The Media Marshmallow Test:

Psychological and Physiological Effects of Applying Self-Control to the Mobile Phone

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Abstract

This research draws on a classic delay of gratification framework from psychology, the Marshmallow Test, to examine the effects of exercising self-control with the mobile phone. A total of 125 subjects were randomly assigned to sit in an unadorned room for six minutes and either (a) use their mobile phone, (b) sit with their device but resist using it, or (c) sit alone with no phone. Participants self-reported more concentration difficulty and more mind wandering with no device present compared to using the phone, while resisting the phone led to greater perceived concentration abilities than sitting without the device. Skin conductance data were consistent across conditions for the first three-minutes of the experiment, after which participants who resisted the phone were less aroused than those who were without the phone. Together, the findings suggest that self-control with mobile media is a complex psychological phenomenon that affects psychological and physiological behavior.

Mobile phones are central to social and professional life in the networked age. For example, meeting a friend at a concert may require purchasing tickets with the phone, a texting conversation or call to arrange the meeting location, and requesting a taxi through a mobile application to arrive at the venue. Despite the relevance and pervasiveness of the mobile phone in everyday settings, researchers often debate the costs and benefits of using the device. Experiments and field studies find that the mobile phone can add social and psychological value to users. People who text with a friend or stranger during surgery require less anesthetic than people who play a game on their phone or do not have the phone (AUTHORS, 2015). High-risk, low-income youths use cell phones to access emergency help, prevent crime, and mobile devices offer psychological reassurance to bring friends and relatives closer (Gonzales, 2014). Mobile phone use can also positively impact civic engagement at scale (Campbell & Kwak, 2010), as phones can be used to organize protests (Neumayer & Stald, 2014) and communicate with distant others that would have been otherwise impossible.

On the other hand, some media theorists (Alter, 2017; Turkle, 2015) argue that mobile phone use may be problematic because it can negatively affect social and psychological well-being. For example, high phone dependency individuals have high rates of anxiety, social dysfunction, and insomnia (Jenaro, Flores, Gómez-Vela, González-Gil, & Caballo, 2007). Interpersonal communication research finds that the mere presence of a phone can negatively influence the quality and closeness of a face-to-face conversation (Przybylski & Weinstein, 2013). Finally, frequent mobile phone use can also encourage addiction behaviors. The phone can make people vulnerable to negative outcomes, such as interpersonal isolation, because constantly using technology can disrupt social life (Turkle, 2015).

Clearly, there are instances when mobile phone use is beneficial or detrimental to personal outcomes and social interactions (Campbell, 2015). Little experimental research, however, has considered if *resisting* the phone produces consequences as well, despite self-control with the phone being common due to social norms (e.g., not using the phone during a meeting), limitations with the technology (e.g., loss of battery or signal), or safety concerns (e.g., not using the phone while driving). In such situations, people must set aside their desire for the technology or communication behavior with technology, and use willpower (i.e., the energy behind self-control) to focus psychological resources elsewhere (Baumeister & Tierney, 2011). The current research examines if exercising self-control by resisting the mobile phone changes how people behave psychologically and physiologically. This approach is timely and novel because prior work has largely examined how media use (e.g., web-surfing, playing video games) results from poor self-control and therefore considers media use a consequence of reduced willpower (Hofmann, Reinecke, & Meier, 2017). Our study tests another possibility and investigates if exercising self-control with the mobile phone has consequences as well. Drawing on delay of gratification research (Mischel, 2014) and work suggesting that mobile media are salient temptations daily life (Bayer, Dal Cin, Campbell, & Panek, 2016; Stothart, Mitchum, & Yehnert, 2015, etc.), this study investigates the psychological and physiological effects of mobile phone resistance.

Delaying Gratification, Self-Control, and the Mobile Phone

The idea that resisting the mobile phone might lead to important psychological consequences is rooted in a tradition of research on delaying gratification. In a classic experiment, Mischel and Ebbesen (1970) demonstrated how there are downstream benefits for children who postpone temptation better than others. The authors randomly assigned 3-5 year

olds to one of four conditions with respect to gratifications that were available (e.g., either an immediate, less preferred reward such as pretzels, or a delayed, more preferred reward such as cookies). In one condition, children were left in a room without any reward. In a second condition, children had both rewards available to them. In the final two conditions, either the less preferred or more preferred reward was present, only. Mischel and Ebbesen (1970) tested how long each child waited before he or she terminated the experiment by eating the reward or calling for the experimenter. When children had any reward present, they waited for less time and had more difficulty delaying gratification than if no reward was present. The authors argue that the saliency (e.g., the treats were placed directly in front of the children), draw, and anticipation of the reward (e.g., cookies, or marshmallows in other versions of the study) were cognitively consuming for the children and applying self-control to temptations, in general, is difficult.

Mischel's overarching paradigm, the Marshmallow Test, found that children have short-term difficulties delaying an immediate reward (e.g., one marshmallow) for a preferred reward (e.g., two marshmallows). In the long-term, Mischel and colleagues also observed that the ability to delay gratification is highly correlated with intelligence (e.g., better delayers have higher SAT scores than worse delayers) and general health (e.g., better delayers have lower body mass indices than worse delayers), suggesting that self-control may be an important predictor of success and well-being (Casey et al., 2011; Mischel, 2014; Mischel, Shoda, & Rodriguez, 1989). These findings, and over forty years of empirical work on delaying gratification and self-control, suggest that there are benefits to successfully resisting temptation (see Baumeister & Tierney, 2011). It is therefore important to understand the conditions that demand self-control with desirable stimuli, such as the mobile phone, and effects that stem from exercising self-control with temptation.

The Draw of Mobile Media

If the phone is a temptation, then resisting it should lead to costs for several reasons. The mobile phone offers social, psychological, and task-completion benefits to users. People use the mobile phone to store personal information such as bank and health records (Kharrazi, Chisholm, VanNasdale, & Thompson, 2012) and to accomplish daily tasks such as web-surfing, news-seeking, and answering email. The phone also consolidates many devices into one (e.g., GPS) and provides entertainment during periods of boredom (e.g., video streaming, access to news; Panova & Lleras, 2016). Mobile phones are even more important for people who rely on them for tasks outside of entertainment, work, and information-seeking. For instance, in the Philippines and Kenya, people use the mobile phone as a vehicle to distribute and obtain salaries for jobs, send money to peers, and to provide loans (van der Boor, Oliveira, & Veloso, 2014). In many African countries, the mobile phone is a primary way to disseminate knowledge about current and impending health issues (Chib, van Velthoven, & Car, 2015). The mobile phone, regardless of location, is a fundamental tool that connects people to resources and it does this more efficiently than any current technology.

The prior evidence suggests that people value the mobile phone because it is a hub for access to social and professional connections, activities, and entertainment (Bayer, Campbell, & Ling, 2016). Although the mobile phone is instrumental for many aspects of everyday life, it is unclear if people desire mobile media and conceptualize the device as a temptation. According to Hofmann et al. (2017), a desire is a motivation that elicits an appetitive response to pursue a stimulus for gain or pleasure. A temptation, on the other hand, is a type of desire that conflicts with goals for self-regulation. This distinction is crucial because desires may be culture-dependent or environment-specific. Our approach conceptualizes the mobile phone as a

temptation and suggests that resisting the mobile phone conflicts with goals or rewards that can be satisfied by using the device (Campbell, 2015).

The desire to use media and act on what they afford is pervasive, as demonstrated in a week-long investigation by Hofmann, Vohs, and Baumeister (2012). The authors created a diary study that pinged participants at seven instances per day, asking them to record their current desire (or one that they just experienced) and if they attempted to resist the reported desire. The data revealed that the desire for media use (e.g., social networking sites, attending to email, using the Internet, watching TV) resulted in one of the highest self-control failures (e.g., 42% of media desires were enacted) and this failure rate was substantially higher than other well-established temptations such as alcohol or sex (Baumeister, 2014).

The prior study reveals that there is a hierarchy of temptations in everyday life and people often fail to self-regulate with media (Hofmann et al., 2012). Why is the mobile phone a challenge for self-control? Hofmann et al. (2017) propose four affordances of mobile media that affect the relationship between mobile communication and self-control. The authors suggest that mobile phones afford, (1) immediate gratifications, (2) habitual usage, (3) ubiquitous availability, and (4) attentional demands facilitated by push notifications. Related to the first affordance, immediate gratifications, the mobile phone allows people to be socially connected at all times and access information whenever they want (e.g., through texting, social media; Reinecke, Vorderer, & Knop, 2014). Connecting with others and learning about their daily activities is a basic desire that can become quickly satisfied with online communication and mobile technology. Therefore, mobile media are desirable because people can turn to social outlets in times when information-seeking and entertainment are particularly salient desires (Hofmann et al., 2017).

The second affordance, habitual usage, considers that self-control failure with the mobile phone is also possible because people form routines with media. LaRose (2010) suggests that people engage with media by first making the conscious decision to perform a media-related activity (e.g., read the newspaper, check status updates, scroll Twitter). Media use, especially with the mobile phone, then becomes reflexive and more difficult to resist when a habit forms (see also Bayer et al., 2016;). For example, if a person often replies to text messages or emails as soon as they are received, he or she is likely to experience distress or discomfort when waiting to respond to a conversation because the habit has been broken. Further, if people typically check their mobile phone during a waiting period to relieve boredom and they break a habit by not using their device, psychological or physiological changes should be observed (LaRose, 2010; Verplanken & Wood, 2006). Therefore, because media habits are difficult to break especially when the habit benefits the self, fulfills a psychological need, or accomplishes a goal that could not be performed in an unmediated environment, self-control with media poses a challenge to most users.

Third, mobile phones are desirable because they make other people and information always available (Campbell, Ling, & Bayer, 2014). Mobile media, either through conversation or feeds on social networking sites (e.g., Facebook), allow a person to maintain contact with others, while having access to the digital traces of the past (e.g., prior text messages or Facebook posts). Therefore, mobile phones allow social connection on demand.

The fourth affordance, attentional demands, suggests that exercising self-control with the mobile phone may be difficult because acquiring the latest information and content is also facilitated by push notifications that demand the user's attention. Push notifications remind the user that the phone can provide entertainment (e.g., Netflix reminding a user that the latest

season of a show is available), the ability to complete tasks (e.g., a food delivery service reminding a user that his or her order is not complete), and immediate boredom relief (e.g., Facebook notifying users that a person is "live;" see Leung, 2008; Panova & Lleras, 2016). In an always on environment, the mobile phone provides lightweight reminders to suggest that a user and his or her new content is available for action (Bayer et al., 2016).

Mobile phone resistance should affect psychological and physiological behavior because the phone is a personal, social, and information tool that provides people with and reminds them of its everyday value. It also allows people to create and access information that is crucial for social connectivity (Bayer et al., 2016; Hofmann et al., 2017). Below, we review evidence that directly addresses the idea that the mobile phone is a temptation and its resistance is associated with psychological consequences.

The Mobile Phone Marshmallow?

To what degree is resisting the mobile phone similar to resisting a marshmallow in Michel's classic paradigm? Recent studies have made correlational attempts to uncover the relationship between media use and self-control. For example, Reinecke, Hartmann, and Eden (2014) investigated the association between self-reported feelings of self-control and procrastination, guilt, recovery experience with using media (e.g., the agreement with statements such as "When I [watched TV/played video games] yesterday after work/school, I relaxed"), vitality after using media, media enjoyment, and preferences for challenging versus easy TV content. As predicted, individuals who reported less self-control also appraised media more negatively, felt guiltier for using media, and viewed media use as an activity of procrastination. Feelings of guilt were negatively associated with the recovery experience of using media, vitality, and enjoyment. That is, people who fail to self-regulate with media often feel worse

about unsuccessful self-control attempts. Further, the guilt associated with self-control failure negatively impacts their ability to rebound psychologically. Those who succumb to temptation "may benefit less from the psychological recovery potential of entertainment media, despite their greater need for recovery" (Reinecke et al., 2014; p. 569).

In another revealing study, Panek (2014) surveyed college students' media use and found a negative relationship between self-reported self-control (e.g., rating agreement with statements such as "I am good at resisting temptation") and time spent using leisure media such as social networking sites, watching television, online videos, previously recorded TV programs, or DVDs. That is, individuals reporting decreased willpower spent more time using media. Perhaps the most important finding from this study, however, concerned the factors that predicted the amount of social networking site use by college students. In addition to the self-control measure, participants reported their motivations for Internet use across four factor-derived categories (e.g., for social means, information or entertainment, for utilitarian reasons, to pass the time). Only self-control predicted the amount of time that students would use social networking sites.

The prior evidence suggests that self-control is an important variable to consider when evaluating how people use and interact with media (Hofmann et al., 2017; Panek, 2014; Reinecke et al., 2014). Given the mixed effects that offer mobile phone use can produce both positive (Bayer et al., 2016; Campbell & Kwak, 2010; Gonzales, 2014; Guillory et al., 2015) and negative social and psychological outcomes (Alter, 2017; Turkle, 2015), it is important to consider other experiences with the mobile phone that are common (e.g., resisting the device) and can inform how people interact with technology. Are there consequences of delaying gratification with and resisting the mobile phone? Although theoretical (Bayer et al., 2016; Hofmann et al., 2017) and survey research suggest that the mobile phone is a temptation and can

draw resources from people (Panek, 2014; Reinecke et al., 2014), little experimentation has investigated the consequences of exercising self-control with the mobile phone, besides anxiety (Sapacz, Rockman, & Clark, 2016). This study experimentally tests if the mobile phone is analogous to a marshmallow temptation, and produces consequences when resisted.

The Current Study

This experiment examines if resisting the mobile phone affects psychological and physiological behavior relative to sitting alone and using the phone. Prior work has shown that people who sit alone and entertain themselves with their thoughts report worse psychological outcomes (e.g., less enjoyment, more concentration difficulty, and more mind wandering) than people who have something to do (e.g., read a book; Wilson et al., 2014). A mind wanders without external stimulation and "a wandering mind is an unhappy mind" (Killingsworth & Gilbert, 2010, p. 932). Crucially, this study examines if resisting the mobile phone amplifies negative psychological consequences that are typically associated with being absent from external stimulation (e.g., less enjoyment, more concentration difficulty, more mind wandering) and relative to using the mobile phone.

Hypotheses. The first prediction considers how participants will report perceived enjoyment, concentration difficulty, and mind wandering when they are told to resist the phone, versus having no phone available or using the device. When the phone is in front of the participant but he or she is resisting the device, this task replicates the treatment condition of the Marshmallow Test experiments. Children and young adults had difficulty resisting the marshmallow because the temptation was directly in front of them. People have a natural gravitation towards satisfying desires (e.g., using the phone) rather than resisting them (Baumeister & Tierney, 2011), suggesting that self-control with media will be difficult. When

the phone is taken away from a participant, the experience should also be unpleasant, but less distressing than if the participant had the phone in front of him or her, and was told not to use the device. This "out of sight, out of mind" mentality was observed in the Marshmallow Test experiments, as children who closed their eyes or looked away from the marshmallow could cope with a nearby temptation and exercise self-control better than those who stared at the marshmallow (Mischel, 2014, p. 31).

When subjects must resist their phone, they should experience lower levels of enjoyment, more concentration difficulty, and more mind wandering relative to when subjects use the phone or sit alone without the device. When people are using the phone, their desires are satisfied and their self-regulation goals are not in conflict. This situation would be similar to children who could eat marshmallows and do not have to exercise self-control.

H_1: Participants who resist their phone will report less enjoyment, more concentration difficulty, and more mind wandering relative to participants who sit without their phone or who use their phone.

To evaluate if resistance affects automatic responses to temptation, electrodermal activity (EDA), also known as skin conductance, will measure physiological behavior. EDA is measured by passing a current through two electrodes that touch the skin (Dawson, Schell, & Filion, 2007). Skin conductance corresponds to changes in sweat levels in the eccrine sweat glands (Lang, Potter, & Bolls, 2009) and suggests the activation of the sympathetic nervous system and fight-or-flight responses (Bradley & Lang, 2000; Lang, Chung, Lee, Schwartz, & Shin, 2005). Crucially, EDA varies with the intensity of the activation to physiological systems (Lang et al., 2009). Highly emotional and arousing images produce greater skin conductance relative to

neutral images (Lang, Greenwald, Bradley, & Hamm, 1993) and people tend to experience the greatest electrodermal responses to highly unpleasant experiences.

The relationship between EDA, self-control, and the mobile phone is complex, with mixed predictions from empirical research. For example, there is evidence suggesting that people display greater physiological arousal when absent from their phone compared to having their device. In a within-subjects design, Clayton, Leshner, and Almond (2015) had participants complete word puzzles with or without their cell phone present. When the participant's phone was placed in a different room, increased heart rate, blood pressure, and anxiety levels were detected relative to when the same person had their phone. On the other hand, social psychological evidence suggests that suppressing impulses (i.e., engaging in self-regulation) is highly arousing. Gross (1998) randomly assigned participants to one of three conditions (e.g., cognitive reappraisal, thought suppression, control) and had them watch a highly negative and arousing film of an amputation. In the cognitive reappraisal condition, participants were instructed to watch the film and "think about it in such a way that they would feel nothing" (p. 227). In the thought suppression condition, participants were instructed to exercise self-control by suppressing their emotions while watching the film. A final control condition did not give participants any instructions to watch the film. The data revealed that participants who suppressed their emotions had increased EDA relative to those who watched the movie or reappraised its content.

Thought suppression and self-regulation, in general, have negative consequences that are well-documented in social psychology. In a classic design, participants who resisted the thought of a white bear experienced a rebound effect (Wegner, Schneider, Carter, & White, 1987, among others), where people who suppressed their thoughts then reflected on the white bear more than

those who were not given thought regulation instructions. Together, evidence from the prior studies offers two possible physiological outcomes for the relationship between self-control and the mobile phone: (1) being without the phone is more arousing than using it (Clayton et al., 2015), and (2) resisting temptation and exercising self-control with the phone is more arousing than ordinary activities with the device (Gross, 1998; Wegner et al., 1987). It is unclear which of these competing predictions will prevail and therefore, contrasting hypotheses are predicted.

H_{2a}: Physiological arousal will be greatest for participants who are without their phone, relative to those who use or resist their phone.

H_{2b}: Physiological arousal will be greatest for participants who resist their phone, relative to those who use or are without their phone.

Method

All preregistered hypotheses and documents relevant to this study are stored on the Open Science Framework (OSF; link removed to preserve author anonymity), including Supplementary Material with additional detail on the Method and Results.

Power

The experimental paradigm from Wilson et al. (2014) required 30 participants to obtain a standardized effect size and correlation coefficient of $r = .67$. Consistent with prior replication attempts of this framework (see Holzmeister, Camerer, Imai, Manfredi, & Nave, 2016), 18 participants are required per condition of the experiment to detect 75% of the original effect, powered at 90%. The current experiment follows this power recommendation.

Consistent with Holzmeister et al. (2016), a second wave of data collection to detect 50% of the original effect size (powered at 90%) if Wave 1 effects were not observed (see Results). An additional 72 participants across three conditions were required for Wave 2, resulting in a

pooled sample size of 126 participants (42 participants per condition). This final number of participants in each condition is consistent with recent studies that have replicated and extended the original Wilson et al. (2014) design (see Alahmadi, Buttrick, Gilbert, Hardin, Westgate, & Wilson, 2017; Westgate, Wilson, & Gilbert, 2017), and we therefore only report the analysis of the combined Wave 1 and 2 data in the Results (see Supplementary Materials for further detail).

Participants and Exclusion Criteria

Participants were students at [Redacted] University and compensated with course credit for their time. The study was approved by the university's Institutional Review Board and advertised as a "Thinking and Concentration" study, to not arouse suspicion or focus any attention on the mobile phone.

Several participant exclusion criteria were predetermined. Data were excluded if: (a) participants terminated the experiment by exiting the room, (b) participants failed to answer all questionnaire items, (c) parts of the study's infrastructure faced technical issues, or (d) a participant held strong views toward media during or after the experiment. One participant was excluded from analysis after expressing strong and unsolicited distaste for mobile phones and was extremely nervous about the study overall, the physiological tracking device in particular.

The final sample had 125 subjects (74 females). Participants were mainly Asian/Pacific Islander (52/125; 41.6%) and Caucasian (39/125; 31.2%), with mixed race (22/125; 17.6%), Hispanic/Latino (7/125; 5.6%), and African American (5/125; 4.0%) orientations being less represented in the sample. There were no age differences across conditions, [$p = .27$].

Procedure

Participants were randomly assigned to one of three conditions: (1) *phone resist*, treatment condition, (2) *no phone*, control condition, or (3) *phone use*, control condition. Before

the experimenter described the study's procedure, participants left all belongings and accessories (except for the mobile phone in relevant conditions) in an adjacent control room. First, the experimenter explained how physiological data would be measured with a tracker. A pretest revealed that having the tracker placed on the participant's wrist produced low and unreliable electrodermal readings. Therefore, participants were instructed to place their index and middle finger of their non-dominant hand on the tracker and keep them in place for the entire experiment (see Empatica, 2017). This method was successful at achieving reliable readings. The experimenter then had the participant sign a consent form and provide demographic data with pencil and paper. The experimenter was consistent across all participants.

In the *phone resist* treatment condition, participants sat in an unadorned room for 6 minutes, a time that was called the "thinking period." The experiment length was not revealed to any participant across conditions. Time during the thinking period was determined after evaluating the length of typical self-control manipulations (see Hagger, Wood, Stiff, & Chatzisarantis, 2010). To signal the start of the 6-minute thinking period, the experimenter tagged the start of the participant's session on the physiological tracker and the tracker was also tagged when the experimenter entered the room at the end of the 6 minutes. Participants in the phone resist condition were told to place their cell phone face down on the desk, but on silent mode with the power on. The participant's task was to spend the thinking period entertaining themselves with their thoughts, not fall asleep, remain seated, and not use their phone (Wilson et al., 2014). Exact instructions to participants in this condition are in the Supplementary Materials.

In the *no phone*, control condition, the participant's phone (and watch, where applicable) was placed in a separate room. Subjects were told to remain seated, entertain themselves with their thoughts, and to not fall asleep.

In the *phone use*, control condition, participants were instructed to entertain themselves with one or more activities on their phone (e.g., watching video clips, reading, or surfing the web) during "the experimental period." Participants were told that they could switch from one mobile phone activity to another, with the goal of "finding something enjoyable to do." They were further instructed not to call or text during the experimental period, "because the goal of the experiment is to find something entertaining that you like to do alone" (Wilson et al., 2014).

For all conditions, after six minutes elapsed, the experimenter entered the room and administered the dependent measures and questionnaires. After the participant submitted responses to the questionnaires, each participant was debriefed by the principal investigator.

Participants were videotaped to surveil room activity and ensure compliance with the procedures. Only one participant in the *phone resist* condition touched her mobile phone, but did not use the device. Video data were recorded with the Logitech Circle HD Wireless Home Security Camera and still photos of participants in each condition are located in Figure 1.

Measures

The demographic questionnaire was administered with pencil and paper. All other questionnaires were administered through the Qualtrics interface.

Enjoyment. Participants first answered three questions about how much they enjoyed the thinking or experimental period. Text in brackets are wording changes for participants in the phone use condition, because their instructions did not mention a "thinking period."

The first question asked, "How enjoyable was [the thinking period/the experience] you just had?" from (1) Not enjoyable at all, to (9) Extremely enjoyable. The second question asked, "How entertaining was [the thinking period/the experience] you just had?" from (1) Not entertaining at all, to (9) Extremely entertaining. The third question asked, "How boring was [the

thinking period/the experience] you just had?" from (1) Not boring at all, to (9) Extremely boring. These three questions were combined into a composite measure of enjoyment [(M = 5.52, SD = 1.77), 95% CI: 5.21 – 5.83; Cronbach's α = 0.87] by averaging the responses to the enjoyable, entertaining, and boring questions (boredom was reverse scored for the creation of the index, only).

Concentration difficulty. Participants were asked, "How difficult was it for you to concentrate [on the thing that you were thinking about/during this experience]?" from (1) Not at all, to (9) Very much (Wilson et al., 2014). The average level of concentration difficulty was below the midpoint [(M = 3.55, SD = 1.84), 95% CI: 3.23 – 3.88].

Mind wandering. Subjects were asked, "To what extent did you find that your mind wandered during [the thinking period/this experience]?" from (1) Not at all, to (9) Very much (Wilson et al., 2014). The average level of mind wandering was close to the midpoint [(M = 5.35, SD = 2.08), 95% CI: 4.98 – 5.72].

A factor analysis of the five self-report psychological variables (e.g., enjoyable, entertainment, boring, concentration difficulty, mind wandering) revealed that the three enjoyment variables represent a single dimension and were distinct from the two cognitive variables, which also represents a single dimension. The enjoyment factor [λ = 2.54] accounted for 50.86% of the variance and the cognitive factor [λ = 1.34] accounted for an additional 26.78% of explained variance.

Positive and negative affect. Participants completed the Positive and Negative Affect Schedule (PANAS) as a measure of general mood (Watson, Clark, & Tellegen, 1988). Participants rated how well positive [(M = 22.54, SD = 7.71), 95% CI: 21.18 – 23.91] and negative adjectives [(M = 14.57, SD = 5.38), 95% CI: 13.62 – 15.52] described their current

mood from (1) Very slightly or not at all, to (5) extremely. Two variables were created, one combining the positive (Cronbach's $\alpha = 0.90$) and one combining the negative attributes (Cronbach's $\alpha = 0.88$).

Mobile phone perceptions, use, and intensity. To understand if perceptions of the mobile phone and its importance in everyday life were different across conditions, a composite scale of five mobile phone use intensity questions was adapted from Ellison, Steinfield, and Lampe (2007) (Cronbach's $\alpha = 0.73$; see Supplementary Materials on the OSF). This variable is henceforth referred to as the *mobile phone perceptions* scale. Participants were also asked to describe how many minutes per day they use specific apps or services on their phone (Cronbach's $\alpha = 0.74$). We refer to this measure as the *mobile phone use* scale. These two measures were correlated, ($r = .20$, $p = .029$), and therefore, a composite dimension called *mobile phone intensity* was created by adding the two standardized scales. This single measure captures the perceived importance of the phone in everyday life and how often people use phone services.

Physiological arousal. Skin conductance was measured with the Empatica E4 tracker [($M = 2.44$ raw μS, $SD = 1.82$ raw μS), 95% CI: 2.37 raw μS – 2.51 raw μS], collected at a sampling rate of 4 hertz per second, and measured in microSiemens (μS). Data from 15 participants were excluded from the EDA analyses because of faulty skin conductance recordings ($n = 4$) and statistical outliers ($n = 6$, including the one participant who was removed because of the exclusion criteria). Based on emerging standards for measuring skin conductance (Empatica, 2017), 5 participants were also excluded because their (raw) average EDA rates registered less than 0.5 μS, resulting in a final sample of 111 participants.

***Preprocessing*.** Skin conductance data for each participant were first divided into 15-second increments and averaged within each epoch to investigate arousal changes over time.

Consistent with established approaches for analyzing physiological responses to media (AUTHORS, 2007), we then transformed the data by subtracting the tonic (baseline) EDA, defined as the average skin conductance one minute before the start of the experimental period (e.g., when the participant filled out the demographic survey), from the raw experimental period EDA. For example, if the average experimental period EDA within the first 15-second epoch registered 1.41μS and the average tonic EDA was 1.50 μS, the -0.09 μS difference reflects the manipulation's effect on arousal level. Here, the participant would be considered less aroused during the experimental period relative to baseline because the sign is negative. This baseline subtraction method was repeated for all time blocks.

Results

Self-Report Variables

The data were analyzed using one-way Analysis of Variance (ANOVA). ANOVA means and standard errors are summarized in Table 1. All multiple comparison tests represented below are *Bonferroni*-corrected to reduce the likelihood of Type I errors that may affect multiple hypothesis testing. Note, nonparametric tests produce the same results.

Enjoyment. The effect of condition on the enjoyment index failed to reach significance, [$F(2, 122) = 0.63$, $p = .53$, $\eta^2_p = .01$]. To inspect if this null effect was consistent across all enjoyment items, we examined the enjoyable, entertainment, and boring variables separately. The entertainment item revealed a significant effect, [$F(2, 122) = 3.80$, $p = .025$, $\eta^2_p = .059$], where participants who resisted their phone viewed the experiment as less entertaining ($M = 4.33$, $SE = 0.43$) than participants who used their phone [($M = 5.51$, $SE = 0.43$); $p = .022$]. There was no entertainment difference between any of the other conditions.

Concentration difficulty. The effect of condition on reported concentration difficulty during the thinking or experimental period was significant, [$F(2, 122) = 6.16$, $p = .003$, $\eta^2_p = .092$]. Participants who resisted their phone had less difficulty concentrating ($M = 3.33$, $SE = 0.39$) than participants with no phone [($M = 4.31$, $SE = 0.39$); $p = .038$]. Participants who used their phone also reported less concentration difficulty ($M = 3.00$, $SE = 0.39$) than participants without their phone as well [$p = .003$]. There was no difference in reported concentration difficulty between participants in the phone resist and phone use conditions, [$p > .80$].

Mind wandering. The effect of condition on reported mind wandering during the thinking or experimental period was significant, [$F(2, 122) = 11.22$, $p < .001$, $\eta^2_p = .155$]. Participants who used their phone ($M = 4.20$, $SE = 0.42$) reported less mind wandering than participants who resisted their phone [($M = 5.76$, $SE = 0.42$); $p = .001$] and did not have their phone [($M = 6.07$, $SE = 0.42$); $p < .001$]. There was no difference in mind wandering between participants who resisted and who did not have their phone, [$p > .80$].

Collectively, the self-report psychological evidence fails to support H_1.

Mobile phone perceptions, use, and intensity. Participants across conditions did not differ on the *mobile phone perceptions*, *mobile phone use,* or composite *mobile phone intensity* measures [F's < 2.02, p's $> .14$]. Entering the *mobile phone intensity* measure as a covariate into the ANOVA calculations maintained the significance levels of all effects [F's > 3.70, p's $< .028$]. No significant main effects for *mobile phone intensity* were found in any model calculation, [F's < 2.11, p's $> .15$].

PANAS. Participants across conditions did not report differences in positive affect [$F(2, 122) = 0.01$, $p = .99$, $\eta^2_p < .001$] or negative affect [$F(2, 122) = 0.69$, $p = .51$, $\eta^2_p = .011$].

Physiological Arousal

Hierarchical linear mixed models were used to compute a Condition (phone resist, no phone, phone use) X Time (24 x 15-second windows) interaction, with a random effect for participant entered into the model to account for the non-independence of repeated observations by the same subject. As expected, the time main effect was statistically significant in the model, [$F(23, 2484) = 13.70$, $p < .001$]. Crucially, the data also revealed a significant Condition X Time interaction [$F(46, 2484) = 1.41$, $p = .038$; see Figure 2 and Supplementary Figure S1 for a more detailed view of EDA for each condition]. The interaction effect reveals an expected decline in EDA for all participants over time. This decline remains robust for subjects who resisted their phone and EDA eventually flattens for participants in the phone use condition. At approximately the three-minute mark, however, EDA for subjects in the phone resist and no phone conditions start to diverge and reveal significant main effect differences.

The condition main effect across the phone resist (M = -0.29 μS, SE = 0.10 μS), no phone (M = -0.18 μS, SE = 0.09 μS), and phone use (M = -0.19 μS, SE = 0.10 μS) conditions was not significant, [$F(2, 108) = 0.44$, $p = .65$].

Discussion

The majority of academic research evaluating the relationship between media and self-control has considered media use as a *consequence* of reduced or exhausted willpower (Hofmann et al., 2017). For example, people who report low levels of self-control often report overusing social media or using social media for procrastination (Meier, Reinecke, & Meltzer, 2016; Reinecke et al., 2014). This study tested another possibility, that exercising self-control with the mobile phone causes psychological and physiological consequences. An experiment was conducted and prescribed participants to sit in an unadorned room and resist using their phone,

sit without their phone, or use their phone. In general, the data reveal that phone resistance causes both positive and negative consequences for psychological and physiological behavior.

As expected, participants who resisted their phone were less entertained than when they used their device. This finding demonstrates one of the many benefits that people receive from mobile communication, as the mobile phone and mobile phone activities are used for entertainment purposes and social interactions. Second, participants perceived negative psychological outcomes (e.g., more concentration difficulty and more mind wandering) when they were without their device relative to when they used their phone. Reported levels of concentration difficulty were attenuated, however, when participants had the device in front of them but resisted it. Together, these results suggest that the relationship between self-control and mobile phones is complex. On the one hand, a positive outcome of mobile phone resistance is decreased perceived concentration difficulty relative to sitting alone. On the other hand, people are less entertained when they resist the phone compared to using the device and they may feel less focused than if they were using their phone.

Why can the presence of the mobile phone focus the mind, even if the device is resisted? Prior theoretical work on self-control suggests that the saliency of a temptation triggers the motivation and value systems of an individual (Inzlicht & Schmeichel, 2012). People see an object, understand what it provides, and its presence allows the individual to reflect on what it means to them (Hofmann et al., 2009; Hofmann et al., 2017). Most people believe that phones are valuable (e.g., for social connection, entertainment, to pass the time; Smith, 2011), and having the phone in the environment provides something to think about compared to an unadorned room that does not provide this kind of cognitive stimulus. Campbell et al. (2014) also argue that at least having the phone offers cognitive reminders about “the potential” for

mediated communication that can be realized if needed (p. 178). Therefore, while concentration difficulty and mind wandering levels were elevated for those who resisted their device relative to those who used it, access to the mobile phone was more comforting and reduced concentration challenges than not having the device at all.

Empirical research also offers clues that the presence of the phone can concentrate the mind. In an experiment, Rieger, Hefner, and Vorderer (2017) had participants color-code combinations of letters in a word, a task that becomes very tiring for participants over time. Subjects who used their mobile phone in a subsequent waiting period reported increased levels of autonomy and control over their experience than subjects who did not use their phone (Rieger et al., 2017). The authors argue that the mobile phone can be a "security blanket" and aid in recovery after mental fatigue. Using the phone provides comfort that the information on the device is secure (e.g., social connections, personal information, other valuable data) and it reinforces a sense of control that people have their social and professional worlds in their own hands (Bayer et al., 2016; Campbell et al., 2014).

Replication and Extension

With an increased focus on replication in the social sciences (Open Science Collaboration, 2015), this preregistered study reports positive replications for the Wilson et al. (2014) entertainment, concentration difficulty, and mind wandering effects. Their paradigm was also extended by evaluating physiological responses to temptation.

The skin conductance data revealed that arousal levels were consistent across conditions through the first three minutes of the study. After three minutes, however, there is a distinct change in arousal patterns. Participants who resisted their mobile phone experienced a steep decline in excitation relative to participants who were without their phone and experienced an

increase in arousal. This trend suggests that it likely takes time for participants to settle into their psychological experience and physiologically respond to their interaction with or without media. Eventually, people who are without their phone display excitation responses with increased skin conductance levels compared to those who at least have the mobile phone in their presence.

The prior perceptive is consistent with research that has observed psychological responses (e.g., reported levels of anxiety) diverge over time when people are in the presence or absence of the mobile phone. For example, Cheever, Rosen, Carrier, and Chavez (2014) randomly assigned low, medium, and high frequency cell phone users to either turn off their device and keep it out of sight at their seat, or the device was removed and exchanged for a claim ticket while filling out surveys. The authors measured anxiety at three distinct points, each twenty-minutes apart. Crucially, high and low frequency users who were without their mobile phone displayed consistent anxiety levels during the first twenty minutes of the experiment. Anxiety levels diverged, however, during the subsequent timeslots with an increase in anxiety for those who were high media users and a decrease for low media users.

Together, these data support the idea that that time plays a crucial role when evaluating psychological and physiological responses to mobile media experiences. We observed that participants in the phone resist and no phone conditions have opposite excitation responses between minutes three and six. Future research should examine the mechanisms at play during this period to understand the processes that contribute to arousal differences over time.

Limitations and Future Research

There are several limitations of this experiment. First, it is unclear what mobile phone activities were performed in the phone use condition because the experiment failed to collect phone activity data. Watching a video may be more entertaining or arousing than reading a

newspaper article, yet were did not record these activities. Future work may try to identify the media that people consume to evaluate if content moderates the reported effects. For participants who resisted the phone, it is also unclear what they thought they were resisting. Future studies should potentially account for the dimensions of mobile phone use, ask people what activities they felt tempted to perform with their phone (e.g., talk to friends, surf the web).

Participants in the phone use condition were also instructed to not text or call others during the experimental period. Instead, they were told to find something entertaining and enjoyable to do by themselves. To some participants, the prior instructions may represent a form of resistance. Future versions of the task may choose to lift this restriction to understand if the no calling or texting directions induced resistance responses and constrained the effects.

Third, the study population was limited to college students who have likely grown up with a mobile phone. Therefore, self-control with the device is perhaps a learned activity and not an overwhelming challenge. This experiment was a first attempt to measure the consequences of mobile resistance and was best suited for a population with above average media use and familiarity. However, future studies should broaden the scope of the subject population to assess how people in different populations or cultures can resist the mobile phone.

Finally, future research should extend the length of being without, resisting, or using the mobile phone to understand the boundaries of arousal as a function of time. Our evidence suggests that participant EDA begins to diverge after approximately three minutes. This effect should be explored further to understand if subjects converge at a future time stamp as well.

Conclusion

The data from this study suggest that people report negative psychological consequences (e.g., more concentration difficulty, more mind wandering) when they are without their phone

relative to when they use the phone. The presence of the phone – despite being told to resist it – reduced reported concentration difficulty, however, relative to not having the phone. Skin conductance data also suggest that resisting the phone eventually becomes less arousing than being without the device. Self-control with the mobile phone is a worthy area of research and future work should continue to investigate the social, psychological, physiological, and design factors that influence one's ability to resist temptation with technology.

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Table 1.

Means and Standard Errors for Self-Report, Time, and Arousal Variables by Condition

	Phone resist (n = 42)		No phone (n = 42)		Phone use (n = 41)				
	M	*SE*	*M*	*SE*	*M*	*SE*	*F*	*p*	η^2_p
Enjoyment	5.30	0.27	5.52	0.27	5.74	0.28	0.63	.53	.01
Enjoyable	5.48	0.29	5.76	0.29	5.66	0.29	0.25	.78	.004
Entertaining	4.33	0.30	4.79	0.30	5.51	0.31	3.80	.025	.059
Boring	3.91	0.33	3.98	0.33	3.95	0.33	0.01	.99	.001
Concentration difficulty	3.33	0.27	4.31	0.27	3.00	0.28	6.16	.003	.092
Mind wandering	5.76	0.30	6.07	0.30	4.20	0.30	11.22	<.001	.155
EDA	-0.29	0.10	-0.18	0.09	-0.19	0.10	0.44	.65	.008

Note. Enjoyment is a composite variable consisting of the enjoyable, entertaining, and boring measures. The boring scale was reverse scored when computing the enjoyment index. EDA = Electrodermal Activity. Multiple comparison tests are provided in-text. EDA data were calculated using a baseline subtraction method, with higher scores representing greater arousal relative to baseline.

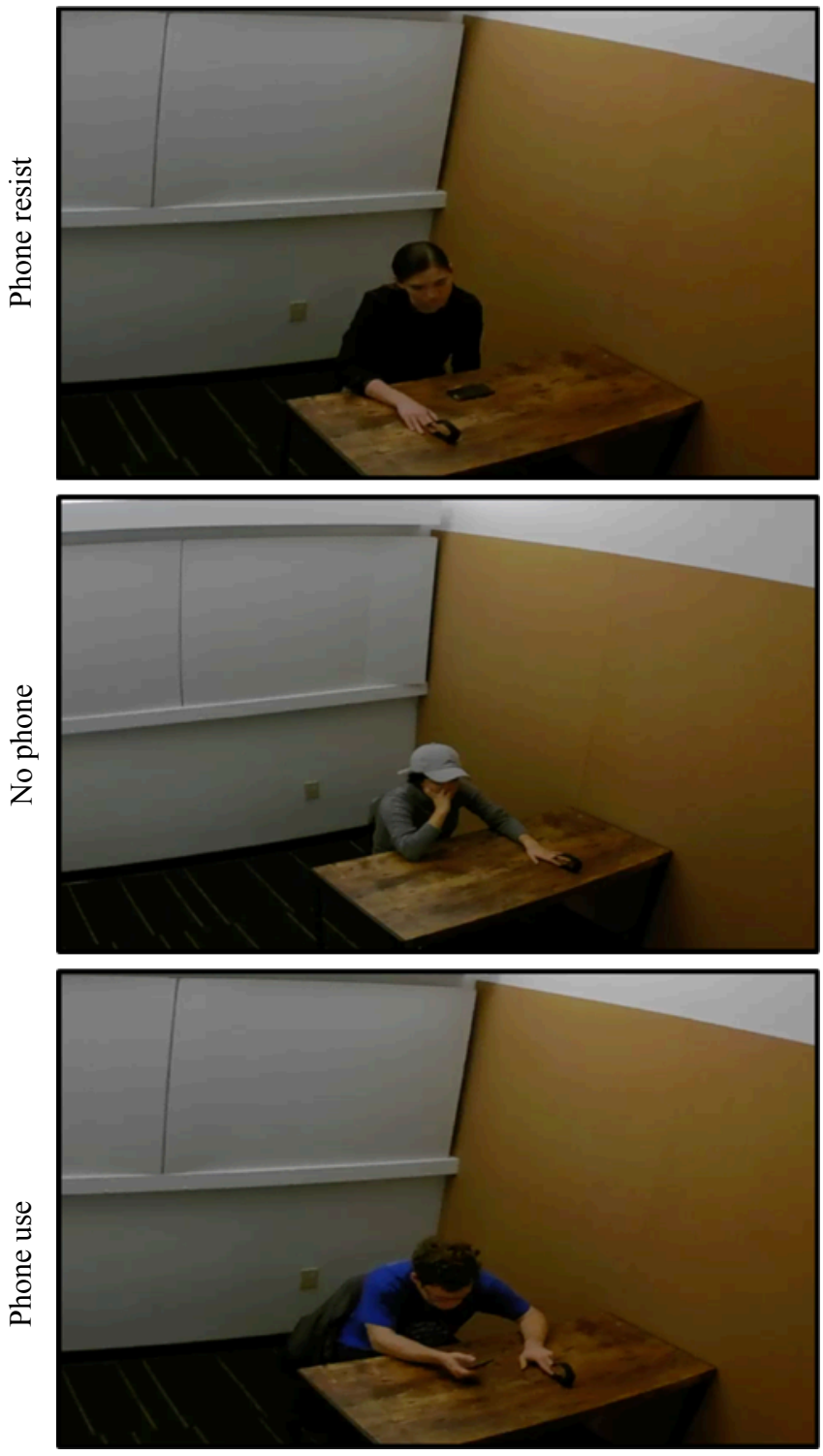

Figure 1. Still photos from the experimental conditions.

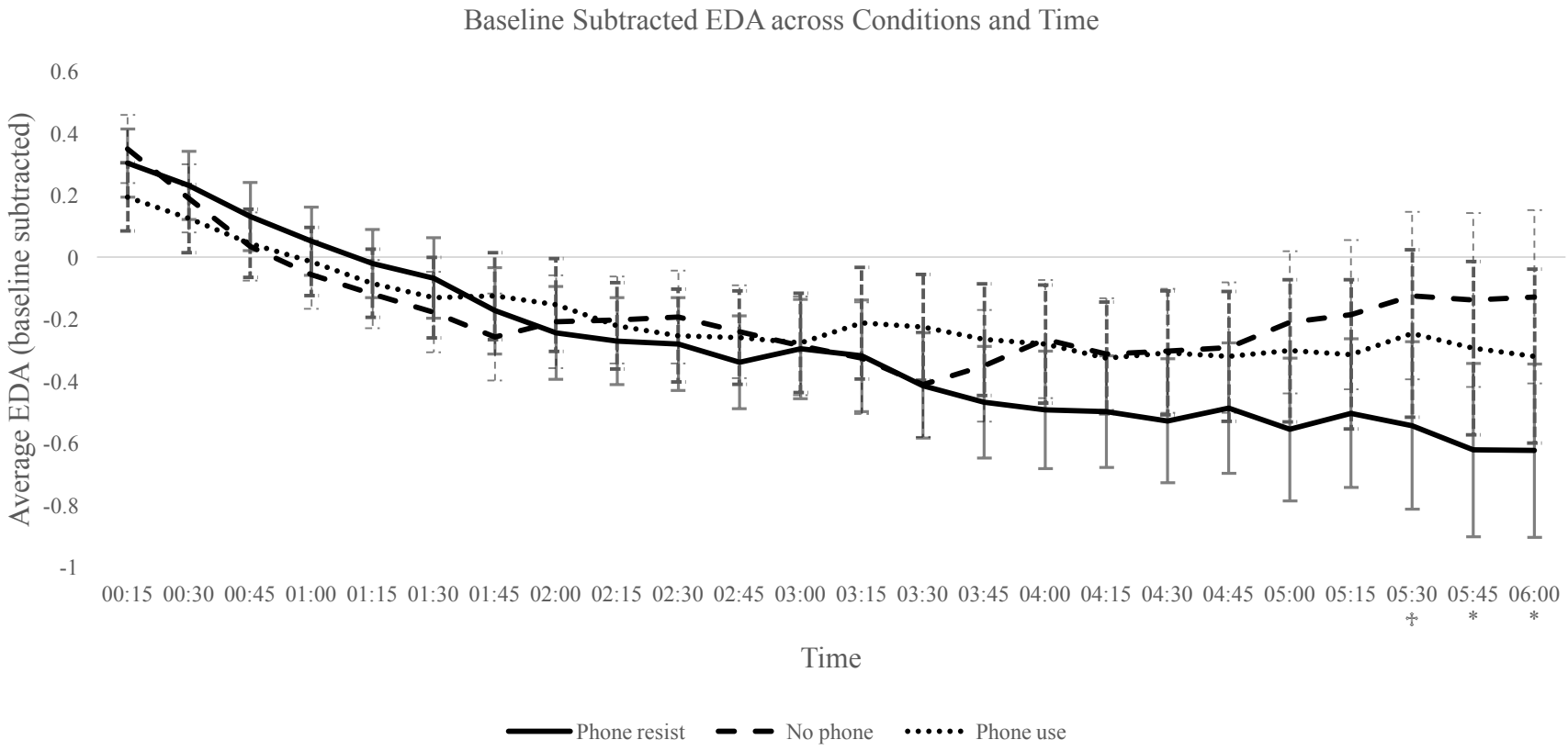

Figure 2. Average EDA is calculated between two time points, represented on the X-axis. * $p < .05$. ✢ $p < .07$. Significant differences at each time marker are *Bonferroni*-corrected and represent differences for the no phone and phone resist conditions. Error bars represent 1 Standard Error above and below each sample mean. Values above and below zero represent increased and decreased arousal relative to baseline, respectively.