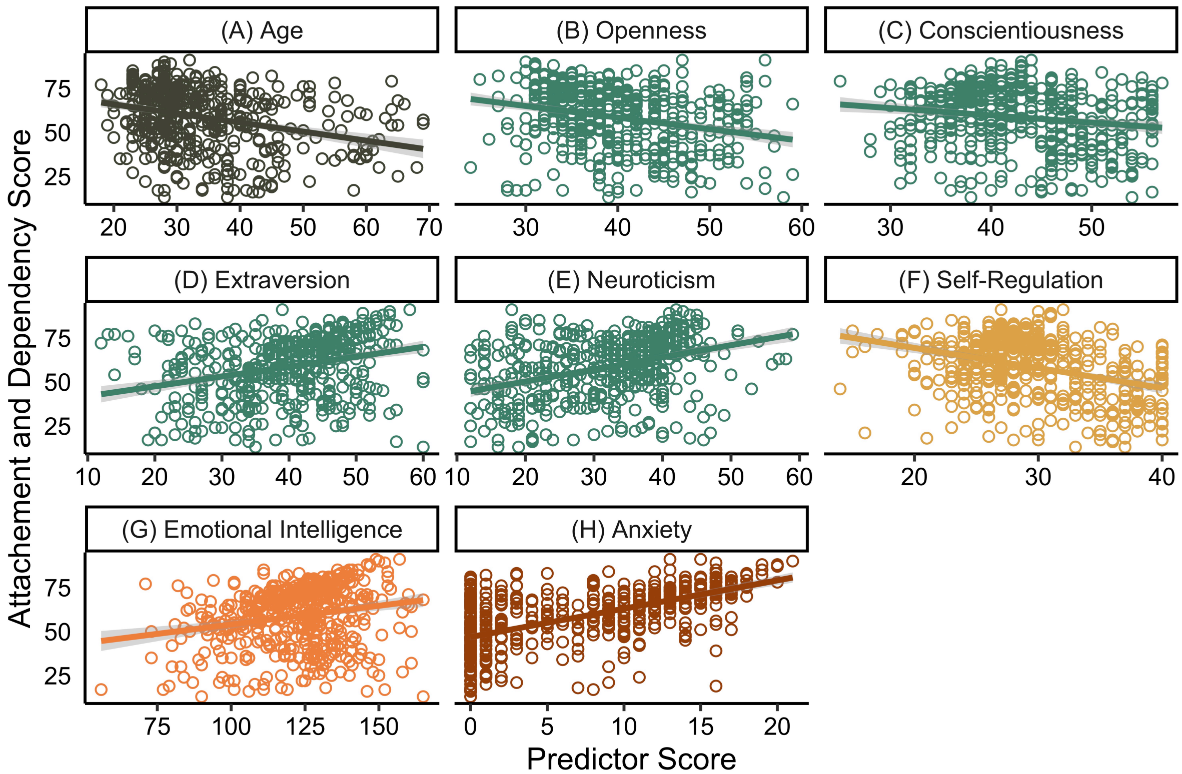
Figure 4.11: *Scatter plot depicting each significant predictor of nomophobia in Study 2.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Age (in years), β_{std} = -.09, $t(491) = -2.27$, $p = .024$. Panel B depicts Conscientiousness, β_{std} = .21, $t(491) = 3.65$, $p < .001$. Panel C depicts Extraversion, β_{std} = .14, $t(491) = 3.00$, $p < .001$. Panel D depicts Neuroticism, β_{std} = .25, $t(491) = 4.26$, $p < .001$. Panel E depicts Self-regulation, β_{std} = -.17, $t(491) = -3.31$, $p < .001$. Panel F depicts Emotional Intelligence, β_{std} = .29, $t(491) = 5.55$, $p < .001$. $N = 505$.

sures (i.e., nomophobia and smartphone attachment and dependency). Significant predictors of nomophobia were younger, more conscientiousness, more extraversion, more neuroticism, less, self-regulation, and more emotional intelligence. Significant predictors of smartphone attachment and dependency were younger, less openness, more conscientiousness, more extraversion, more neuroticism, less self-regulation, more emotional intelligence, and more anxiety. These findings suggest that most of our predictors can predict smartphone reliance. Compared to Study 1, Study 2 found that age was a significant predictor. This was likely due to the large age and general demographic (e.g., education, employment status, current country of residence) in Study 2. The implications of these findings are discussed further in the general discussion.

Figure 4.12: *Scatter plot depicting each significant predictor of smartphone attachment and dependency in Study 2.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting smartphone attachment and dependency. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Age, β_{std} = -.09, $t(491) = -2.55$, $p = .011$. Panel B depicts Openness, β_{std} = -.08, $t(491) = -2.03$, $p = .043$. Panel C depicts Conscientiousness, β_{std} = .15, $t(491) = 2.82$, $p < .001$. Panel D depicts Extraversion, β_{std} = .14, $t(491) = 3.13$, $p < .001$. Panel E depicts Neuroticism, β_{std} = .22, $t(491)$ = 4.09, $p < .001$. Panel F depicts Self-regulation, β_{std} = -.29, $t(491) = -6.12$, $p < .001$. Panel G depicts Emotional Intelligence, β_{std} = .35, $t(491) = 7.09$, $p < .001$. Panel H depicts Anxiety, β_{std} = .25, $t(491) = 3.10$, $p < .001$. N = 505.

4.4 General Discussion

4.4.1 Smartphone Use Tendencies

Unsurprisingly, our sample in Study 2 was similar to previous studies but with nuances likely due to the nature of the larger online-based study on non-university students. Over a ten-year difference was found in the average age of getting one's first smartphone. This was likely an artifact of the age range in Study 2, which included much older participants than Study 1. Another difference between typical smartphone use was in participants' most used application.

As seen in most previous studies, Study 1 found social media applications as the most used; however, Study 2 saw almost equal proportions for social media and entertainment applications for both all smartphone users and iPhone users. Subjective value was not as stable as our previous studies. Both studies found that one of the lower and the highest values were chosen the most. This is likely due to the age difference we saw in both studies. It is likely that splitting the data into age cohorts would differentiate between the typical smartphone use measure. Participants in Study 2 showed a much larger proportion who used their smartphone for work and used a company-specific application. This was not surprising since participants in Study 2 were more likely to be outside of university and working a full-time job. Another cohort difference was the fact that participants in Study 2 were almost equally likely to use their smartphone to communicate with family or friends, compared to just friends in Study 1. Both studies did find that most people experience phantom vibrations. This aligns with Deb (2015); Ruiz Pardo and Minda (2021), who found similar patterns across multiple studies.

With respect to the Screen Time measures, we saw a much smaller proportion reported having Screen Time activated prior to the study (32.08 % in Study 2 compared to 72.92 % in Study 1). There was a reduction in total screen time (in hours), and pickups and notifications (per day). Additionally, the range in each of the Screen Time measures was much smaller in Study 2. This is likely due to the older cohort collected in Study 2. With respect to comfort levels, both studies showed that participants seem to be comfortable with leaving their smartphone unattended and even in another room while completing a task.

Although both studies found that one's smartphone is the most distracting device, Study 2 showed a much smaller proportion for each situation, especially in a social context. This might be due to differences in smartphone use or reliance tendencies that would lead the more people in the Study 1 sample to perceive their smartphone as distracting than in Study 2. These differences are explored in the main analyses.

Although participants reported keeping their smartphone powered off during only the exam situation, this trend was not as strong in Study 2. For typical smartphone locations, both studies showed the same overall pattern: most participants placed their smartphone in their pocket or bag, followed by on their desk, and very few in another room. However, when looking at each individual situation, Study 2 had some who preferred placing their smartphone on their desk. These results should be interpreted cautiously since there was a much smaller sample size in Study 2 for the student-related situations (i.e., study, lecture, exam). Overall, the was consistency between our two studies for both typical smartphone power and location.

4.4.2 The Relationship between Smartphone Reliance Measures and Individual Difference Measures

The correlation analysis depicted that the smartphone reliance measures were related to each other across both studies, as seen in previous studies (e.g., Ruiz Pardo and Minda, 2021). In Study 1, those who were more neurotic and stressed showed correspondingly higher nomophobia. Those who were more neurotic, emotionally intelligent, depressed, anxious, and stressed tended to have higher smartphone attachment and dependency. It was interesting to see that more predictors were significantly related to smartphone attachment and dependency (i.e., five) compared to nomophobia (i.e., two). Age did not significantly correlate with any measure. Although age has been seen to relate to some of our measures, namely our smartphone reliance measures (e.g., Romero-Rodríguez et al., 2020), our sample's age was only representative of a small age cohort. In Study 2, those with higher impulsivity, extraversion, neuroticism, self-esteem, emotional intelligence, depression, anxiety, and stress; and lower age, openness, conscientiousness, agreeableness, and self-regulation showed tendencies for higher levels of both smartphone reliance measures. Excluding emotional intelligence, all measures were significantly correlated with age. This was a direct contrast to Study 1 and is likely due to the better age representation in the Study 2 sample. Overall, the results in Study 2 expanded on the trends in Study 1.

We compared the levels of each of our measures using five levels (i.e., low, mild, moderate, high, and very high), which depicted an increase of the respective measure starting at low. In both studies, our smartphone reliance measures were primarily in the moderate (top in Study 1) and high (top in Study 2) levels and fit with previous literature that shows the prevalence of smartphone reliance in a university population. Interestingly, our sample showed very few in the low level across our reliance measures. This was true for both studies. Across our studies, our predictor measures showed the same trends with their highest proportions being in the moderate and high levels, respectively. But, the smallest proportion was in the very high level, which was a direct contrast to the smartphone reliance proportions. These trends suggest that there are less extreme individual differences in our sample, which is expected from a non-clinical population. In Study 1, over half of participants were in the moderate level for conscientiousness, neuroticism, self-esteem, and self-regulation. In Study 2, over half of participants were in the moderate level for openness and agreeableness. These were both inline with the over all moderate-level trend across the studies.

Although the primarily moderate predictor measures were not the same across our studies, the same trend was seen across the studies. Conscientiousness, neuroticism, self-esteem, and self-regulation were primarily in the moderate level in Study 2, and a high proportion of participants were in the moderate or high level for openness and agreeableness in Study 1. In both studies emotional intelligence was mostly in the high level, and depression, anxiety, and stress were all firmly in the low levels. The ladder was not surprising since the DASS measure is typically used for a clinical population and the levels are more heavily weighted to the lower levels (Lovibond and Lovibond, 1995). Since our sample was not from a clinical population, primarily low levels for these measures was expected.

4.4.3 Predicting Smartphone Reliance

The overall regression models significantly predicted nomophobia and smartphone attachment and dependency in Study 1 and Study 2. In Study 1, four predictors added significantly to the model predicting nomophobia: openness (negative), neuroticism (positive), self-regulation (negative), and emotional intelligence (positive). Therefore, higher nomophobia was predicted by those who were more neurotic and emotionally intelligent, and less open to new experiences and self-regulated[5]. Three predictors significantly added to the model predicting smartphone attachment and dependency: openness (negative), neuroticism (positive), and emotional intelligence (positive). Therefore, higher smartphone attachment and dependency was predicted by those who were more neurotic and emotionally intelligent, and less open to new experiences. Study 1 findings suggest that neuroticism, openness, and emotional intelligence are consistent predictors of our smartphone reliance measures. Although self-regulation was not a significant predictor of smartphone attachment and dependency, it did trend in the same direction as in the nomophobia model. Study 1 was limited in age range and overall had a limited demographic (i.e., primarily university-aged students). Therefore, our second study explored these measures on a larger and more diverse sample.

In Study 2, six predictors added significantly to the model predicting nomophobia: age (negative), conscientiousness (positive), extraversion (positive), neuroticism (positive), self-regulation (negative), and emotional intelligence (positive). Therefore, higher nomophobia was predicted by those who were younger, more conscientious, extraverted, neurotic, and emotionally intelligent, and less self-regulated. Eight predictors added significantly to the model predicting smartphone attachment and dependency: age (negative), openness (negative), conscientiousness (positive), extraversion (positive), neuroticism (positive), self-regulation (negative), emotional intelligence (positive), and anxiety (positive). Therefore, higher smartphone attachment and dependency was predicted by those who were younger, more conscientious, extraverted, neurotic, emotionally intelligent, and anxious; and less open to new experiences

[5]The present study compared the samples in Study 1 (i.e., university students) and Study 2 (i.e., global population) in a cross-sectional manner, however, no formal statistical comparison was completed to compare the samples in Study 1 and Study 2.

and self-regulated. These findings not only showed consistency between the two smartphone reliance measures, but also some consistency with Study 1.

These findings suggest that most of our predictors can predict smartphone reliance, especially in our larger and diverse sample in Study 2. As depicted in the summary Table 4.28, we found consistent evidence that more neuroticism and emotional intelligence predict more smartphone reliance across both studies. This was consistent with our hypothesis for neuroticism and adds to the existing literature which support the notion that highly neurotic (e.g., self-pitying, tense, unstable, touchy) people will experience more smartphone reliance (Horwood and Anglim, 2021; Marengo et al., 2020; Thomée, 2018). Our findings did not support our hypothesis for emotional intelligence. We predicted that there would be a negative relationship, such that higher emotional intelligence would predict less smartphone reliance. However, these findings did not support the notion that poor emotional intelligence leads to higher addictive behaviours (Kun and Demetrovics, 2010). In fact, the opposite was seen across our smartphone reliance measures in both studies. Our findings depict that higher emotional intelligence predicts higher smartphone reliance. This was likely due to the participants using smartphones to meet their emotional needs. It is likely that those with higher emotional intelligence have a better sense of how to manage their emotions and use their smartphone to accomplish this. Therefore, people become more reliant on their smartphone as their emotional stability is linked to their smartphone use tendencies, meaning they become more reliant on their smartphone. This was a very interesting contrast to the negative relationship between self-regulation and smartphone reliance. Overall, openness and self-regulation were negatively associated with our smartphone reliance measures, where those who are less open to new experiences and have worse self-regulation are more reliance on their smartphone. This supported our prediction for the these measures and was in line with previous studies (Marengo et al., 2020; Thomée, 2018). Our hypotheses for the age measure were only met in Study 2. This was likely due to the increase in age range in our second study. Therefore, being younger predicts higher smartphone reliance. Both conscientiousness and extraversion were significant predictors of smartphone reliance in our second study, were those who were more conscientious and extraverted were more reliant on their smartphone. This matched our prediction for extraversion, but was in the opposite direction for conscientiousness. It seems that people who were more responsible, organized, and efficient (Chittaranjan et al., 2011) experience more smartphone reliance. The weakest consistency was seen for the anxiety predictor, which only predicted smartphone attachment and dependency in our second study. Although this does not match with previous literature on problematic smartphone use and measures of well-being (Augner et al., 2021), our sample was from a non-clinical population and had primarily low levels in this measure. This same pattern can explain why self-esteem, depression, and stress did not significantly predict smartphone reliance across both studies. Therefore, if well-being measures are predictive of smartphone reliance, testing a clinical population may be needed to provide a better range in levels for those measures.

Table 4.28: Summary table for multiple regression models predicting smartphone reliance measures across Study 1 and Study 2.

Summary of model results across Study 1 and Study 2.

		Study 1 (240)		Study 2 (505)	
Predictor	*Hypothesis*	NMPQ	SAD	NMPQ	SAD
Age	–			–	–
BIS	+				
NEO: O	–	–	–		–
NEO: C	–			+	+
NEO: E	+			+	+
NEO: A	–				
NEO: N	+	+	+	+	+
RSES	–				
SRS	–		–	–	–
SSEIT	–	+	+	+	+
DASS: D	+				
DASS: A	+				+
DASS: S	+				

Note. Summary of results for multiple regression models predicting Nomophobia (NMPQ) and Smartphone Attachment and Dependency (SAD) in Study 1 and Study 2 compared to hypotheses. All overall models were significant, $p < .001$. Significant predictor measures depicted with respective direction (i.e., "–" for negative and "+" for positive). Predictors defined as follows: Age (in years), Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Sample sizes shown in parentheses.

Overall, it seems that smartphone reliance can be predicted using different personality and well-being measures. Our studies found that the typical study investigating this relationship should strive for non-university samples, or at least one with larger age and demographic diversity. This is evident from the differences between our studies, where some predictors, namely age, were only significant predictors in Study 2. However, it is clear from our findings that age or age cohort is not the only predictor that should be considered. One of the strongest predictors, in fact, was emotional intelligence. This measure is still relatively unexplored in the smartphone literature. Our findings suggest that this, along with some NEO personality measures such as neuroticism, play a larger role that age alone. This differentiates our studies from previous literature, which tended to focus on age as a key indicator of smartphone reliance. Future studies could also explore other moderating factors such as substance use disorder and other addictive tendencies. For example, Demkow-Jania et al. (2021) found that smartphone use disorder status moderated the relationship between openness and neuroticism on mobile phone problem use.

4.4.4 Conclusions

It seems that age on its own may not be the determining predictor of smartphone reliance. Our findings suggest that there may be a personality profile that makes you susceptible to smartphone reliance. This is an important addition to the smartphone literature as it expands on the notion that our smartphones are not innately the issue, but rather that some of us may be more prone to the negative effects of smartphone use. These findings can be used in future studies to build a personality profile and assess whether this moderates cognitive performance differences during a smartphone manipulation experiment.

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Chapter 5

Discussion

This dissertation adds to the booming smartphone literature that investigates the effect of smartphone presence on cognition, and the individual differences that make up smartphone reliance. This chapter provides a brief summary of the key findings across the studies in Chapters 2 to 4 and discusses the implications, limitations, and future directions from the findings.

5.1 Summary of Key Findings

Using a smartphone allows users to have a miniature computer at-hand and can help facilitate every-day tasks (e.g., using a map application, searching for a place to eat). Smartphone are not only ubiquitous in our society, but they provide us with endless utility from having access to your calendar, email, and text messages to connecting to the global environment such as the news and social media. We can use our smartphone to stay connected with our friends, family, and work; or even disconnect from our surroundings with music, videos, and games. The limiting factor to the utility of a smartphone lies with the user, with new and updated versions of both the devices themselves and their software and applications released almost annually across brands. It is this vast utility and potential that has won smartphones their popularity, and they are not likely to lose this popularity anytime soon. As shown by (Pew Research Center, 2021), smartphone ownership has steadily increased and smartphone ownership is still more prevalent than any other popular electronic device (e.g., computer, tablet).

Given this, it is not surprising that an entire field of researchers have devoted their efforts to investigating the potential negative (and positive) effects of smartphones on cognition. Previous literature has investigated how active smartphone use affects us (e.g., Stothart et al., 2015; Thornton et al., 2014; Wilmer and Chein, 2016). More recently, researchers have explored how even the mere presence of one's smartphone impacts our cognition (e.g., Hartmann et al., 2020; Tanil and Yong, 2020; Thornton et al., 2014; Ward et al., 2017). This was investigated in Chapters 2 and 3. A parallel field has also explored differences in personality traits and how they are related to typical and problematic smartphone use (Harris et al., 2020; Marengo et al., 2020; Thomée, 2018). This was investigated in Chapter 4.

In Chapter 2, I completed a direct replication of Ward et al.'s (2017) second experiment, where they found that placing one's phone on your desk resulted in worse performance on a difficult working memory task (i.e., the Automated Operation Span Task; Unsworth et al., 2005) and that this effect was moderated by smartphone dependence. Using the same measures, I tested whether smartphone location (i.e., on your desk, in your pocket or bag, or outside of the testing room) and smartphone power (i.e., powered on or off) affected performance on a difficult working memory task and a response inhibition task (i.e., the Cue-Dependent Go/No-Go Task; Bezdjian et al., 2009). My study did not replicate the original findings. These results suggested that either smartphone presence does not affect cognition or that the measures we used were not sensitive enough to capture the performance differences.

To address the limitations of Chapter 2, Chapter 3 explored which cognitive functions might be affected by smartphone presence. I completed three studies which (1) assessed smartphone use tendencies, including smartphone location and power preferences (Study 1) and (2) evaluated performance on a battery of cognitive tests (i.e., the 12 Cambridge Brain Science Tests; Hampshire et al., 2012) between different smartphone locations in either a lab setting (Study 2) or an online setting (Study 3[1]). Study 1 provided an overview of smartphone use tendencies and decided the three smartphone locations for Study 2 (i.e., on your desk, in your pocket or bag, and outside of the testing room). Study 2 found an effect of smartphone location on verbal ability, where those who placed their smartphone on their desk had lower performance compared to those who placed their smartphone in their pocket or bag. Study 3 completed a conceptual replication of these findings using an online platform. Findings did not replicate our Study 2 results: there was no performance differences between placing your smartphone on your desk (and within your line-of -sight) or away from you (and outside of your line-of-sight). Chapter 3 therefore concluded that smartphone presence might only have a localized and inconsistent effect on cognition. Across Study 2 and Study 3 in Chapter 3, there were 24 total cognitive tests, where only one test (i.e., Digit Span, which measured verbal short-term memory) showed a significant effect of smartphone location in Study 2 only. Although this effect was intriguing and did support some previous findings (e.g., Tanil and Yong, 2020; Ward et al., 2017), this was likely a false positive. Additionally, I concluded that smartphone reliance measures and other individual difference measures should be explored to see if there issue lies

[1]It is worth noting that Study 3 was completed between December 2020 and April 2021, which was during an variety of province-wide lock downs due to the COVID-19 pandemic. Participants were university students who would have completed their respective academic year fully online.

with specific people's relationship with heir smartphone rather than the smartphone itself.

Chapter 4 explored this very relationship. I completed two studies which assessed psychological predictors of smartphone reliance (i.e., nomophobia, which is the fear of being without your phone or the internet; Yildirim and Correia, 2015; and smartphone attachment and dependency; Ward et al., 2017). The commonly investigated predictors in previous studies were used (i.e., age, impulsiveness, the five-facet personality traits, self-esteem, self-regulation, emotional intelligence, depression, anxiety, and stress; Augner et al., 2021; Marengo et al., 2020; Thomée, 2018). Study 1 found that less openness, and more neuroticism, and emotional intelligence predicted smartphone reliance in a university population. Study 2 found that being younger, more conscientious, extraverted, neurotic, and emotionally intelligent; and less self-regulated predicted more smartphone reliance in a global population. The best predictors of smartphone reliance were higher neuroticism and higher emotional intelligence. These results indicate that there is a personality profile that is more susceptible to smartphone reliance and potentially any cognitive effects from smartphone use.

Overall, my studies in this dissertation demonstrates that the smartphone itself should not be vilified. The cognitive deficits seen in previous studies (e.g., Courtright and Caplan, 2020; Tanil and Yong, 2020; Ward et al., 2017 and public opinion of smartphones has warped our perceptions on how our smartphone can affect us. My work suggests that the mere presence of your smartphone is not enough to impact our cognition reliably. Additionally, psychological traits such as emotional intelligence and their relationship with problematic smartphone use or reliance should be more closely explored. Only by doing this can future research evaluate how smartphones are affecting us.

5.2 Broader Implications and a Theoretical Perspective

It seems logical that smartphone use and potentially the mere presence of our smartphone can have negative effects on our cognitive abilities. However, based on this dissertation, smartphone presence alone seems to have, at best, inconsistent effects on cognition (see Chapter 2 and 3). Smartphone use has been linked with reduced performance while driving (Caird et al., 2014), reduced self-regulation (Wilmer and Chein, 2016), and reduced performance on a demanding attention task (Stothart et al., 2015). Why do we see that smartphone use and sometimes smartphone presence can affect us, but not always? Why does an intimate object have any effect on cognition? First, I will discuss Belk's Extended Self Theory (1988; 2013) to addresses these questions and then I discuss the mechanisms that would be involved.

5.2.1 Extension of Self Theory

The Pre-Digital Age

Belk's (1988) Extended Self Theory posits that an individual's possessions, whether knowingly or unknowingly, intentionally or unintentionally, can become an extension of one's self. These possessions or objects can be a person, place, thing, or an event. The process of self-extension, or incorporating a possession into the Extended Self, is described through three methods: (1) control or mastery, (2) creating, and (3) knowing. Control or mastery refers to how owning and being able to assert control over an object leads to self-extension. For example, a mountain climber who has conquered a new climb can feel ownership over the climb itself and interpret this accomplishment as a new extension of themselves. Creating refers to either a physical or abstract thought. As long as the object remains connected to a person's identity, this object becomes and is maintained as a self-extension. An example of self-extension through creating can be seen through scientific citations (i.e., maintaining an association with that research or work) or even as simple as buying an object and 'creating' it as one's own. Lastly, knowing is a method of self-extension, which refers to the relationship that one has with a given object. For example, a close friend or a favourite mug can become something we 'know'. Shared and prolonged experiences with an object like a favourite mug can produce a sense of connection with the object itself (i.e., due to the emotional entanglement between object and shared experiences involving that object).

The three methods of self-extension are mostly active and international, however, Belk also described an unintentional method of self-extension: contamination. Contamination refers to when an outside, and usually unwanted, object becomes a self-extension through force. This method of self-extension was broken down into six modes: (1) violation of one's personal space; (2) touching and bodily contact; (3) glancing, looking, and staring; (4) noise pollution; (5) talking to or addressing one; and (6) bodily excreta (i.e., corporal excreta like spit or fecal matter, odor, body heat, and markings left on the body). Although not explicitly stated by Belk, contamination as a method of self-extension that could explain some of the probable negative impacts from smartphone use. Smartphone users may choose their typical use of their device, however, the content they are exposed to is predetermined via an algorithm, including paid advertisements, political messages, and recent events (e.g., news coverage).

The Digital Age

Self-extension was described before smartphones were readily available; however, in a follow-up paper, Belk (2013) discussed how this theory fits into a digital world. Five major phenomena were caused by the digital age: (1) dematerialization, (2) re-embodiment, (3) sharing, (4) co-

construction of self, and (5) distributed memory.

Dematerialization This refers to attaching oneself to the virtual self. Specifically, Belk (2013) describes this as the phenomenon of losing the material in our possessions (e.g., information, photos, written words, data) to a virtual world. For example, the loss of physical CDs or DVDs for music and movies to digital versions. We can even view or create playlists to share with the online world, which essentially shares our online self with the digital world. Denegri-Knott and Molesworth (2010) argued that digital and material good consumption inherently differ. Specifically, digital consumption fulfill four functions: (1) stimulation of desire for material goods, (2) realizing daydreams (e.g., wealth, status), (3) realizing impossible fantasies (e.g., avatars in a video game), and (4) facilitate experimentation (e.g., acting like a criminal in a video game). However, Belk (2013) argues that both material and virtual goods have a conceptual presence in one's self-extension. It should be noted that virtual possessions do inherently lack some value when compared to physical possessions. For example, a digital e-card or album can be easier to throw away or delete than a physical card or CD. However, these differences tend to dissipate with different age groups, where younger age groups do report holding the same level of attachment to their digital possessions (Belk, 2013).

Re-embodiment This refers to how an online avatar affects the 'online self'–we are no longer constrained to our physical bodies (Belk, 2013). As we become more comfortable with a digital self, an avatar or online presence progressively becomes a stronger reflection of oneself as we begin to identify with the virtual representation shown to the online world. In the re-embodiment phenomenon, people not only build a sense of attachment to their avatar, they also experience changes in their offline behaviour due to their virtual self. An avatar is selected by the user (e.g., features such as height, personality, abilities) and can cause offline behavioural changes such as increased confidence. This also allows users to have the possibility to create multiple avatars with differing personality and physical characteristics, which allows users to explore these differences in themselves from a safe context. This also implies a key change to Belk (2013) original theory: there is no singular or 'core' self.

Sharing This refers to self-revelation and a loss of control (Belk, 2013). Unsurprisingly, the digital world allows users to share content and update on their day-to-day life. This constant accessibility to other's personal lives leads to a disinhibition in the form of greater self-disclosure in a digital context. For example, sharing photos on social media or posting a blog that would, prior to the digital age, only be available to close family or friends. This sharing comes with an inherent fallback: a loss of control. All users have access to the digital sharing world, therefore, no one can control or stop another from sharing something without consent. This includes those who comment on a post or share their own post that we would not have shared ourselves. The phenomenon of sharing relates back to Belk's (1988) original concept of contamination: events or objects that become an extension of one's self-identity by force.

Co-construction of Self This refers to how building self-identity through the online self is a social process rather than a solitary process Belk (2013). Although it is possible to have an online presence in isolation, most online activities involve an interactive nature between multiple users. Therefore, the digital construction of the self becomes a community-built persona. This stems from affirmation seeking behaviour that occurs in the virtual world and can be compared to Belk's (1988) original concept of contamination. This co-construction can be consensual and positive, but since users cannot control other user's online materials and invasive aspects can take place. Both the positive and negative aspects of co-construction take place.

Distributed Memory This refers to the narratives of the self that are built in the digital world (Belk, 2013). The digital tracking of autobiographical memory allows an expanded archive of both individual and collective memories with those we share our digital world with.

5.2.2 Implications for Smartphone Research

Belk's Extended Self Theory (2013) can be excellently applied to the digital age: people who use technology tend to use it in a dependent manner and become attached, as with other possessions. This holds important implications for how people relate to, interact with, and feel about their smartphones. This relationship with one's smartphone is directly related and supports my findings regarding the psychological traits I measured in Chapter 4. Excessive and problematic smartphone use can cause a sense of dematerialization in the same ways Belk (2013) posits. Although our smartphone is a physical possession, it's contents are far beyond the physicality. For example, we have constant access to our media (e.g., music, pictures). With respect to re-embodiment, smartphones allow us to construct and maintain an online persona, which can differ between the platforms we are using on our smartphone (e.g., social media versus work-related applications) and cause a split in our previously theorized 'core' self. The sharing phenomenon is especially evident with respect to smartphone use. The constant access to platforms such as social media can be detrimental to our sense of privacy and be anxiety-provoking (Augner et al., 2021). Along with the sharing phenomenon, the co-construction of self has its own research implications. Consider that younger age cohorts would not know a world without a smartphone. In Chapter 4, we saw a participant report getting their first smartphone at the age of two years old. This is a vivid example of how early our smartphones can begin to mold our perception of who we are and how we explore, learn, and interact with the world. In conclusion, Belk's (2013) Extension of Self Theory provides a social-psychological framework for why smartphones can affect us and how this relationship can lead to smartphone reliance.

The Cognitive Context

How is this explained with respect to the cognitive mechanism that is occurring? A cognitive mechanism describes how we receive, think about, interpret, assess, and then act upon the initial information or stimulus we received. The hypothesized effect of smartphone presence on our cognition was that of the mechanism of attention. Smartphones are designed to capture and retain our attention. Therefore, the close proximity of your smartphone (i.e., on your desk) interferes with the way you receive and act upon a task such as a CBS test (see Chapter 3). Consider the findings in Chapter 3, specifically from Study 2, where I found that participants who placed their smartphone on their desk performed significantly worse than those who placed their smartphone in their pocket or bag on the Digit Span CBS test (i.e., a verbal short-term memory task).

Although these findings were not replicated in Study 3, the effect on verbal short-term memory begs the question: why would we see any effect on this test to begin with? Attending to our smartphone (e.g., checking for notifications, thinking about potential notifications) has become a condition response. That is, there is a stimulus-response association without smartphone. For example, consider if you have just posted on a social media platform and this post has drawn some comments/replies, shares. If you are then required to attend to a separate task (e.g., a digit span task), you might still be thinking about checking your smartphone to see that social media post (e.g., wondering what others have said, who is sharing). You may not be able to use your smartphone, but you might look towards it or think about when you will be able to check it. In this example, thinking about your smartphone would interfere with your ability to complete the task. Your smartphone is a stimulus-response cue: in this case, for a social media post. In this example, you are not able to check your smartphone but are thinking about being able to check it. This inanimate object becomes a visual reminder of the function you would like to perform (i.e., check your social media post). The thought of your smartphone therefore activates the memory of the social media post and the traction it might be getting online. Attending to your smartphone therefore competes with the digit span task and your task performance worsens as your resources are split between the two processes. This example explores the potential cognitive mechanisms behind Ward et al.'s (2017) original "brain drain" effect; however, my findings in Chapter 3, Study 2 were likely a false positive and therefore any interpretation of the underlying mechanisms are only theoretical in nature.

This example also emphasizes the potential entanglement between how people feel about their smartphone and what they use their smartphone for: do they primarily use their smartphone to use social media or other platforms? In this dissertation, this connection is further supported as most participants reported a social media application as their most used smartphone application. With respect to social media users is the distinction between a *content creator* and a *content consumer*. A content creator tends to use social media primarily to create material (entertaining or educational) through any medium[2] or platform (e.g., writing a tweet, posting a picture on Instagram, posting a video on TikTok). A content consumer tends to use social media primarily to view, share, or engage with content created by other social media users (e.g., liking an Instagram photo, commenting on a Facebook post, sharing a tweet). This distinction is important with the increase in Online Influencer Marketing (OIM), which involves content creators using their social media platforms to promote products or services for payment from the respective company or organization (Leung et al., 2022). These users direct their content to the content consumer users with the goal of increasing their engagement with the content. OIM is still relatively new and under researched but has many implications for how we reach and engage a target audience (Leung et al., 2022). This content type distinction could play a crucial role in how we interact with and perceive our smartphones. For example, a content creator might be more invested in checking their smartphone compared to a content consumer. Therefore, smartphone research should not only focus on smartphone use tendencies (e.g., for social media), but also the motivations behind the use (e.g., content creator versus consumer for social media users).

5.3 Methodological Benefits and Future Directions

This dissertation used a combination of experimental (Chapter 2; and Chapter 3, Study 2 and 3) and correlational methodologies (mainly in Chapter 3, Study 1; and Chapter 4, Study 1 and 2). The experimental designs allowed me to measure how randomly assigning people to smartphone location (and power for Chapter 2) conditions effected cognitive performance.

All my studies had at least one correlational (or descriptive) component. This allowed me to provide vivid descriptions of my samples. This not only included the typical demographic information (e.g., age, gender, English proficiency), but also other additional demographic information such as country of current residence, main or first language, employment status, and education level. These demographic measures were useful because they provided a clear depiction of our sample for each study and can be compared across studies as potential reason for any differences in our main measures. The other correlational measures I used were related

[2]For social media users, the medium tends to be in a digital medium such as a photo, video, etc.

to typical smartphone use or smartphone tendencies. This included measures specific to the way or frequency of people's smartphone use (e.g., most used application, Screen Time use for iPhone users) and measures regarding people's perception of distractibility due to their smartphone and comfort in different situations with their smartphone. I also collected people's smartphone location and power tendencies in Chapter 3 and 4. These measures served for more than a methodological decision in Chapter 3, Study 1. The typical smartphone location measure depicted consistency in typical smartphone locations between Chapter 3 (Study 1, 2, and 3) and Chapter 4 (Study 1), but not in Chapter 4, Study 2. This provided evidence for a shift in typical smartphone use among the non-university sample, which provides further evidence that psychological research should be collecting more diverse samples. These insights in typical smartphone use were only possible because I used similar questions across my studies. Future studies should use the measures (or similar) in this dissertation to provide further comparison points and continue mapping the evolution of typical smartphone use.

Other correlational designs included formal correlation or regression analyses. These helped identify relational patterns in the data. Namely, these allowed me to determine the best predictors of smartphone reliance in Chapter 4. This design provided the first known view of a battery of personality and well being traits. The results can be used to guide future studies looking to evaluate how other factors can moderate this relationship. For example, in a future study I would like to collect a large enough sample to run an exploratory factor analysis on the predictor variables I measured. This analysis would give me a "profile" of related concepts which can better predict smartphone reliance than they would individually. These findings would then be used in an experimental study where participants would be asked to place their smartphone either on their desk, in their pocket of bag, or outside of the testing room. Then participants would complete tasks measuring cognitive aspects such as working memory and attention. Half of the participants would receive a notification on their smartphone during the study at designated intervals, while the others would not. The notification would be a momentary reminder or alert sent by the experimenter. Participants would be required to address the alert by selecting something on their smartphone. This design would allow me to evaluate the effect of smartphone location and receiving notifications during a battery of cognitive tests. Specifically, I would be interested in how the active use of their smartphone would affect their performance compared to those without that interference. Additionally, I would measure the same predictor measures from Chapter 4. These measures would be used to develop a profile for predicting smartphone reliance. Lastly, I would complete a moderation analysis using smartphone reliance as a moderator of performance on the cognitive tasks. I would predict that those who received a notification during the tasks would show lower performance, relative to their smartphone location. Additionally, I would predict that smartphone reliance would moderate this effect, where those with higher smartphone reliance would show worse performance. This is just one example of some future studies that would benefit from the results in this dissertation.

Some limitations to the studies in this dissertation are the university participants for most studies. This was a limiting factor because the population was primarily first-year science or social science students who are participating for course credit. This recruitment methodology was used to mitigate the cost of the larger sample sizes and due to the easy access of the participation pool. However, it would be beneficial to address these measures in other samples. These benefits were evident in Chapter 4, Study 2 where Amazon's Mechanical Turk (Mturk) was used to provide a global population. The data from this study showed different smartphone use tendencies and provided a large sample size that was collected in a matter of days. These are just some of the benefits of collecting data using online platforms. Future studies should use similar methods to expand their samples demographic diversity. A more specific limitation in my work was that of the smartphone location conditions in Chapter 3, Study 3. Although it was chosen to mitigate the complicity issue, only two location conditions were chosen: on your desk and within your line-of-sight, and away from you and outside of your line-of-sight. Only using these two conditions did not provide the same physical and perceptual differences between the three locations used in Chapter 3, Study 2. I would use three conditions in a similar study: on your desk (within your line-of sight), in your pocket or bag (outside of your line-of-sight), and in another room (outside of your line-of-sight). These three smartphone location conditions would provide a better comparison to Chapter 3, Study 2. Additionally, future studies should complete a small pilot study with online participants to determine the most clear instructions for such an experiment to try to maximize complicity and reduce attrition.

5.4 Conclusion

Using six studies, this dissertation investigated the effect of smartphone presence on cognition and predictors of smartphone reliance. A direct replication of Ward et al.'s (2017) second experiment did not replicate their "brain drain" effect on working memory. Although I saw an effect of smartphone location on verbal ability (specifically verbal short-term memory) in Chapter 3, Study 2, this effect did not replicate in a subsequent study. Overall, it seems that smartphone presence may impact a small aspect of cognition, but not in a reliable manner. Furthermore, predictors of smartphone reliance measures identified higher emotional intelligence and neuroticism as the most consistent predictors of higher smartphone reliance. These findings represent a first step into evaluating more complex and larger-scale studies investigating the nuances of our relationship with our smartphones and how these are the key to assessing how our smartphones affects us. These findings have many applications to future studies. Future work should focus on the differences in smartphone reliance and continue investigating its predictors. Smartphones will continue to play an irreplaceable role in our daily lives, therefore, exploring our relationship with our smartphone and how this can affect our cognition should be explored further.

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Appendix A

Chapter 2: Ethics Approval

Date: 23 November 2017

To: Dr. John Paul Minda

Project ID: 110296

Study Title: Cognitive psychology and smartphone use

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: December 8 , 2017

Date Approval Issued: 23/Nov/2017

REB Approval Expiry Date: 23/Nov/2018

Dear Dr. John Paul Minda

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
CBS Tasks	Other Data Collection Instruments		
DebriefingForm (1)	Debriefing document	13/Oct/2017	
DebriefingVerbal	Debriefing document	04/Nov/2017	1
LOI_CONSENT_PAID_CLEAN	Written Consent/Assent	04/Nov/2017	2
LOI_CONSENT_SONA_CLEAN	Written Consent/Assent	04/Nov/2017	3
Phone_Attachment_and_Dependence_Questionnaire	Online Survey	13/Oct/2017	
SmartPhone_Usage_Poster_CLEAN	Recruitment Materials	04/Nov/2017	2
SONA Descriptions	Recruitment Materials	06/Oct/2017	1
Task Descriptions- OSpan & GoNoGo	Other Data Collection Instruments		

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Appendix B

Chapter 2: Demographic Questionnaire

General Demographics

1. What is your gender?
   (a) Male
   (b) Female
   (c) Other (please specify)
   (d) Prefer not to say
2. Age (in years):
3. Program:
4. Year of Study:
5. Is your first language English?
   (a) Yes
   (b) No

Appendix C

Chapter 2: Smartphone Use Questionnaire

Smartphone Use Frequency

1. On average, how many **text messages** do you send **per day**?

    (a) 0-5

    (b) 6-10

    (c) 11-15

    (d) >15

2. On average, how many **social media based <u>messages</u>** do you send **per day** from your smartphone? (iMessage, Facebook Messenger, WhatsApp, WeChat, direct messages within social media platforms, etc.)

    (a) 0-5

    (b) 6-10

    (c) 11-15

    (d) >15

3. On average, how many **social media <u>posts</u>** (e.g., written post, picture, article, etc.) do you send **per day** from your smartphone? (Facebook, Twitter, Instagram, etc.)

    (a) 0-5

    (b) 6-10

(c) 11-15

(d) >15

Smartphone Use with External Stimulation or During Other Activities

For the following questions, please indicate how often the following statements apply to you.

Never			Neutral			Always
1	2	3	4	5	6	7

Tendency to turn to one's smartphone in the absence of external stimulation:

1. I look at my smartphone before I roll out of bed in the morning.

2. If I am waiting to meet a friend, I pass the time by using my smartphone.

Tendency to turn to one's smartphone in the midst of other activities:

3. I use my smartphone while driving.

4. If my smartphone rings or vibrates in the middle of personal business, I look at it.

Exploratory Items

Smartphone subjective value:

1. How much money would it take for you to give up your phone for a full day?

   (a) $0-$20

   (b) $21-$40

   (c) $41-$60

   (d) >$60

Types of smartphone notifications:

2. Do you receive notifications (a sound or vibration) on your phone? Please indicate all that apply.

   ◦ Email

   ◦ Twitter

   ◦ LinkedIn

- Facebook
- Instagram
- Snapchat
- Other (please specify)

Phantom vibration experiences:

3. Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?

   (a) Yes

   (b) No

Appendix D

Chapter 3: Ethics Approval

Study 1 and Study 2

Western Research

Date: 28 January 2019

To: Dr. John Paul Minda

Project ID: 110296

Study Title: cognitive psychology and smartphone use

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: March 1 2019

Date Approval Issued: 28/Jan/2019

REB Approval Expiry Date: 23/Nov/2019

Dear Dr. John Paul Minda,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
LOI_CONSENT_PAID - CLEAN	Written Consent/Assent	10/Jan/2019	2
LOI_CONSENT_SONA - CLEAN	Written Consent/Assent	10/Jan/2019	2
Mobile Phone Involvement Questionnaire (MPIQ)	Paper Survey	08/Nov/2018	
Nomophobia Questionnaire	Paper Survey	08/Nov/2018	
Paradigm and Exploratory Questionnaire	Paper Survey	08/Nov/2018	
Smartphone Protocol - CLEAN	Protocol	08/Nov/2018	

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
CBS Tasks - CLEAN	Other Materials	08/Nov/2018	2

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Study 3

Date: 16 March 2021

To: Dr. John Paul Minda

Project ID: 110296

Study Title: cognitive psychology and smartphone use

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: April 9 2021

Date Approval Issued: 16/Mar/2021 12:41

REB Approval Expiry Date: 23/Nov/2021

Dear Dr. John Paul Minda,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Smartphone Protocol - CLEAN	Protocol	19/Feb/2021	2
Smartphone Usage Questionnaire-Revised (SUQ-R2) - CLEAN	Online Survey	19/Feb/2021	2

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson , Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix E

Chapter 3: Test Validity for the Cambridge Brain Sciences Tests

Cambridge Brain Sciences (CBS) tests have a *Validity Indicator*[1] that depict whether participant performance patterns are unusual. That is, an "invalid" indicator detects participants who misunderstood the test or did not follow the instructions. Each test has defined parameters[2] that must be met to be considered a "valid" test score. The table below shows the conditions for each of the 12 CBS tests.

Feature	Monkey Ladder	Spatial Span	Token Search	Paired Associates	Rotations	Polygons	Odd One Out	Spatial Span	Grammatical Reasoning	Digit Span	Feature Match	Double Trouble**
Number of attempts	>0	>0	>0	>0	≥7 & ≤36	>0	≥12 & ≤36	>0	>0	>0	≥14 & ≤37	>0
Number correct	≥11 & ≤105	≥1 & ≤7	≥1 & ≤12	≥2 & ≤8	≥5 & ≤30	≥7 & ≤31	≥8 & ≤34	≥0 & ≤19	≥6 & ≤46	≥1 & ≤11	≥13 & ≤33	≥11 & ≤105
Number of errors	=3	=3	=3	=3	≥0 & ≤12	≥0 & ≤14	≥0 & ≤15	≥0 & ≤4	≥0 & ≤9	=3	≥0 & ≤8	≥0 & ≤37
Duration (seconds)	≥60 & ≤277	≥39 & ≤180	≥24 & ≤751.3	≥6 & ≤283	≥89.5 & ≤90.5	≥89.5 & ≤90.5	≥179.5 & ≤180.5	≥179.5 & ≤180.5	≥89.5 & ≤90.5	≥40 & ≤362	≥89.5 & ≤90.5	≥89.5 & ≤90.5
Max score	≥5 & ≤11	≥3 & ≤9	≥2 & ≤14	≥2 & ≤8	– – –	– – –	– – –	– – –	– – –	≥3 & ≤12	– – –	– – –
Average score	≥3.4 & ≤7	≥2.5 & ≤6.71	≥2 & ≤9.08	≥2 & ≤5	– – –	– – –	– – –	– – –	– – –	≥3 & ≤8.4	– – –	– – –
Final score	– – –	– – –	– – –	– – –	≥-4 & ≤294	≥-4 & ≤137	≥-2 & ≤33	≥0 & ≤127	≥-1 & ≤45	– – –	≥30 & ≤256	≥-5 & ≤102
Correct Score***	– – –	– – –	– – –	– – –	≥20 & ≤326	– – –	– – –	– – –	– – –	– – –	≥50 & ≤288	– – –
Max Level****	– – –	– – –	– – –	– – –	≥5 & ≤18	– – –	≥9 & ≤20	– – –	– – –	– – –	≥6 & ≤16	– – –

**Double Trouble includes additional measures of validity related to performance on different types of problems, such as 1) Congruent / Congruent (CC) problems, 2) Congruent / Incongruent (CI) problems, 3) Incongruent / Congruent problems (IC) and 4) Incongruent / Incongruent (II) problems. Additional validity metrics for the Double Trouble Task include: Percent of CC problems answered correctly (≥60% and ≤ 100%); Average reaction time in seconds when attempting CC problems (≥.752 and ≤4.81); Average reaction time in seconds when attempting CI problems (≥.778 and ≤6.15); Average reaction time in seconds when attempting IC problems (≥.761 and ≤5.65); Average reaction time in seconds when attempting II problems (≥.784 and ≤6.01).
***Correct score refers to the sum of all points obtained from successfully completed problems.
****Max level refers to the difficulty level of the hardest problem successfully completed.

[1] This validity indicator table was recreated with permission from Cambridge Brain Sciences.

[2] 99 % of scores in the Cambridge Brain Sciences normative database fall within the bounds of these parameters.

Appendix F

Chapter 3: Study 1 and Study 2 Demographic questionnaire

General Demographic Questions

1. What is your age?
2. Please select your gender:
   (a) Male
   (b) Female
   (c) Other (please specify)
   (d) Prefer not to say
3. Please select your first language:
   (a) English
   (b) Other (please specify)
4. Please indicate your language proficiency in English (i.e., reading, writing, and speaking):
   (a) Low
   (b) Moderate
   (c) High
5. Please select your program of study (shown by faculty):

(a) Arts & Humanities (e.g., English, Film, Visual Arts)

(b) Music

(c) Education

(d) Engineering

(e) Health Science (e.g., Kinesiology, OT, PT)

(f) Information & Media Studies (e.g., MIT)

(g) Law

(h) Business (e.g., BMOS, Ivey)

(i) Science (e.g., Math, Chemistry, Computer Science, Physics, Biology, Medical Science)

(j) Social Science (e.g., History, Neuroscience, Psychology, Sociology)

(k) Schulich Dentistry

(l) Graduate Studies

(m) Other (please specify)

6. Please select your year of study:

(a) 1st year

(b) 2nd year

(c) 3rd year

(d) 4th year

(e) 5th+ year

(f) Graduate Student

Previous Test Exposure Questions [1]

1. You just completed the ”Cambridge Brain Sciences” or ”CBS” Tasks. Have you ever heard of these tasks before?

(a) Yes

(b) No

[1]Items only used in chapter 2, study 2.

2. You just completed the ”Cambridge Brain Sciences” or ”CBS” Tasks. Have you ever completed any of these tasks before? (e.g., in another study, in class, or on your own time).

    (a) Yes

    (b) No

Appendix G

Chapter 3: Study 1 and Study 2 Smartphone Use Questionnaire

General Use

1. At what age did you first get a smartphone?

Frequency of Use

All Smartphone Users

1. What is your most used app on your smartphone (excluding text message/messenger apps)?

    (a) Games (e.g., candy crush, clash of clans)

    (b) Social Networking (e.g., Instagram, Facebook, Snapchat)

    (c) Entertainment (e.g., music, YouTube)

    (d) Other (please specify)

2. Please specify your most used app:

iPhone Users Only

1. Do you currently own an iPhone?

    (a) Yes

(b) No

For the following questions, please use your iPhone's "Screen Time" app to answer.

To access your "screen time", please go to your phone's settings, scroll, and select "Screen Time". Then, select "iPhone" or your iPhone's name, and then look under "Last 7 Days" to proceed to the following questions. [1]

2. What is the most used app in the last 7 days (excluding text message/messenger apps)? [1]
   (a) Games (e.g., candy crush, clash of clans)
   (b) Social Networking (e.g., Instagram, Facebook, Snapchat)
   (c) Entertainment (e.g., music, YouTube)
   (d) Other (please specify)
3. Was your most used app in the last 7 days a text message / messenger app? [1]
   (a) Yes
   (b) No
4. What is your weekly total screen time in hours (e.g. 5)? [1]
   (a) 0-10
   (b) 11-20
   (c) 21-30
   (d) 31-40
   (e) 40+
5. What are your "total pickups" per day? (e.g. 20) **Found below your screen time** [1]
   (a) 0-50
   (b) 51-100
   (c) 101-150
   (d) 151-200
   (e) 200+

[1] Item only shown to those who responded "Yes" to iPhone Users Only Question 1.

6. What are your notifications per day (i.e., ”around ___ per day)? **Found below your pickups**[1]

   (a) 0-50

   (b) 51-100

   (c) 101-150

   (d) 151-200

   (e) 200+

Smartphone Distraction

For the following questions, please indicate how much you agree or disagree to the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I find my phone can distract me from my daily activities (e.g., work, school, social interactions).

2. I find my phone distracting during this study.

3. In **general**, I find the following the most distracting electronic device: (choose one)

   (a) Computer

   (b) Phone

   (c) iPad / Tablet

   (d) Smartwatch

   (e) Other (please specify)

4. I find the following the most distracting when I am **studying/working**:

   (a) Computer

   (b) Phone

   (c) iPad / Tablet

(d) Smartwatch

(e) Other (please specify)

5. I find the following the most distracting when I am in a **social context** (e.g., with friends):

(a) Computer

(b) Phone

(c) iPad / Tablet

(d) Smartwatch

(e) Other (please specify)

Paradigm Decision Questions

Smartphone Power Questions

For the following questions, please indicate how much you agree or disagree to the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I tend to turn my phone off when I am not using it.

2. I tend to have my notifications turned on.

3. I tend to have my phone on vibrate.

4. When I study, I typically keep my phone on.

5. When I write an exam, I tend to keep my phone on.

6. When I am in a lecture, I tend to keep my phone on.

7. When I sleep, I tend to keep my phone turned on.

Smartphone Location Questions

1. **Typically**, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
2. When I **study**, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
3. When I **write an exam**, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
4. When I am **in a lecture**, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
5. When I am in a **social setting** (i.e., with friends, family), I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room

Smartphone Comfort Level Questions

For the following questions, please indicate how much you agree or disagree to the following statements.

1. I am comfortable with letting others use my phone.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

2. I leave my phone unattended.
3. I leave my phone with other people.
4. I make sure my phone is locked when it is not in my hands.
5. I would feel comfortable leaving my phone in another room while completing a task.

Exploratory Questions

1. How much money would it take for you to give up your phone for a full day?
   (a) $0-$20
   (b) $21-$40
   (c) $41-$60
   (d) >$60
2. Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?
   (a) Yes
   (b) No
3. Who do you mostly communicate with on your phone?
   (a) Family
   (b) Friends
   (c) Work
   (d) Other (please specify)
4. What do you use your phone for the most?
   (a) Calling / Texting
   (b) Social media (e.g., Facebook, Instagram, Twitter, Snapchat)
   (c) Games (e.g., candy crush, clash of clans)

(d) Email

(e) Other (please specify)

Appendix H

Chapter 3: Study 3 Demographic Questionnaire

General Demographics

1. What is your age?
2. Please select your gender:
    (a) Male
    (b) Female
    (c) I prefer to self-identify (please specify)
    (d) Prefer not to say
3. Please select your first language:
    (a) English
    (b) Spanish
    (c) Portuguese
    (d) French
    (e) Mandarin
    (f) Arabic
    (g) Other (please specify)
    (h) Prefer not to say

4. Please indicate your language proficiency in English (i.e., reading, writing, and speaking):

    (a) Low
    (b) Moderate
    (c) High

5. Where do you currently live?

    (a) North America
    (b) Central America
    (c) South America
    (d) Europe
    (e) Africa
    (f) Asia
    (g) Australia
    (h) Pacific Islander
    (i) Caribbean Islands
    (j) Other (please specify)
    (k) Prefer not to say

6. What is your highest grade or level of school completed or the highest degree received?

    (a) Some high school
    (b) High school or equivalent (e.g. GED)
    (c) Some college, no degree
    (d) Associate degree (e.g., AA, AS)
    (e) Bachelor's degrees (e..g, BA, BS)
    (f) Master's degree (e.g., MA, MS, MSc, MEd)
    (g) Professional degree (e.g., MD, DDS, DVM)
    (h) Doctorate or higher (e.g., PhD, EdD)
    (i) Prefer not to say

7. What is your current employment status? (select all that apply)

- Employed full-time (40+ hours/week)
- Employed part-time (less than 40 hours/week)
- Self-employed
- Unemployed (seeking opportunities)
- Student
- Retired
- Unable to work
- Prefer not to say

8. Which of the following best describes the **industry** of your profession? (select all that apply)

- Student
- Goods-producing sector (e.g. agriculture, mining, etc.)
- Utilities
- Construction
- Manufacturing
- Services-producing sector (e.g. retail, transportation)
- Finance, insurance, real estate, rental and leasing
- Professional, scientific and technical services
- Business, building and other support services
- Educational services
- Health care and social assistance
- Information, culture and recreation
- Accommodation and food services
- Public administration
- Other (please specify)
- Does not apply to me

Appendix I

Chapter 3: Study 3 Smartphone Use Questionnaire

Manipulation Check

Location

1. At the start of the study, you were asked to place your phone in a specific location. Indicate below **where your phone was during the cognitive tasks** that you completed. Please be honest as your response will not alter your compensation for your participation in this study. [1]

    (a) On my desk

    (b) In my pocket or bag (i.e., backpacks and or purses)

    (c) In another room

    (d) Other (please specify)

Settings

1. Was your phone **faced-down** in its location?

    (a) Yes

    (b) No

[1]Participants primarily focused on the ”within-sight” component of the instructions, therefore, this item was not primary manipulation check for the final analysis.

2. Was your phone **on "silent"** (i.e., with notifications, including vibrations, turned off) in its location?

   (a) Yes

   (b) No

3. Was your phone **turned ON** in its location?

   (a) Yes

   (b) No

4. Was your phone **within your line-of-sight** during the cognitive tasks (i.e., could you see your phone while you completed the tasks)? [2]

   (a) Yes

   (b) No

Exploratory

Browser Tab(s) / Other Application(s)

1. At the start of the study, you were asked to close any other browser tabs / other application (e.g., instant or direct message applications). Indicate below **whether you had or have any other browser tabs / other applications open** while you completed the study.

   Please be honest as your response will not alter your compensation for your participation in this study.

   (a) I **did not** have other browser tab(s)/other application(s) open during this study.

   (b) I **did** have other browser tab(s)/other application(s) open during this study.

2. **How many other browser tab(s)/other applications(s)** did you have open during this study (e.g., 5)? [3]

3. **Which other browser tab(s)/other application(s)** did you have open during this study (please list them all)?[3]

4. If you did have other browser tab(s)/other application(s) open during the study, **was this distracting**?[3]

---

[2] Item was used as primary manipulation check for the final data analysis.

[3] Item only shown to those who chose "I **did not** have other browser tab(s)/other application(s) open during this study." in Browser Tab(s) / Other Application(s) Question 1

(a) Yes

(b) No

(c) Does not apply to me

Notifications: General

1. Did you **receive any notification(s)** ***that you noticed*** during the study on any of the following devices (select all that apply)?

   (a) Computer

   (b) Phone

   (c) iPad / Tablet

   (d) Smartwatch

   (e) Other (please specify)

Notifications: Computer

1. If you did receive a notification on your **computer** during the study and noticed, **was this distracting**? [4]

   (a) Yes

   (b) No

   (c) Does not apply to me

2. If you did receive a notification on your **computer** during the study and noticed, **how many notifications did you receive** (e.g., 5)? [4]

3. If you did receive a notification on your **computer** during the study and noticed, what **type of notification(s)** did you receive (select all that apply)? [4]

   - Call / Text
   - Games (e.g., candy crush, clash of clans)
   - Social Networking (e.g., Instagram, Facebook, Snapchat)
   - Entertainment (e.g., music, YouTube)
   - Business/Productivity (e.g., banking, company-specific apps)
   - Other (please specify)
   - Does not apply to me

[4] Item only shown to those who chose ”Computer” in Notifications: General Question 1

Notifications: Phone

1. If you did receive a notification on your **phone** during the study and noticed, **was this distracting**? [5]

   (a) Yes

   (b) No

   (c) Does not apply to me

2. If you did receive a notification on your **phone** during the study and noticed, **how many notifications did you receive** (e.g., 5)? [5]

3. If you did receive a notification on your **phone** during the study and noticed, what **type of notification(s)** did you receive (select all that apply)? [5]

   - Call / Text
   - Games (e.g., candy crush, clash of clans)
   - Social Networking (e.g., Instagram, Facebook, Snapchat)
   - Entertainment (e.g., music, YouTube)
   - Business/Productivity (e.g., banking, company-specific apps)
   - Other (please specify)
   - Does not apply to me

Notifications: iPad / Tablet

1. If you did receive a notification on your **iPad / Tablet** during the study and noticed, **was this distracting**? [6]

   (a) Yes

   (b) No

   (c) Does not apply to me

2. If you did receive a notification on your **iPad / Tablet** during the study and noticed, **how many notifications did you receive** (e.g., 5)? [6]

[5] Item only shown to those who chose ”Phone” in Notifications: General Question 1
[6] Item only shown to those who chose ”iPad / Tablet” in Notifications: General Question 1

3. If you did receive a notification on your **iPad / Tablet** during the study and noticed, what **type of notification(s)** did you receive (select all that apply)? [6]

   - Call / Text
   - Games (e.g., candy crush, clash of clans)
   - Social Networking (e.g., Instagram, Facebook, Snapchat)
   - Entertainment (e.g., music, YouTube)
   - Business/Productivity (e.g., banking, company-specific apps)
   - Other (please specify)
   - Does not apply to me

Notifications: Smartwatch

1. If you did receive a notification on your **smartwatch** during the study and noticed, **was this distracting**? [7]

   (a) Yes

   (b) No

   (c) Does not apply to me

2. If you did receive a notification on your **smartwatch** during the study and noticed, **how many notifications did you receive** (e.g., 5)? [7]

3. If you did receive a notification on your **smartwatch** during the study and noticed, what **type of notification(s)** did you receive (select all that apply)? [7]

   - Call / Text
   - Games (e.g., candy crush, clash of clans)
   - Social Networking (e.g., Instagram, Facebook, Snapchat)
   - Entertainment (e.g., music, YouTube)
   - Business/Productivity (e.g., banking, company-specific apps)
   - Other (please specify)
   - Does not apply to me

[7] Item only shown to those who chose ”Smartwatch” in Notifications: General Question 1

General Smartphone Questions

1. At what age did you first get a smartphone?

Frequency of Use

All Smartphone Users

1. What is your most used app on your smartphone (excluding text message/messenger apps)?

   (a) Games (e.g., candy crush, clash of clans)

   (b) Social Networking (e.g., Instagram, Facebook, Snap chat)

   (c) Entertainment (e.g., music, YouTube)

   (d) Business/Productivity (e.g., banking, company-specific apps)

   (e) Other (please specify)

2. Please specify your most used app:

iPhone Users Only

1. Do you currently own an iPhone?

   (a) Yes

   (b) No

2. On your iPhone, there is an app called the ”Screen Time” app. This app tracks your iPhone usage and has to be activated to start tracking. Please check your app now and respond below accordingly: [8]

   (a) I had the screen time app activated on my iPhone prior to this study.

   (b) I now have the app activated on my iPhone, but did not have it prior to this study.

   (c) No, I do not have the app activated on my iPhone.

[8] Item only shown to those who responded ”Yes” to iPhone Users Only Question 1.

For the following questions, please use your iPhone's "Screen Time" app to answer.

To access your "screen time", please go to your phone's settings, scroll, and select "Screen Time". Then, select "iPhone" or your iPhone's name, and then look under "Last 7 Days" to proceed to the following questions. [8]

3. What is the most used app in the last 7 days (excluding text message/messenger apps)? [8]
   (a) Games (e.g., candy crush, clash of clans)
   (b) Social Networking (e.g., Instagram, Facebook, Snapchat)
   (c) Entertainment (e.g., music, YouTube)
   (d) Business/Productivity (e.g., banking, company-specific apps)
   (e) Other (please specify)
4. Was your most used app in the last 7 days a text message / messenger app? [8]
   (a) Yes
   (b) No
   (c) I do not have the Screen Time app
5. Please specify your most used app:
6. What is your weekly total screen time in hours (e.g. 5)? [8]
7. What are your "total pickups" per day? (e.g. 20) **Found below your screen time** [8]
8. What are your notifications per day (e.g., 301)? **Found below your pickups** [8]

Comfort Level Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I am comfortable with letting others use my phone.
2. I leave my phone unattended.

3. I leave my phone with other people.

4. I make sure my phone is locked when it is not in my hands.

5. I would feel comfortable leaving my phone in another room while completing a task.

Distraction Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I find my phone can distract me from my daily activities (e.g., work, school, social interactions).

2. I find my phone distracting during this study.

3. In general, I find the following the most distracting electronic device:

   (a) Computer

   (b) Phone

   (c) iPad/Tablet

   (d) Smartwatch

   (e) Other (please specify)

4. I find the following the most distracting when I am studying/working:

   (a) Computer

   (b) Phone

   (c) iPad/Tablet

   (d) Smartwatch

   (e) Other (please specify)

5. I find the following the most distracting when I am in a social context (e.g., with friends):

(a) Computer

(b) Phone

(c) iPad/Tablet

(d) Smartwatch

(e) Other (please specify)

Locations and Power Questions

Smartphone Power Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I tend to turn my phone off when I am not using it.

2. I tend to have my notifications turned on.

3. I tend to have my phone on vibrate.

4. When I study, I typically keep my phone on.[9]

5. When I write an exam, I tend to keep my phone on.[9]

6. When I am in a lecture, I tend to keep my phone on.[9]

7. When I am working, I tend to keep my phone on.

8. When I am in a meeting, I tend to keep my phone on.

9. When I sleep, I tend to keep my phone turned on.

[9] Item only shown to those who responded ”Student” to General Demographics Question 7 (employment status) and/or 8 (industry of profession), found in Appendix H.

Smartphone Location Questions

1. Typically, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me
2. When I study, I keep my phone:[9]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me
3. When I write an exam, I keep my phone:[9]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me
4. When I am in a lecture, I keep my phone:[9]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me
5. When I am working, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

6. When I am in a meeting, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me
7. When I am in a social setting (i.e., with friends, family), I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

Subjective Value

1. How much money would it take for you to give up your phone for a full day?
   (a) \$0-\$20
   (b) \$21-\$40
   (c) \$41-\$60
   (d) >\$60

Phantom Vibrations

1. Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?
   (a) Yes
   (b) No

Exploratory

1. Does your profession require the use of a smartphone for work purposes?
   (a) Yes

(b) No

(c) Does not apply to me

2. Does your profession require that you use company-specific apps for your work?

   (a) Yes

   (b) No

   (c) Does not apply to me

Appendix J

Chapter 3: Study 3 Attention Check Questions

The following **three items** were used to check that participants were attentive during study 3. Each item was presented after a questionnaire. Therefore, the order was as follows: questionnaire 1, attention check (item 1), questionnaire 2, attention check (item 2), questionnaire 3, attention check (item 3).

1. This is an attention check, please type in the word **“time”** in all CAPS (i.e., the word “want” in all CAPS is: “WANT”).

2. This is an attention check, please type in the word **“some”** in all CAPS (i.e., the word “want” in all CAPS is: “WANT”).

3. This is an attention check, please type in the word **“much”** in all CAPS (i.e., the word “want” in all CAPS is: “WANT”).

Appendix K

Chapter 3: Study 3 Smartphone Location Instructions

The following are the instructions given to participants prior to completing the Cambridge Brain Science (CBS) tests during Study 3. Each participant was randomly assigned to one of the two smartphone location conditions, shown their respective instructions, and then indicated their compliance prior to continuing on in the study.

"*Desk*" Condition

For the next tasks, please keep your phone **on your desk, face-down, and in front of you**. Your phone should be turned ON and set to "silent" (i.e., with notifications, including vibrations, turned off).

Do not check or use your phone during the cognitive tasks. We will ask you about where your phone was later.

If you have any other devices (e.g., computer, iPad/tablet, smartwatch) that receive notifications, please put them on "silent" or "do not disturb" during the study. Additionally, please close any other browser tabs / other applications (e.g., instant or direct message applications) while you complete this study.

Please indicate below that you have placed your phone in the correct location.

- I have placed my phone **on my desk, faced-down, in front of me**. It is **turned on** and set to **"silent"**.

"*Away*" Condition

For the next tasks, please keep your phone **away from you, where you can't see it, preferably in another room (if possible)**. Your phone should be turned ON and set to "silent" (i.e., with notifications, including vibrations, turned off). Do not check or use your phone during the cognitive tasks. We will ask you about where your phone was later.

If you have any other devices (e.g., computer, iPad/tablet, smartwatch) that receive notifications, please put them on "silent" or "do not disturb" during the study. Additionally, please close any other browser tabs / other applications (e.g., instant or direct message applications) while you complete this study.

Please indicate below that you have placed your phone in the correct location.

- I have placed my phone **away from myself, where I cannot see it**. It is **turned on** and set to **"silent"**.

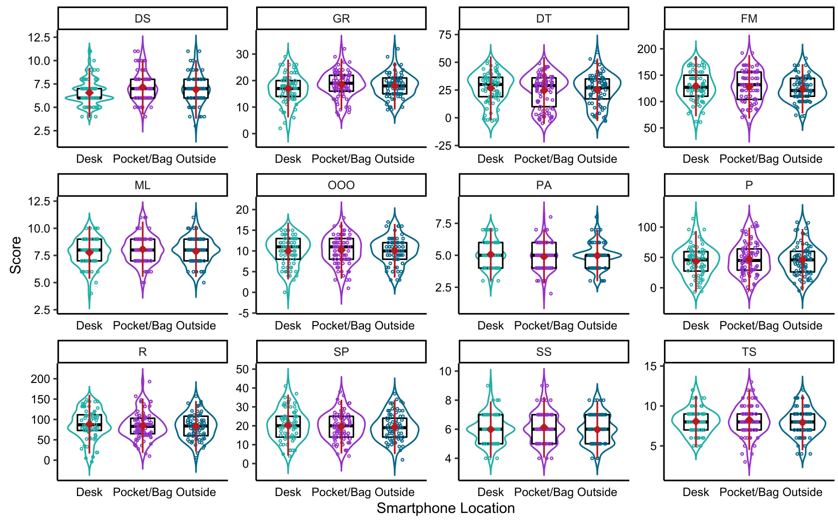
Appendix L

Chapter 3: Supplemental Analyses for Study 2 and Study 3

The following depicts results from supplementary analyses for individual ANOVAs (Study 2) or t-tests (Study 3) for each of the 12 Cambridge Brain Sciences tests. There was a significant difference in performance on the Digit Span test in Study 2. No other individual tests were significant.

Study 2: The Effect of Smartphone Presence on Cognition

Study 3: An Attempt to Reveal the Smartphone Effect with an Online Study

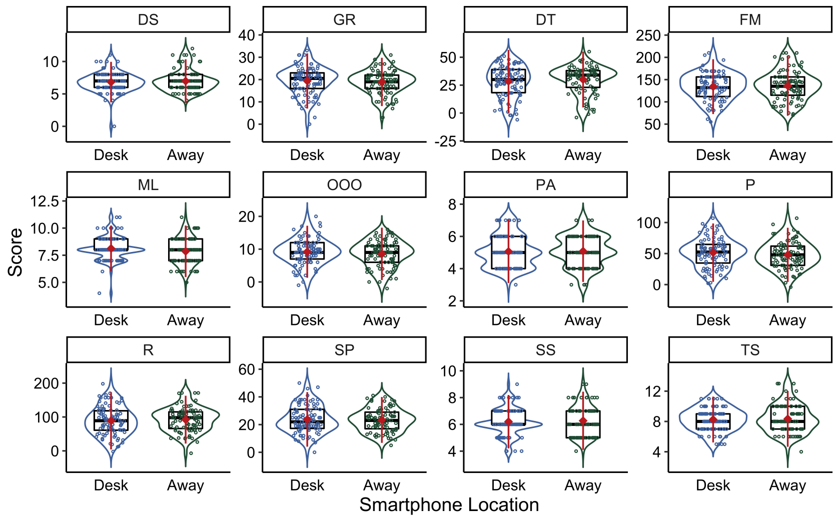


Note. For each Cambridge Brain Sciences (CBS) test score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Test were assessed for a secondary analysis exploring the driving force behind the effect of smartphone location on the verbal ability composite score. Panel A depicts performance on the digit span test. Panel B depicts performance on the grammatical reasoning test. N = 175.

Results for one-way ANOVAs assessing the effect of smartphone location on 12 CBS tests in Study 2.

Measure	SSn	SSd	$F(2, 233)$	p	η_p^2
Individual Tests					
Monkey Ladder	3.65	350.66	1.21	.30	.01
Spatial Span	1.22	234.51	0.61	.55	.005
Token Search	4.63	714.50	0.76	.47	.006
Paired Associates	1.19	246.66	0.56	.57	.005
Rotations	1054.49	262412.30	0.47	.63	.004
Polygons	600.80	151377.84	0.46	.63	.004
Odd One Out	2.20	2650.43	0.10	.91	.001
Spatial Planning	31.03	12884.07	0.28	.76	.002
Digit Span	14.03	494.65	3.30	.04	.028
Grammatical Reasoning	99.60	5664.35	2.05	.13	.017
Double Trouble	190.10	49023.52	0.45	.64	.004
Feature Match	1149.21	177484.18	0.75	.47	.006

Note. Results for the one-way ANOVAs for the effect of smartphone location (i.e., on desk, in pocket or bag, or outside) for each of the 12 Cambridge Brain Science (CBS) tests and composite scores. The memory composite score included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. The reasoning composite score included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. The verbal ability composite score included performance on Grammatical Reasoning and Digit Span. The concentration or attention composite score included performance on Feature Match and Double Trouble. SSn depicts the numerator sum of squares. SSd depicts the denominator sum of squares. Degrees of freedom is depicted in parentheses. Effect Size is partial eta squared (η_p^2).
N = 237



Note. For each Cambridge Brain Sciences (CBS) test score, the violin plot shows the density curve of the data (violin), individual data for each participant (hollow dots), interquartile range and median (box and horizontal line), and the mean and standard deviation (solid dots and vertical whiskers). Test were assessed for a secondary analysis exploring the driving force behind the effect of smartphone location on the verbal ability composite score. Panel A depicts performance on the digit span test. Panel B depicts performance on the grammatical reasoning test. N = 175.

Results for independent t-tests assessing the effect of smartphone location on 12 CBS tests in Study 3.

Measure	CI (low)	CI (high)	SE	*t*(173)	*p*	*d*
Individual Tests						
Monkey Ladder	-0.07	0.60	0.17	1.55	0.12	0.23
Spatial Span	-0.38	0.24	0.16	-0.45	0.65	-0.07
Token Search	-0.59	0.42	0.25	-0.34	0.74	-0.05
Paired Associates	-0.30	0.27	0.15	-0.11	0.91	-0.02
Rotations	-15.04	8.25	5.90	-0.58	0.57	-0.09
Polygons	-3.20	10.35	3.43	1.04	0.30	0.16
Odd One Out	-0.54	1.83	0.60	1.07	0.28	0.16
Spatial Planning	-2.33	3.11	1.38	0.28	0.78	0.04
Digit Span	-0.64	0.33	0.25	-0.63	0.53	-0.10
Grammatical Reasoning	-1.30	2.17	0.88	0.50	0.62	0.07
Double Trouble	-5.54	2.41	2.01	-0.78	0.44	-0.12
Feature Match	-11.56	7.68	4.87	-0.40	0.69	-0.06

Note. Results for independent samples t-tests for the effect of smartphone location (i.e., desk-IN or away-OUT) for each of the 12 Cambridge Brain Science (CBS) tests and composite scores. The memory composite score included performance on Monkey Ladder, Spatial Span, Token Search, and Paired Associates. The reasoning composite score included performance on Rotations, Polygons, Odd One Out, and Spatial Planning. The verbal ability composite score included performance on Grammatical Reasoning and Digit Span. The concentration or attention composite score included performance on Feature Match and Double Trouble. CI depicts the 95% confidence interval. SE depicts the standard error. Degrees of freedom is depicted in parentheses. Effect Size is Cohen's *d*.
N = 175

Appendix M

Chapter 4: Ethics Approval

Date: 10 March 2020

To: Dr. John Paul Minda

Project ID: 110296

Study Title: cognitive psychology and smartphone use

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: April 3 2020

Date Approval Issued: 10/Mar/2020

REB Approval Expiry Date: 23/Nov/2020

Dear Dr. John Paul Minda,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Barratt Impulsiveness Scale-Brief (BIS-Brief) (Steinberg et al., 2013)	Online Survey	25/Feb/2020	1
Depression Anxiety and Stress Scale (DASS-21) (Lovibond & Lovibond, 1995)	Online Survey	25/Feb/2020	1
International Personality Item Pool NEO (IPIP-NEO-60) (Maples-Keller et al., 2019)	Online Survey	25/Feb/2020	1
LOI_Implied_CONSENT_SONA & PAID_CLEAN	Implied Consent/Assent	03/Mar/2020	2
Rosenberg Self-Esteem Scale (RSES) (Rosenberg, 1965)	Online Survey	25/Feb/2020	1
Schutte Self-Report Emotional Intelligence Test (SSEIT) (Schutte et al., 1998)	Online Survey	25/Feb/2020	1
Self-Regulation Scale (SRS) (Schwarzer et al., 1999)	Online Survey	25/Feb/2020	1
Smartphone Usage Questionnaire-Revised (SUQ-R)	Online Survey	25/Feb/2020	1
Study Descriptions _ Recruitment Ad - mturk	Recruitment Materials	25/Feb/2020	1
Study Descriptions _ Recruitment Ad - SONA	Recruitment Materials	25/Feb/2020	1
Study Descriptions _ Recruitment Ad - Websites (Feacebook, Twitter)	Recruiting Advertisements	25/Feb/2020	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Appendix N

Chapter 4: Study 1 and Study 2 Demographic Questionnaire

General Demographics

1. What is your age (in years)?
2. Please select your gender:
   (a) Male
   (b) Female
   (c) Other (please specify)
   (d) Prefer not to say
3. Please select your first language:
   (a) English
   (b) Other (please specify)
4. Please indicate your language proficiency in English (i.e., reading, writing, and speaking):
   (a) Low
   (b) Moderate
   (c) High
5. Where do you currently live?

(a) North America
(b) Central America
(c) South America
(d) Europe
(e) Africa
(f) Asia
(g) Australia
(h) Pacific Islander
(i) Caribbean Islands
(j) Other (please specify)
(k) Prefer not to say

6. What is your highest grade or level of school completed or the highest degree received?

    (a) Some high school
    (b) High school or equivalent (e.g. GED)
    (c) Some college, no degree
    (d) Associate degree (e.g., AA, AS)
    (e) Bachelor's degrees (e..g, BA, BS)
    (f) Master's degree (e.g., MA, MS, MSc, MEd)
    (g) Professional degree (e.g., MD, DDS, DVM)
    (h) Doctorate or higher (e.g., PhD, EdD)
    (i) Prefer not to say

7. What is your current employment status? (select all that apply)

    - Employed full-time (40+ hours/week)
    - Employed part-time (less than 40 hours/week)
    - Self-employed
    - Unemployed (seeking opportunities)
    - Student
    - Retired

- Unable to work
- Prefer not to say

8. Which of the following best describes the industry of your profession? (select all that apply)
    - Student
    - Goods-producing sector (e.g. agriculture, mining, etc.)
    - Utilities
    - Construction
    - Manufacturing
    - Services-producing sector (e.g. retail, transportation)
    - Finance, insurance, real estate, rental and leasing
    - Professional, scientific and technical services
    - Business, building and other support services
    - Educational services
    - Health care and social assistance
    - Information, culture and recreation
    - Accommodation and food services
    - Public administration
    - Other (please specify)
    - Does not apply to me

Appendix O

Chapter 4: Study 1 and Study 2 Smartphone Use Questionnaire

General Smartphone Questions

1. At what age did you first get a smartphone?

Frequency of Use

General

1. What is your most used app on your smartphone (excluding text message/messenger apps)?
   (a) Games (e.g., candy crush, clash of clans)
   (b) Social Networking (e.g., Instagram, Facebook, Snapchat)
   (c) Entertainment (e.g., music, YouTube)
   (d) Business/Productivity (e.g., banking, company-specific apps)
   (e) Other (please specify)
2. Please specify your most used app:

Screen Time Questions

1. Do you currently own an iPhone?

(a) Yes
(b) No

2. On your iPhone, there is an app called the "Screen Time" app. This app tracks your iPhone usage and has to be activated to start tracking.

   Please check your app now and respond below accordingly: [1]

   (a) I had the screen time app activated on my iPhone prior to this study.
   (b) I now have the app activated on my iPhone, but did not have it prior to this study.
   (c) No, I do not have the app activated on my iPhone.

For the following questions, please use your iPhone's "Screen Time" app to answer.

To access your "screen time", please go to your phone's settings, scroll, and select "Screen Time". Then, select "iPhone" or your iPhone's name, and then look under "Last 7 Days" to proceed to the following questions. [2]

3. What is the most used app in the last 7 days (excluding text message/messenger apps)? [2]

   (a) Games (e.g., candy crush, clash of clans)
   (b) Social Networking (e.g., Instagram, Facebook, Snapchat)
   (c) Entertainment (e.g., music, YouTube)
   (d) Business/Productivity (e.g., banking, company-specific apps)
   (e) Other (please specify)
   (f) I do not have the Screen Time app

4. Was your most used app in the last 7 days a text message / messenger app? [2]

   (a) Yes
   (b) No
   (c) I do not have the Screen Time app

5. Please specify your most used app: [2]

6. What is your weekly total screen time in hours (e.g. 5)? [2]

[1] Item only shown to those who responded "Yes" to Screen Time Question 1

[2] Item only shown to those who responded "I had the screen time app activated on my iPhone prior to this study." to Screen Time Question 2.

7. What are your “total pickups” per day? (e.g. 20) **Found below your screen time** [2]

8. What are your notifications per day (e.g. 301)? **Found below your pickups** [2]

Privacy Questions

1. Do you have a passcode to access your smartphone?
   (a) Yes
   (b) No

2. Do any other individuals know your passcode? [3]
   (a) Yes
   (b) No

3. What is the relationship of the individuals who know your passcode? (choose all that apply) [4]
   (a) Parents
   (b) Other family members
   (c) Significant other
   (d) Friends
   (e) Co-workers / Supervisor
   (f) Other (please specify)
   (g) Does not apply to me

4. I would allow another individual to use my smartphone.
   (a) Yes, only in my presence
   (b) Yes, depending on the individual and only in my presence
   (c) Yes, depending on the individual and does not need to be in my presence
   (d) No

5. I would leave my phone in another room in the presence of another individual.
   (a) Yes
   (b) No

[3] Item only shown to those who responded ”Yes” to Privacy Question 1.
[4] Item only shown to those who responded ”Yes” to Privacy Question 2.

Distraction and Comfort Questions

Distraction Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I find my phone can distract me from my daily activities (e.g., work, school, social interactions).
2. I find my phone distracting during this study.
3. In general, I find the following the most distracting electronic device:
   (a) Computer
   (b) Phone
   (c) iPad/Tablet
   (d) Smartwatch
   (e) Other (please specify)
4. I find the following the most distracting when I am studying/working:
   (a) Computer
   (b) Phone
   (c) iPad/Tablet
   (d) Smartwatch
   (e) Other (please specify)
5. I find the following the most distracting when I am in a social context (e.g., with friends):
   (a) Computer
   (b) Phone
   (c) iPad/Tablet
   (d) Smartwatch
   (e) Other (please specify)

Comfort Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I am comfortable with letting others use my phone.
2. I leave my phone unattended.
3. I leave my phone with other people.
4. I make sure my phone is locked when it is not in my hands.
5. I would feel comfortable leaving my phone in another room while completing a task.

Location and Power Questions

Power Questions

For the following questions, please indicate how much you agree or disagree with the following statements.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6	7

1. I tend to turn my phone off when I am not using it.
2. I tend to have my notifications turned on.
3. I tend to have my phone on vibrate.
4. When I study, I typically keep my phone on. [5]
5. When I write an exam, I tend to keep my phone on. [5]

[5] Item only shown to those who indicated they were a student in the Demographic Questionnaire (see Appendix **??**, Question 7).

6. When I am in a lecture, I tend to keep my phone on.[5]

7. When I am working, I tend to keep my phone on.

8. When I am in a meeting, I tend to keep my phone on.

9. When I sleep, I tend to keep my phone turned on.

Smartphone Location Questions

1. Typically, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

2. When I study, I keep my phone: [5]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

3. When I write an exam, I keep my phone: [5]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

4. When I am in a lecture, I keep my phone: [5]
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

5. When I am working, I keep my phone:

(a) On my desk
(b) In my pocket or bag (i.e., backpacks and or purses)
(c) In another room
(d) Does not apply to me

6. When I am in a meeting, I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

7. When I am in a social setting (i.e., with friends, family), I keep my phone:
   (a) On my desk
   (b) In my pocket or bag (i.e., backpacks and or purses)
   (c) In another room
   (d) Does not apply to me

Other Questions

1. How much money would it take for you to give up your phone for a full day?
   (a) \$0-\$20
   (b) \$21-\$40
   (c) \$41-\$60
   (d) >\$60

2. Have you ever thought you heard your phone ring or thought you felt it vibrate, only to find out you were wrong?
   (a) Yes
   (b) No

3. Who do you mostly communicate with on your phone?
   (a) Family

   (b) Friends
   (c) Work
   (d) Other (please specify)

4. What do you use your phone for the most?
   (a) Calling / Texting
   (b) Social media (e.g., Facebook, Instagram, Twitter, Snapchat)
   (c) Games (e.g., candy crush, clash of clans)
   (d) Email
   (e) Other (please specify)

5. Does your profession require the use of a smartphone for work purposes?
   (a) Yes
   (b) No
   (c) Does not apply to me

6. Does your profession require that you use company-specific apps for your work?
   (a) Yes
   (b) No
   (c) Does not apply to me

Appendix P

Chapter 4: Supplemental Analyses for Study 1 and Study 2

The following depicts results from supplementary analyses (i.e., multiple regression models) for Study 1 and Study 2[1]. These analyses were completed to explore whether the dichotomous measure of gender (i.e., male versus female) significantly added to the overall models. Additionally, these results were compare to the main analysis results. These analyses were explored as supplementary analyses due to the unbalanced samples between our two studies. In Study 1, our sample consisted of more females than males (i.e., 126 versus 114, respectively). In contrast, our sample in Study 2 consisted of more males than females (i.e., 311 versus 190, respectively). In order to compare the models from Study 1 and Study 2 we therefore decided to exclude gender from the main analysis.

For each study, a multiple regression analysis was completed for each of the smartphone reliance measures (i.e., nomophobia and smartphone attachment and dependency). The predictors were added in simultaneously and are presented in the following order: age (measured with our demographic questionnaire); gender (dichotomous variable: male and female), impulsivity (measured with the BIS; Steinberg et al., 2013); the five personality traits measured by the NEO (Maples-Keller et al., 2019), which were openness, conscientiousness, extraversion, agreeableness, and neuroticism; self-esteem (measured by the RSES; Rosenberg, 1965); self-regulation (measure by the SRS; Schwarzer et al., 1999); emotional intelligence (measured by the SSEIT; Schutte et al., 1998); and the three DASS (Lovibond and Lovibond, 1995) measures, which were depression, anxiety, and stress.

[1]The methodology was identical to the main analyses found in Chapter 4.

Study 1: Predicting Smartphone Reliance in University Students

The overall model regression predicting nomophobia (i.e., as measured with the NMPQ; Yildirim and Correia, 2015) using all predictor measures was significant, $F(14, 225) = 3.31$, $p < .001$, $R^2 = .17$, $R^2_{adj.} = .12$. Gender, $\beta_{std} = .19$, $t(225) = 2.85$, $p < .01$ and emotional intelligence, $\beta_{std} = .24$, $t(225) = 2.71$, $p = .01$, significantly added to the model and were positively associated with nomophobia. Openness, $\beta_{std} = -.17$, $t(225) = -2.41$, $p = .02$, and self-regulation, $\beta_{std} = -.18$, $t(225) = -2.46$, $p = .01$, significantly added to the model and were negatively associated with nomophobia. For more details see Figure P.1 and Table P.1. Each significant predictor is further visualized as a scatter plot in Figure P.2.

Table P.1: Supplementary Analysis: Multiple regression model results predicting nomophobia in Study 1.

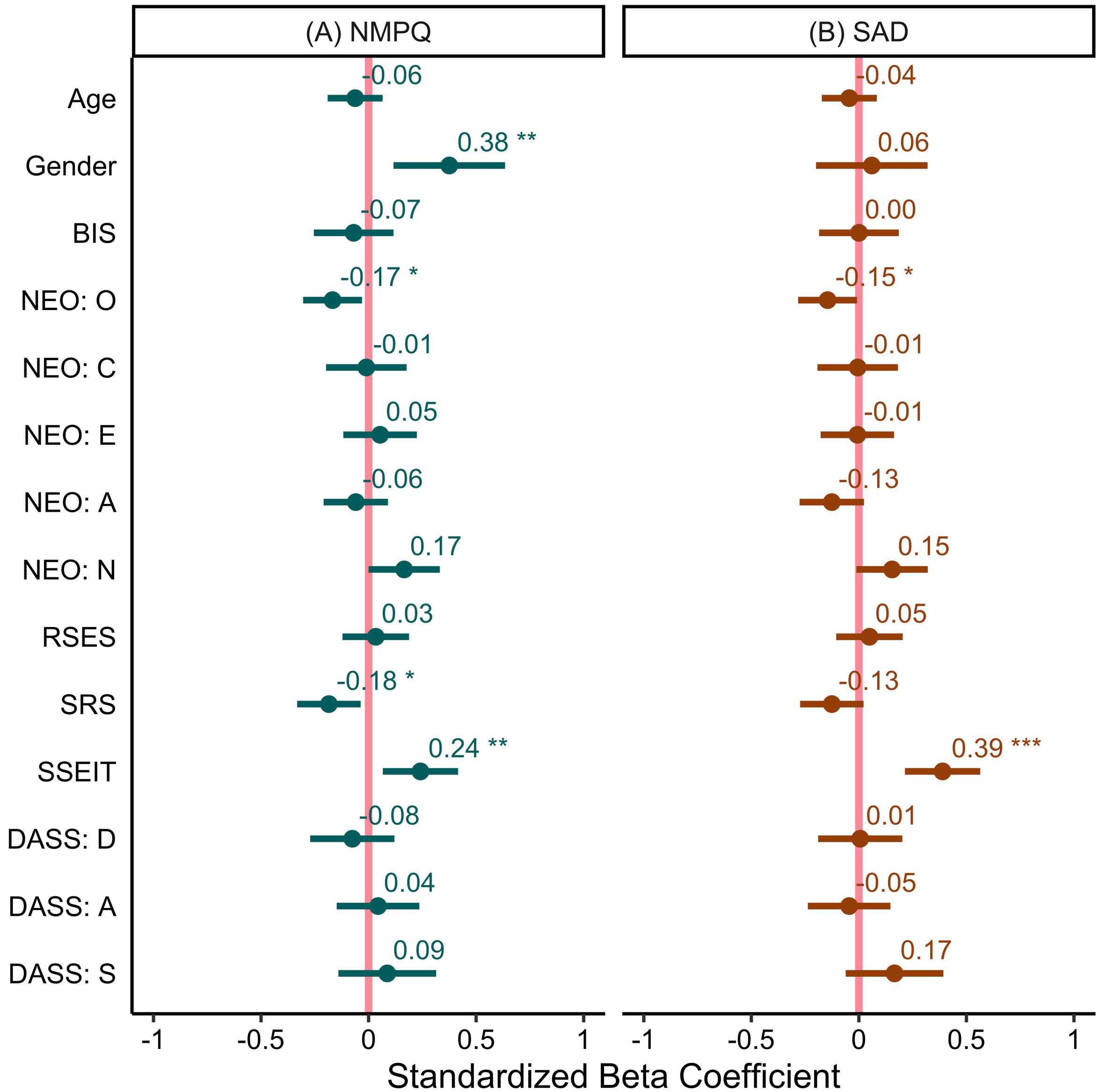
Multiple regression results from a supplementary analysis predicting nomophobia in Study 1.

Predictor	β	*SE*β	Std. β	Std. *SE*β	*t*(225)	*p*
Age	-0.64	0.66	-.06	0.06	-0.96	.34
Gender	8.43	2.96	.19	0.07	2.85	< .01
BIS	-0.41	0.56	-.07	0.09	-0.74	.46
NEO: O	-0.59	0.24	-.17	0.07	-2.41	.02
NEO: C	-0.04	0.36	-.01	0.10	-0.11	.91
NEO: E	0.16	0.26	.05	0.09	0.62	.54
NEO: A	-0.19	0.25	-.06	0.08	-0.78	.43
NEO: N	0.51	0.26	.17	0.08	1.97	.05
RSES	0.15	0.36	.03	0.08	0.42	.67
SRS	-0.94	0.38	-.18	0.07	-2.46	.01
SSEIT	0.33	0.12	.24	0.09	2.71	.01
DASS: D	-0.37	0.48	-.08	0.10	-0.76	.45
DASS: A	0.26	0.57	.04	0.10	0.45	.65
DASS: S	0.48	0.64	.09	0.12	0.75	.45

Note. Overall model was significant, $F(14, 225) = 3.31$, $p < .001$, $R^2 = .17$, $R^2_{adj} = .12$. Gender is a dichotomous variable (i.e., male and female). Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 240$

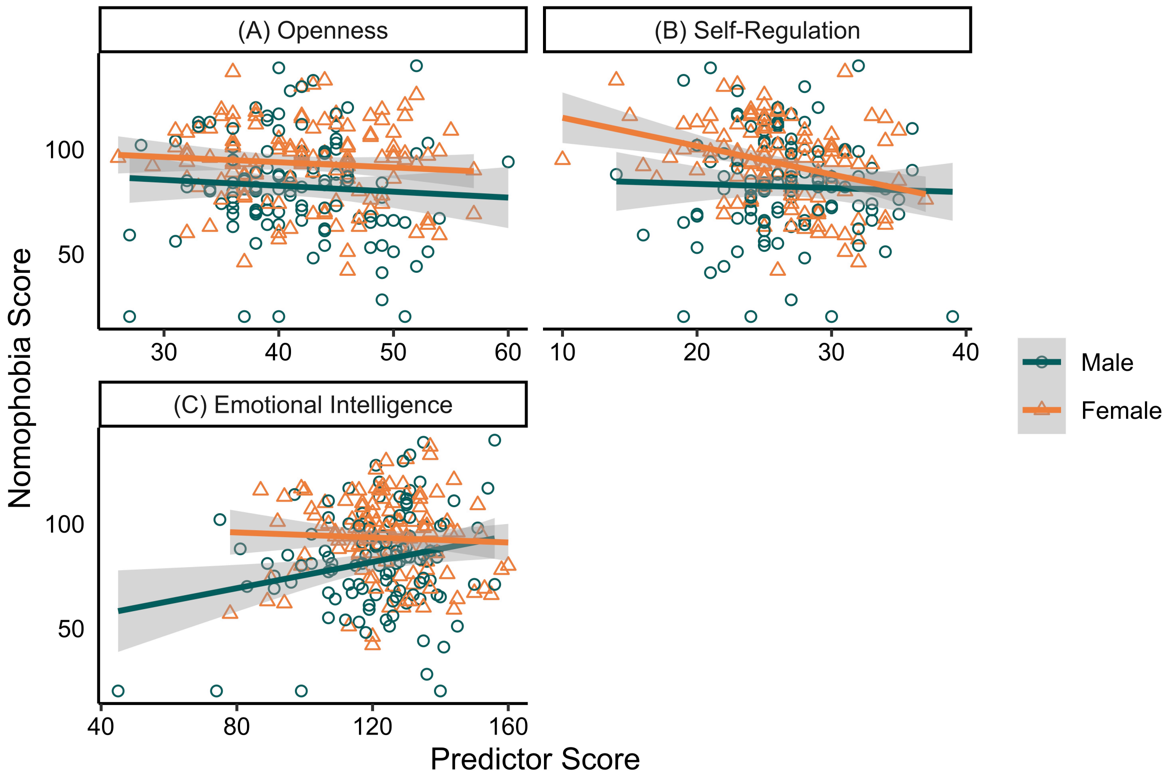
The overall model regression predicting smartphone attachment and dependency (i.e., as measured with the SAD; Ward et al., 2017) using all predictor measures was significant, $F(14, 225) = 3.33$, $p < .001$, $R^2 = .17$, $R^2_{adj.} = .12$. Emotional intelligence, $\beta_{std} = .39$, $t(225) = 4.38$, $p < .001$, significantly added to the model and was positively associated with smartphone attachment and dependency. Openness significantly added to the model, $\beta_{std} = -.15$, $t(225) = -2.09$, $p = .04$, and was negatively associated with smartphone attachment and dependency. For

Figure P.1: *Supplementary Analysis: Standardized beta coefficients for multiple regression models predicting smartphone reliance measures in Study 1.*



Note. Forest plot for the two multiple regression models. Panel A depicts the model predicting Nomophobia (NMPQ) and panel B depicts the model predicting Smartphone Attachment and Dependency (SAD). Standardized beta coefficients (dots) and the 95 % confidence interval (whiskers) are shown for each model. Vertical line represents the neutral point or no relationship between the predictor and the criterion. Predictors were identical for both models and are shown across the y-axis: Age, Gender (dichotomous variable: male and female), Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). $N = 240$.

Figure P.2: *Supplementary Analysis: Scatter plot depicting each significant predictor of nomophobia by gender in Study 1.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Openness, β_{std} = -.17, $t(225)$ = -2.41, p = .02. Panel B depicts Self-Regulation, β_{std} = -.18, $t(225)$ = -2.46, p = .01. Panel C Emotional Intelligence, β_{std} = .24, $t(225)$ = 2.71, p = .01. N = 240.

more details, see Table P.2. Each significant predictor is further visualized as a scatter plot in Figure P.3.

Study 2: Predicting Smartphone Reliance on a Global Scale

The overall model regression predicting nomophobia (i.e., as measured with the NMPQ; Yildirim and Correia, 2015) using all predictor measures was significant, $F(14, 486) = 29.67$, $p < .001$, $R^2 = .46$, $R^2_{adj.} = .45$.[2] Four predictors significantly added to the model and were positively related to nomophobia: conscientiousness, $\beta_{std} = .20$, $t(486) = 3.44$, $p < .001$, extraversion, $\beta_{std} = .14$, $t(486) = 2.86$, $p < .001$, neuroticism, $\beta_{std} = .25$, $t(486) = 4.14$, $p < .001$, and emo-

[2] Four participants were removed in order to have a dichotomous variable for Gender (i.e., male and female).

Table P.2: Supplementary Analysis: Multiple regression model results predicting smartphone attachment and dependency in Study 1.

Multiple regression results from a supplementary analysis predicting smartphone attachment and dependency in Study 1.

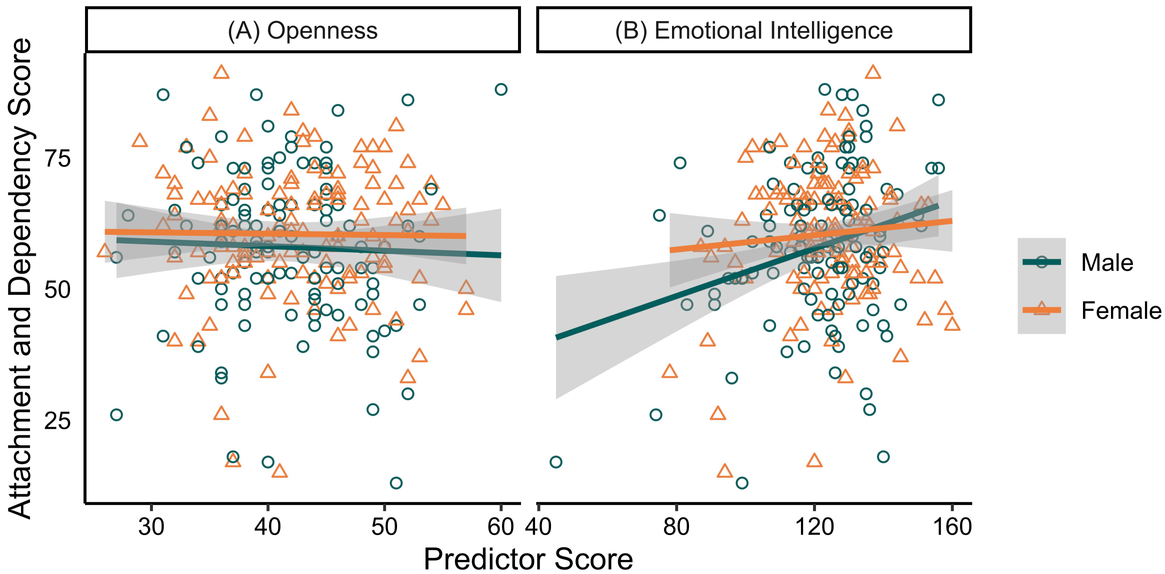
Predictor	β	$SE_β$	Std. β	Std. $SE_β$	$t(225)$	p
Age	-0.28	0.41	-.04	0.06	-0.69	.49
Gender	0.83	1.81	.03	0.07	0.46	.65
BIS	0.00	0.35	.00	0.09	0.00	1.00
NEO: O	-0.31	0.15	-.15	0.07	-2.09	.04
NEO: C	-0.01	0.22	-.01	0.10	-0.06	.95
NEO: E	-0.01	0.16	-.01	0.09	-0.08	.94
NEO: A	-0.25	0.15	-.13	0.08	-1.66	.10
NEO: N	0.29	0.16	.15	0.08	1.83	.07
RSES	0.14	0.22	.05	0.08	0.63	.53
SRS	-0.39	0.23	-.13	0.07	-1.68	.09
SSEIT	0.33	0.07	.39	0.09	4.38	< .01
DASS: D	0.02	0.30	.01	0.10	0.06	.95
DASS: A	-0.16	0.35	-.05	0.10	-0.46	.64
DASS: S	0.56	0.39	.17	0.12	1.44	.15

Note. Overall model was significant, $F(14, 225) = 3.33$, $p < .001$, $R^2 = .17$, $R^2_{adj} = .12$. Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 240$

tional intelligence, $\beta_{std} = .30$, $t(486) = 5.52$, $p < .001$. Two predictors significantly added to the model and were negatively related to nomophobia: age, $\beta_{std} = -.08$, $t(486) = -2.07$, $p = .04$, and self-regulation, $\beta_{std} = -.17$, $t(486) = -3.22$, $p < .001$. For more details see Figure P.4 and Table P.3. Each significant predictor is further visualized as a scatter plot in Figure P.5.

The overall model regression predicting smartphone attachment and dependency (i.e., as measured with the SAD; Ward et al., 2017) using all predictor measures was significant, $F(14, 486) = 40.24$, $p < .001$, $R^2 = .54$, $R^2_{adj.} = .52$. Five predictors significantly added to the model and were positively related to smartphone attachment and dependency: conscientiousness, $\beta_{std} = .15$, $t(486) = 2.69$, $p = .010$, extraversion, $\beta_{std} = .13$, $t(486) = 2.97$, $p < .001$, neuroticism, $\beta_{std} = .22$, $t(486) = 3.98$, $p < .001$, emotional intelligence, $\beta_{std} = .345$, $t(486) = 6.88$, $p < .001$, and anxiety, $\beta_{std} = .25$, $t(486) = 2.97$, $p < .001$. Three predictors significantly added to the model and were negatively related to smartphone attachment and dependency: age, $\beta_{std} = -.08$, $t(486) = -2.33$, $p = .02$, openness, $\beta_{std} = -.08$, $t(486) = -2.02$, $p = .04$, and self-regulation, $\beta_{std} = -.28$, $t(486) = -5.85$, $p < .001$. For more details, see Table P.4. Each significant predictor is further visualized as a scatter plot in Figure P.6.

Figure P.3: *Supplementary Analysis: Scatter plot depicting each significant predictor of smartphone attachment and dependency in Study 1.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Openness, β_{std} = -.15, $t(225) = -2.10$, $p = .04$. Panel B depicts Neuroticism, β_{std} = .16, $t(225) = 2.03$, $p = .04$. Panel C depicts Emotional Intelligence, β_{std} = .39, $t(225) = 4.38$, $p < .001$. $N = 240$.

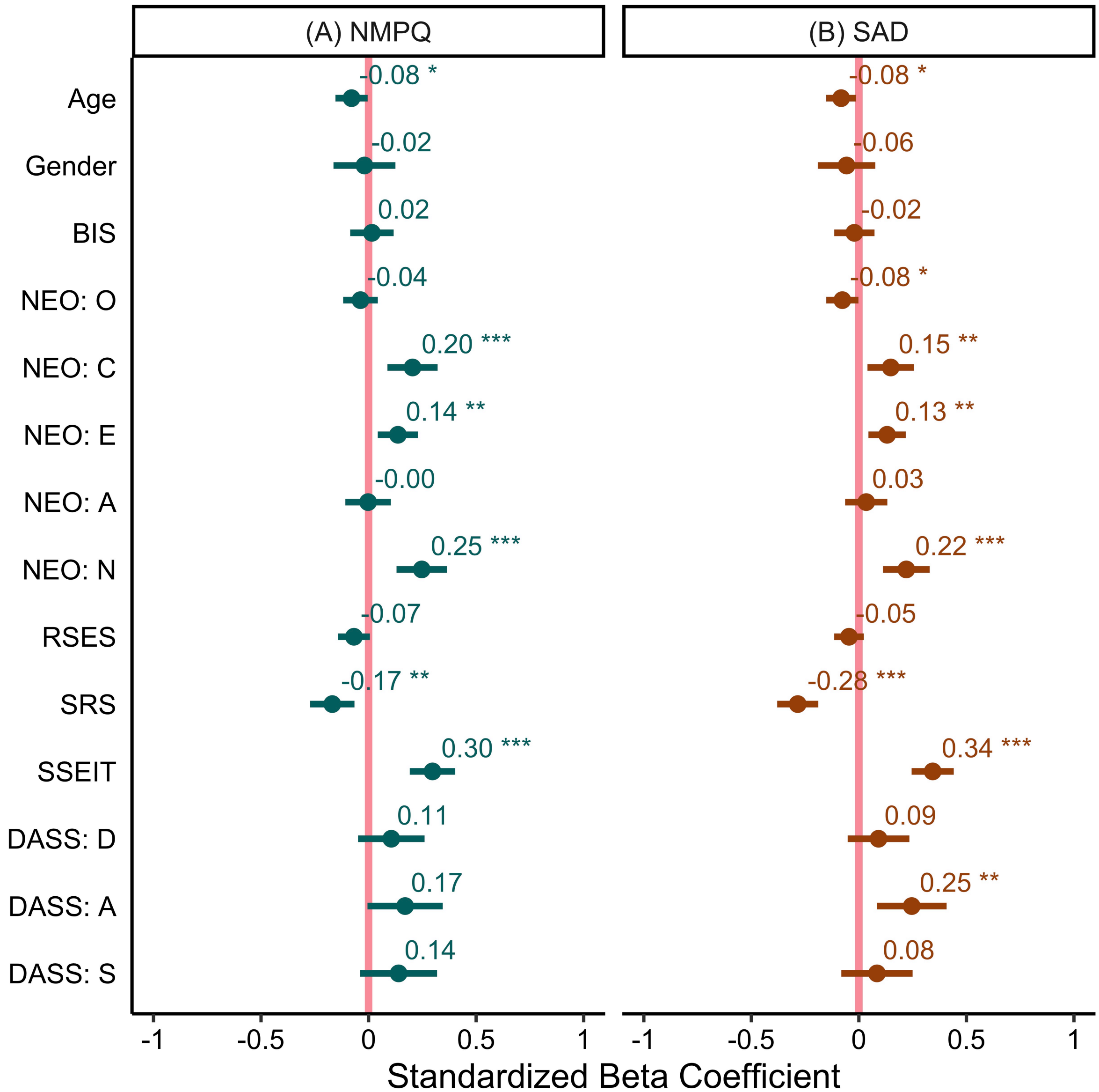
Discussion

Results from our supplementary analysis found that gender was a significant predictor in Study 1 (for nomophobia only) but not in Study 2. In Study 1, gender was the strongest predictor of nomophobia. Additionally, Neuroticism was no longer a significant predictor for both models in Study 1. All other predictors in both Study 1 and Study 2 were generally the same as in our main analysis. Although gender is a commonly researched variable with respect to not only smartphone tendencies, but also individual differences, our results suggest that this relationship might not be stable in a global population (i.e., Study 2). In our university sample (i.e., Study 1), gender predicted nomophobia but not smartphone attachment and dependency, which suggests that those who identified as female were more likely to have higher nomophobia.

Conclusions

Overall, this supplemental analysis supported our initial decision to exclude gender from the main analysis in order to compare the models between Study 1 and Study 2. Future research

Figure P.4: *Supplementary Analysis: Standardized beta coefficients for multiple regression models predicting smartphone reliance measures in Study 2.*



Note. Forest plot for the two multiple regression models. Panel A depicts the model predicting Nomophobia (NMPQ) and panel B depicts the model predicting Smartphone Attachment and Dependency (SAD). Standardized beta coefficients (dots) and the 95 % confidence interval (whiskers) are shown for each model. Vertical line represents the neutral point or no relationship between the predictor and the criterion. Predictors were identical for both models and are shown across the y-axis: Age, Gender (dichotomous variable: male and female), Impulsivity (BIS), Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). $N = 501$.

Table P.3: Supplementary Analysis: Multiple regression model results predicting nomophobia in Study 2.

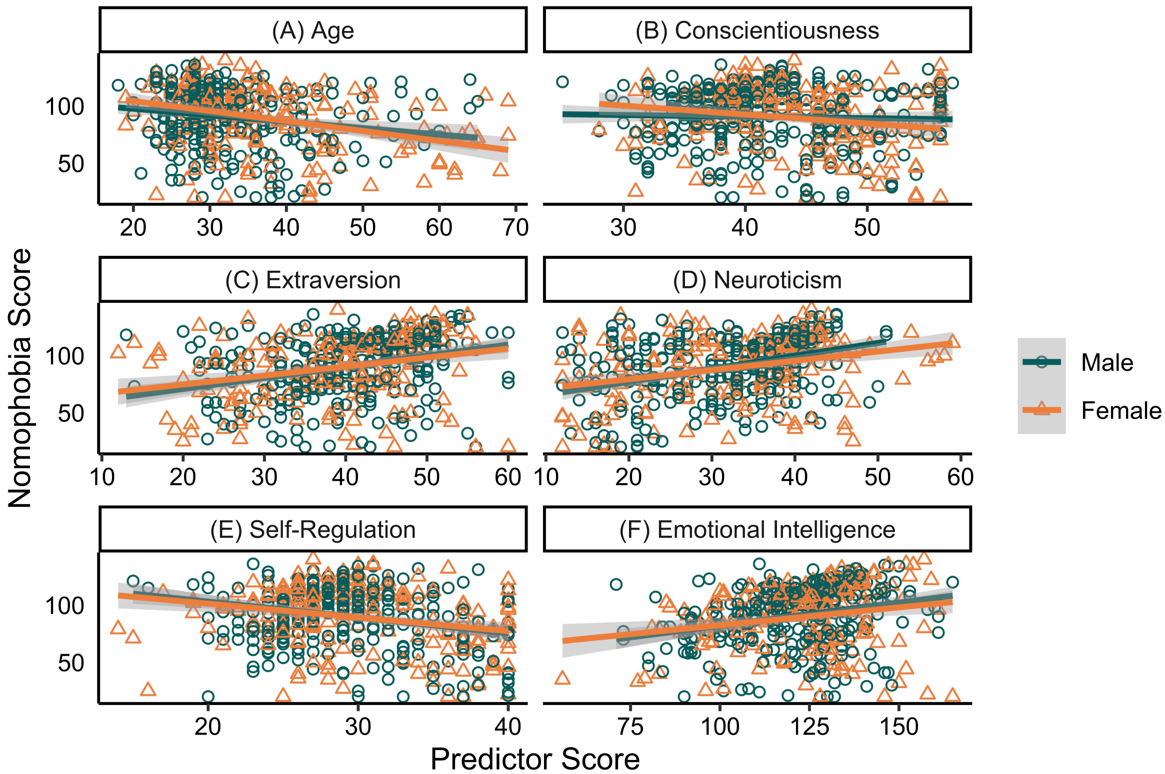
Multiple regression results from a supplementary analysis predicting nomophobia in Study 2.

Predictor	β	SE_β	Std. β	Std. SE_β	t(486)	p
Age	-0.21	0.10	-.08	0.04	-2.07	.04
Gender	-0.52	2.00	-.01	0.04	-0.26	.79
BIS	0.10	0.32	.02	0.05	0.30	.76
NEO: O	-0.15	0.16	-.04	0.04	-0.92	.36
NEO: C	0.82	0.24	.20	0.06	3.44	< .01
NEO: E	0.41	0.14	.14	0.05	2.86	< .01
NEO: A	-0.01	0.19	.00	0.05	-0.04	.97
NEO: N	0.69	0.17	.25	0.06	4.14	< .01
RSES	-0.27	0.15	-.07	0.04	-1.80	.07
SRS	-0.87	0.27	-.17	0.05	-3.22	< .01
SSEIT	0.46	0.08	.30	0.05	5.52	< .01
DASS: D	0.44	0.33	.11	0.08	1.34	.18
DASS: A	0.72	0.38	.17	0.09	1.91	.06
DASS: S	0.62	0.40	.14	0.09	1.53	.13

Note. Overall model was significant, $F(14, 486) = 29.67$, $p < .001$, $R^2 = .46$, $R^2_{adj} = .45$. Gender is a dichotomous variable (i.e., male and female). Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 501$

should strive to maintain a better gender balance in order to better assess this variable in a global sample.

Figure P.5: *Supplementary Analysis: Scatter plot depicting each significant predictor of nomophobia in Study 2.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting nomophobia. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Age (in years), β_{std} = -.08, $t(486)$ = -2.07, p = .04. Panel B depicts Conscientiousness, β_{std} = .20, $t(486)$ = 3.44, p < .001. Panel C depicts Extraversion, β_{std} = .14, $t(486)$ = 2.86, p < .001. Panel D depicts Neuroticism, β_{std} = .25, $t(486)$ = 4.14, p < .001. Panel E depicts Self-regulation, β_{std} = -.17, $t(486)$ = -3.22, p < .001. Panel F depicts Emotional Intelligence, β_{std} = .30, $t(486)$ = 5.52, p < .001. N = 501.

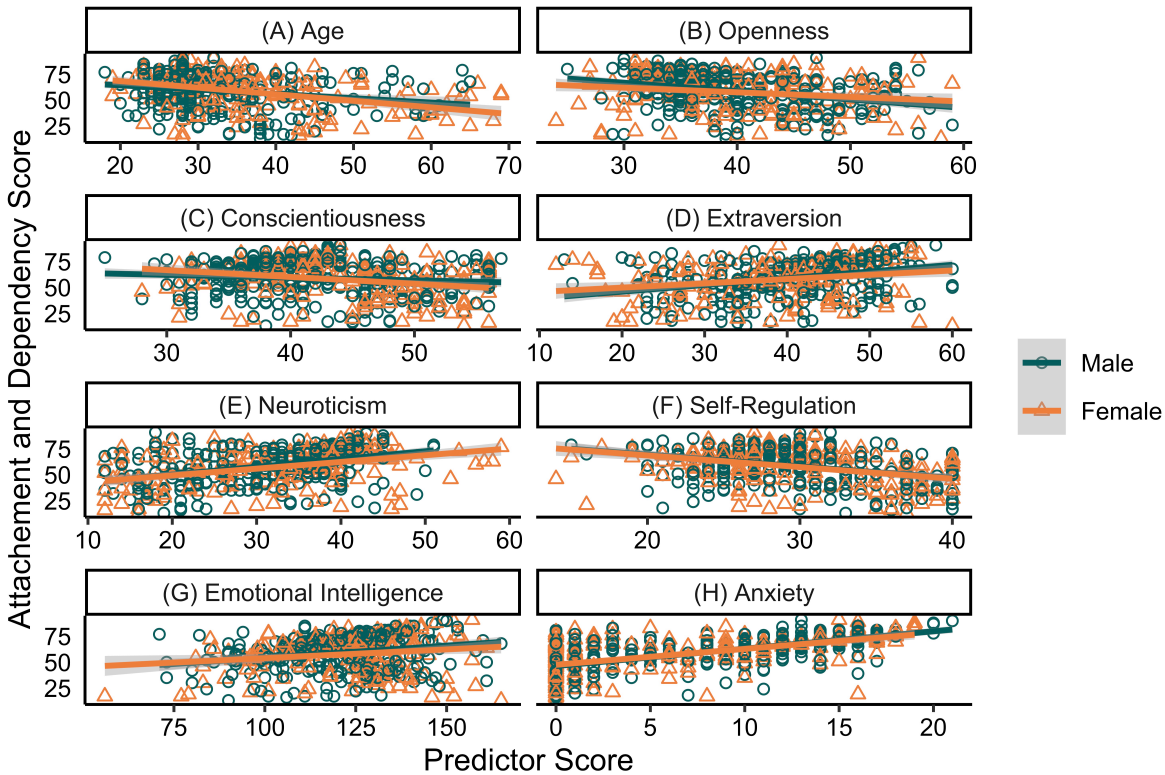
Table P.4: Supplementary Analysis: Multiple regression model results predicting smartphone attachment and dependency in Study 2.

Multiple regression results from a supplementary analysis predicting smartphone attachment and dependency in Study 2.

Predictor	β	$SE_β$	Std. β	Std. $SE_β$	$t(486)$	p
Age	-0.14	0.06	-.08	0.04	-2.33	.02
Gender	-0.99	1.18	-.03	0.03	-0.84	.40
BIS	-0.08	0.19	-.02	0.05	-0.44	.66
NEO: O	-0.19	0.10	-.08	0.04	-2.02	.04
NEO: C	0.38	0.14	.15	0.06	2.69	.01
NEO: E	0.25	0.08	.13	0.04	2.97	< .01
NEO: A	0.08	0.11	.03	0.05	0.68	.50
NEO: N	0.39	0.10	.22	0.06	3.98	< .01
RSES	-0.11	0.09	-.05	0.04	-1.31	.19
SRS	-0.93	0.16	-.28	0.05	-5.85	< .01
SSEIT	0.34	0.05	.34	0.05	6.88	< .01
DASS: D	0.24	0.19	.09	0.07	1.25	.21
DASS: A	0.66	0.22	.25	0.08	2.97	< .01
DASS: S	0.24	0.24	.08	0.08	1.00	.32

Note. Overall model was significant, $F(14, 486) = 40.24$, $p < .001$, $R^2 = .54$, $R^2_{adj} = .52$. Gender is a dichotomous variable (i.e., male and female). Impulsivity (BIS, Openness (NEO: O), Conscientiousness (NEO: C), Extraversion (NEO: E), Agreeableness (NEO: A), Neuroticism (NEO: N), Self-Esteem (RSES), Self-Regulation (SRS), Emotional Intelligence (SSEIT), Depression (DASS: D), Anxiety (DASS: A), and Stress (DASS: S). Score value ranges for each respective level shown in parentheses.
$N = 501$

Figure P.6: *Supplementary Analysis: Scatter plot depicting each significant predictor of smartphone attachment and dependency in Study 2.*



Note. Scatter plot for the predictors which added significantly to the overall model predicting smartphone attachment and dependency. For each predictor, the x-axis depicts the actual raw score for the respective measure. Individual participants are depicted (dots), with a line of bets fit (line) and 95 % confidence interval (grey zone) for the respective measure. Panel A depicts Age, β_{std} = -.08, $t(486)$ = -2.33, p = .02. Panel B depicts Openness, β_{std} = -.28, $t(486)$ = -5.85, p < .001. Panel C depicts Conscientiousness, β_{std} = .15, $t(486)$ = 2.69, p = .010. Panel D depicts Extraversion, β_{std} = .13, $t(486)$ = 2.97, p < .001. Panel E depicts Neuroticism, β_{std} = .22, $t(486)$ = 3.98, p < .001. Panel F depicts Self-regulation, β_{std} = -.29, $t(486)$ = -6.12, p < .001. Panel G depicts Emotional Intelligence, β_{std} = .345, $t(486)$ = 6.88, p < .001. Panel H depicts Anxiety, β_{std} = .25, $t(486)$ = 2.97, p < .001. N = 501.

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Preprints

Ruiz Pardo, A. C., Minda, J. P. (2021, October 16). Reexamining the "Brain Drain" Effect: Does Ward et al. (2017) Replicate?. PsyArXiv. https://doi.org/10.31234/osf.io/5y34g

Related Presentations:

Ruiz Pardo, A. C., Khemani, N., Ghai, M., Ghulamhussain, Z., McKenzie, C., Minda, J. P. (November 2021). Investigating Category Learning in an Online Platform: The Relationship between Analytic and Holistic Thinking Styles. *Annual Meeting of the Psychonomic Society*, Virtual Conference (National: Poster Presentation)

Ruiz Pardo, A. C., Schnurr K., Foreman-Tran, K. S., Minda, J. P. (May 2019). Individual Differences in Smartphone Use: What Aspects of Cognition are Affected by Smartphones? *Annual Convention of the Association for Psychological Science (APS)*, Washington, DC, USA (National: Poster Presentation)

Foreman-Tran, K., Schnurr K., **Ruiz Pardo, A. C.**, Minda, J. P. (March 2019). Should It Stay or Should It Go: Smartphone Dependency. *Western Student Research Conference (WSRC)*, London, ON, Canada (Provincial: Poster Presentation)

Ruiz Pardo, A. C., Minda, J. P. (November 2018). Re-Examining the "Brain Drain" Effect: Replicating Ward et al. (2018). Annual Meeting of the Psychonomic Society, New Orleans, LA, USA (National: Poster Presentation)