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Smartphone Use and Mindfulness: Empirical Tests of a Hypothesized Connection

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SMARTPHONE USE AND MINDFULNESS:
EMPIRICAL TESTS OF A HYPOTHESIZED CONNECTION

by

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DEDICATION

This work is dedicated to my family: my beautiful, supportive, and badass wife, and best friend, Katie Davis Woodlief, and my son and a source of great joy, Emerson Aiden-Hite Woodlief. I would also like to thank my parents Fred and Carole Woodlief for their invaluable, unflagging support. To my friends near and far, your support and guidance make all things possible.
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ABSTRACT

The current study is the first test of a newly developed conceptual model of the effect of smartphone use on mindfulness. Previous research has shown the capacity for mindfulness is strongly associated with increased psychological well-being (e.g. higher self-esteem and lower perceived stress, anxiety, and psychological distress). We argue that smartphones can be used in an automatic and mindless or experientially avoidant way, and that this use can lead to a decreased capacity for mindfulness, with adolescents being most vulnerable to this potential impact. Components of mindfulness, such as the capacity for sustained attention and the areas of the brain implicated in attentional control (e.g., the prefrontal cortex) show significant growth through young adulthood. This developing, malleable capacity is vital as adolescents learn to deal appropriately with negative thoughts and unwelcome emotions. Using self-report augmented with objective measures in a planned missingness design, the current study tested the relation of highly involved smartphone use with mindfulness. Among a sample of university students aged 18-20 (N=668), we found smartphone involvement to be significantly associated with lower trait mindfulness ($b = -0.83$; bootstrapped 95% CI [-1.97, -0.51], $z = 4.86$, $p < .001$). Additionally, exploratory analysis of smartphone involvement as a mediator of the effect of smartphone use on mindfulness found a significant estimated indirect effect of -0.25 (bootstrapped 95% CI: [-0.70, -0.05]). These results provide the first layer of empirical support for an association between use of smartphones in a cognitively and behaviorally involved way and mindfulness.
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CHAPTER 1
INTRODUCTION

A recent survey of a nationally representative sample of Americans aged 13-17 found that nearly three-quarters have access to a smartphone, with 94% of them going online at least daily (Pew Research Center, 2015). Although little is known about the developmental impact of smartphone use, there is growing evidence that higher levels of smartphone use are associated with such negative outcomes as higher levels of anxiety and lower levels of self-esteem (Hong, Chiu, & Huang, 2012), increased sleep difficulties (Lee et al., 2014), problems with sustained attention and learning in the classroom (Ellis, Daniels, & Jauregui, 2010), and greater risk of vehicle accidents (Atchley, Atwood, & Boulton, 2011). The primary aim of the present study was the preliminary test of a conceptual model that describes theoretical connections between mindfulness, smartphone use, and cognitively and behaviorally involved smartphone use (aka smartphone involvement), summarized in Figure 1.1. The current dissertation project is the first empirical test of implications of these theorized connections. We argue that smartphone design lends itself to highly involved smartphone use, which is automatic, mindless use and use for the purpose of experiential avoidance, and that such highly involved use can negatively impact the capacity for mindfulness. Bayer, Dal Cin, Campbell, & Panek (2015) found such automatic smartphone use to be negatively related to the awareness facet of mindfulness. Our working definition (see Figure 1.2) characterizes mindfulness, as did Brown, Ryan, and Creswell (2007) and others, as both
an inherent, malleable capability and a state. Much as mindfulness training (i.e., practice engaging the state of mindfulness) has been shown to increase the inherent capacity for mindfulness (what Brown et al. called trait mindfulness), the use of smartphones in a cognitively and behaviorally involved way could decrease it, with the still developing capacity of adolescents being particularly vulnerable to this effect.

The development of mindfulness during adolescence has not been directly studied. However, it has been shown that the capacity for sustained attention (McKay, Halperin, Schwartz, & Sharma, 1994) and regions in the prefrontal cortex associated with components of mindfulness (e.g., sustained attention; Huttenlocker & Dabholkar, 1997) continue to develop into young adulthood. Trait mindfulness has been associated with important indicators of psychological well-being, such as higher self-esteem and lower perceived stress, anxiety, and psychological distress (Brown, West, Loverich, & Biegal, 2011). The current study is based on evidence presented herein that mindfulness is malleable, especially among adolescents, and that smartphones are designed to elicit highly involved use that could decrease the capacity for mindfulness, with adolescents more vulnerable to this potential impact. This study is an empirical test of relations among mindfulness, smartphone use, and smartphone involvement (as shown in Figure 1.1), tested among older adolescents/young adults, who are among those most vulnerable to the potential effects.

**Mindfulness**

The term mindfulness has its roots in the Pali word sati, which means, “to remember” (Bodhi, 2011). In Buddhist tradition, Sati, as a mode of consciousness, referred to this remembrance and also a non-reactive, non-judging awareness of the
present moment (Thera, 1972). Kabat-Zinn (1982) first introduced mindfulness, via Mindfulness-based Stress Reduction (MBSR), into western clinical settings in the late 1970s. By the early 1990s, other therapies were incorporating mindfulness, either as the basis for treatment, as in Mindfulness-based Cognitive Therapy (MBCT; Teasdale, Segal, & Williams, 1995), or as a key tenet of treatment, as in Dialectical Behavior Therapy (DBT; Linehan, 1993) and Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999). Although each of the aforementioned therapies using mindfulness has demonstrated effectiveness in clinical trials, there is still no consensus on the definition of mindfulness.

Although some definitions include components such as “lovingkindness” (Kabat-Zinn, 1990) or focus exclusively on attentional aspects (e.g., Brown, et al., 2007), most researchers have followed a two-factor model comprising self-regulation of attention and an open, accepting awareness (e.g., Bishop et al., 2004; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). For example, Bishop and colleagues conceptualized mindfulness as a mode of awareness, and described it as a skill that one can develop with practice. The first component, self-regulation of attention, is broken down into three sub-components: (1) sustained attention in order to maintain awareness of the present moment; (2) attention switching to return attentional focus to the current experience if it wanders; and (3) inhibition of elaborative processing of thoughts, feelings, and sensations about the current experience, with this third sub-component reflecting the ability to experience the present moment rather than being distracted by one’s own thoughts about the experience. The second component, an accepting awareness, is theorized to enhance
the experience of the present moment by lessening the impact of filters such as beliefs, assumptions, and preconceived notions.

Bishop et al.’s (2004) conceptualization of mindfulness offers testable predictions about each facet of mindfulness. They hypothesized that the development of the skill of mindfulness would be associated with improvements in the ability to sustain attention on the present moment and the flexibility to return one’s attention if it wanders. Improvements in these abilities could be evaluated with tests measuring sustained attention (e.g., Sustained Attention Response Task (SART), Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) and the ability to shift mind-set (e.g., Trail Making Test (TMT), Army Individual Test Battery (AITB), 1944), respectively. Bishop et al. also predicted that mindfulness enhancement would be associated with an increased ability to inhibit elaborative processing of thoughts or feelings that arise in the present moment, as in rumination. Accepting awareness, or an ability to observe without preconceived notions, is expected to be associated with an increased ability to observe objects as if seeing them for the first time. This can be tested in settings such as the eye-tracking experiments of Henderson, Weeks, and Hollingsworth (1999), which, in part, measured the ability to identify objects in unexpected contexts. An increase in this attitude of acceptance has been shown in a public school adolescent sample to be correlated with an increase in dispositional levels of ‘Openness to Experience’ and decreases in fear of and suppression of negative emotion (Brown et al., 2011).

Some other widely used definitions of mindfulness do not include awareness as a separate factor (e.g., Brown et al., 2007; Shapiro, Carlson, Astin, & Freedman, 2006). Brown et al. conceptualize mindfulness as “a receptive attention to and awareness of
present events and experience” (p. 212). They argue that openness and acceptance is “embedded within the capacity to sustain attention to and awareness of what is occurring” (p. 245). Their contention is that if one were not accepting of what is occurring in a given moment, whether externally or internally, then one would naturally seek to change, escape from, or avoid the experience.

Moreover, while Bishop et al. (2004) characterize mindfulness primarily as a mode (or state), Brown et al. (2007) conceive mindfulness as both an inherent capability (or trait) and a state that can vary intraindividually. That is, they posit that people vary both in their inherent capacity for mindfulness and in their level of mindful engagement at different moments, and also that these variations are influenced by individuals’ differing opportunities to practice mindfulness capabilities. This view is supported by studies such as Kiken et al. (2015), which demonstrated that both trait mindfulness, as measured by the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), and state mindfulness, as measured by the Toronto Mindfulness Scale (TMS; Lau et al., 2006), varied in their levels and rates of change during an MBSR intervention. Chiesa (2012) also argued that trait and state conceptions are not mutually exclusive, asserting that repeated practice of engaging in the mode of mindfulness could increase dispositional levels of mindfulness.

Shapiro and colleagues (2006) based their definition of mindfulness on more classical definitions and Kabat-Zinn’s (1990) conceptualization. From Shapiro et al. (2006): “When Western psychology attempted to extract the essence of mindfulness practice from its original religious/cultural roots, we lost, to some extent, the aspect of intention, which for Buddhism was enlightenment and compassion for all beings” (p.
They incorporated intention into their model (Shapiro & Schwartz, 2000), believing that one’s intention defines the capacity for mindfulness. Intention, as Shapiro and colleagues conceive it, is specifically associated with meditation and other mindfulness practices. In their model, one’s motivation for increasing mindfulness (i.e., why they are meditating) needs to be included. As Shapiro et al. (2006) stated, “How we attend is also essential” (p. 376). Aside from intention, their model does not differ significantly from Bishop et al. (2004). They also incorporate aspects of attitude along with attention, both of which are similar to Bishop et al.’s conceptualization of accepting awareness.

In creating the Kentucky Inventory of Mindfulness Skills (KIMS), a commonly used mindfulness measure, Baer, Smith, and Allen (2004), conceptualized mindfulness as having four facets: Observing, Describing, Acting with awareness, and Accepting without judgment. Baer, Smith, Hopkins, and Krietemeyer updated the KIMS in 2006 to also include a fifth aspect, Nonreactivity to inner experience. This aspect, along with Observing, Acting with awareness, and Accepting without judgment, is encompassed within Bishop et al.’s (2004) definition. An example of an item from the other original factor, Describing, is “I’m good at finding words to describe my feelings“ (Baer et al., 2006, p. 29). This facet can be easily conceptualized as a way to measure a potential outcome or correlate of mindfulness practice rather than an actual component of mindfulness.

**A Working Definition of Mindfulness**

In summary, all of the above researchers agree that attention and acceptance are core components, with some disagreement about the conceptualization of the relation between acceptance and attention as it relates to mindfulness. Shapiro et al. (2006)
include an additional component of intention, which in the classical definition of mindfulness was comprised of compassion and enlightenment, and Baer et al. (2006) include the ability to describe what has been observed and nonreactivity to inner experience. From the perspective of Bishop et al. (2004) and other researchers using a two-factor approach (e.g., Cardicatto et al., 2008), the ability to describe feelings could be also better conceptualized as a way to measure possible outcomes of mindfulness training rather than an aspect of mindfulness, and intention and nonreactivity are encompassed within their two-factor definition.

Our model builds on and integrates the previously described models. Mindfulness, as Bishop et al. (2004) described, is composed of self-regulation of attention (comprising sustained attention, attention switching, and inhibition of elaborative processing) and an accepting awareness (see Figure 1.2). The working definition adopted in the current paper diverges from Bishop et al. by characterizing mindfulness in a similar manner to Brown and Ryan (2003), who conceived of it as both a trait and a state, both of which vary intraindividually and interindividually. So, mindfulness comprises both the capacity to invoke the inherent trait of the above three aspects of self-regulation of attention and an accepting awareness, and also the actual state of such at a given moment. This ability to engage mindfully is malleable, implying that abilities to sustain attention, return attention to focus if distracted, inhibit elaborative processing, and be accepting of the present moment can all vary over time and can be highly dependent on environmental supports or barriers for its development.
Importance of Mindfulness

Although there has been inconsistency in the operationalization of mindfulness, there has been clear consistency in findings demonstrating the relationship between capacity for mindfulness and psychological well-being. This capacity can be especially important when negative thoughts, unpleasant memories, or unwelcome emotions arise. Hayes (1994) emphasizes the importance of being able to experience inner events without defense. This is not a passive acceptance or a resignation to the experience, but instead an observation of the experience without preoccupation or suppression (Keng, Smoski, & Robins, 2011). Brown et al. (2007) characterized the refusal to attend to or acknowledge a thought or emotion that arises (i.e., becoming aware of it but refusing to accept it) as mindlessness, but it can also be characterized as experiential avoidance (Cardaciotto et al., 2008). Experiential avoidance has been shown to be associated with increased post-traumatic symptomology, and greater symptoms of panic, depression, and anxiety (see Hayes, Luoma, Bond, Masuda, & Lillis, 2006, for a review). Suppression of thoughts has also been shown to paradoxically increase the phenomena trying to be suppressed, potentially resulting in greater distress (Marcks & Woods, 2005) and increased anxiety (Koster, Rassin, Crombez, & Naring, 2003).

Non-judgmental attention also enables an individual to step back and relate objectively to a current experience rather than getting caught up mentally and emotionally in elaborative judgment of the experience. Shapiro et al. (2006) called this shift in perspective reperceiving. This shift could potentially increase one’s ability to act mindfully rather than reacting automatically (Josefsson & Broberg, 2011). As Brown and Ryan (2003) stated, “(m)indfulness is…compromised when individuals behave
compulsively or automatically” (p. 823). They posited that mindfulness could play an important role in helping people disengage from unhealthy thoughts, habits, and behaviors; this is precisely the role that mindfulness is theorized to play in such interventions as ACT (Hayes et al., 1999). In essence, compulsive, automatic functioning is the polar opposite of mindful engagement.

There are many correlational studies that have provided support for the positive relation of mindfulness with well-being. For example, experienced meditators were found to report higher psychological well-being (Ortner, Kilner, & Zelazo, 2007), and score higher on self-compassion, well-being and lower on cognitive failures, rumination, thought suppression, fear of emotion, and difficulties in emotion regulation than demographically similar non-meditators (Lykins & Baer, 2009). In the latter study, decreased rumination and fear of emotion were found to mediate the relationship between higher levels of self-reported mindfulness and well-being. This aligns with our conceptual model and our working definition of mindfulness, and with the concomitant predictions that increased non-elaborative awareness would be associated with decreased rumination, and increased acceptance would be correlated with decreased fear of negative emotion. Similarly, in a cross-sectional study of 14-18 year olds (Brown et al., 2011), scores on the Mindful Attention Awareness Scale for Adolescents (MAAS-A) were found to be positively related to Openness to Experience, Agreeableness, Conscientiousness, higher life satisfaction, positive affect, wellness, and negatively correlated with Neuroticism.

Two recent meta-analyses that give substantial support for the efficacy of mindfulness-based therapies (MBTs) provide even stronger evidence for the importance
of mindfulness. A meta-analysis (Zoogman et al., 2014) focused on MBTs for youth under the age of 18 ($N = 20$) and found an overall small effect size ($d_{el} = .23$) in comparison with active alternative treatments. Outcome measures included anxiety, depression, social skills, quality of life, as well as measures of mindfulness and attention.

In a meta-analysis (Khoury, Sharma, Rush, & Fournier, 2015) of MBSR training for nonclinical populations of adults, MBSR showed moderate effectiveness in pre-post analyses ($N = 26; g = .55$) and in between-group analyses ($N = 22; g = .53$) in increasing quality of life and decreasing anxiety, depression, and distress among healthy individuals.

Other randomized control trials of MBTs not included in the above meta-analyses have also demonstrated their salubrious, lasting effects. For example, Shapiro et al. (2011) found that MBSR participants showed increases in subjective well-being and empathy versus a waitlist control at 2 and 12 months post-treatment. Participation in MBSR (compared to a waitlist control) has also been associated with significantly greater increases in self-compassion and greater decreases in absent-mindedness, difficulties regarding emotions, fear of emotions, and worry both immediately following treatment and at a 2 month follow-up (Robins, Keng, Ekblad, & Brantley, 2012). MBCT (vs. waitlist control) has been associated with positive outcomes, including greater reductions in symptoms of depression and anxiety and in the frequency of negative automatic thoughts (Kaviani, Javaheri, & Hatami, 2011). These studies show that MBTs contribute to the positive outcomes that are directly predicted by our theoretical model (decreased fear of emotion, absent-mindedness, and frequency of negative thought).
Malleability of Mindfulness

One of the inherent purposes of mindfulness practice is increasing one’s capacity for mindfulness, which is only possible if that capacity is malleable. Studies of self-reports, objective measures, and neurological correlates from interventions explicitly designed to increase the capacity for mindfulness demonstrate that practicing state mindfulness increases the inherent capacity to engage this state. MBSR (Kabat-Zinn, 1982) was the first mindfulness-based intervention to appear in the literature and is still widely used. In subsequent years, many others have also been developed and implemented, including DBT (Linehan, 1993), ACT (Hayes et al., 1999), and MBCT (Segal, Williams, & Teasdale, 2002). Along with mindfulness studies that have demonstrated the effectiveness of mindfulness practice on multiple indicators of adjustment, some mindfulness interventions have sought to directly evaluate increases in mindfulness, thereby demonstrating its malleability, and change in mindfulness as a critical mediator on change in targeted outcomes.

MBSR is perhaps the most widely studied among therapies that focus on mindfulness. Meditation practice is the primary mechanism in MBSR, driving personal change. It is a group-based, fixed-duration (typically 8 weeks) intervention which initially targeted individuals in physical and psychological clinical populations but has been expanded to use with generally healthy populations dealing with life stress. The meditation practice in MBSR is both sitting and movement-based, with this practice focused on enhancing attentional stability, nonreactive internal and external observation, and awareness of the present moment, including thoughts, feelings, and behavior.
In 2005, Cohen-Katz et al. conducted one of the first studies to evaluate whether MBSR increased mindfulness, as measured by the MAAS (Brown & Ryan, 2003). This was a randomized, small sample (N=25), quantitative and qualitative study of MBSR, as offered to professional nurses at a hospital in the northeast U.S. This study found a significant increase in self-reported mindfulness, as compared with control, after eight weeks of standard MBSR. Shapiro, Brown and Biegel (2007) found similar results in a prospective, nonrandomized, cohort-controlled study of therapists in training. Their MBSR participants also showed a significant increase in self-reported mindfulness, as measured by the MAAS, compared to control. In 2011, Brown et al. conducted a randomized, manualized MBSR intervention with adolescents aged 14 to 18 with Axis I disorders. The MAAS-A showed no differences between treatment and control in mindfulness at baseline, but showed significant gains in self-reported mindfulness for the MBSR participants from pretest to follow-up, with effect size in the medium range ($d = 0.61$). These are but a few of many studies that show increases in self-reported trait mindfulness for MBTs versus waitlist control (Klatt et al., 2008; Robins et al, 2012; Shapiro et al., 2008; Shapiro et al., 2011) and versus active control (Levy et al., 2013; Ortner et al., 2007; Zeidan et al., 2010) using the MAAS or other self-report measures. A recent meta-analysis (Khoury et al., 2013) found 93 MBT studies that included measures of mindfulness at the end of treatment. Twenty-three of these were treatment-controlled studies with a combined effect size of $g = .42$.

Although self-report measures are useful, objective measures provide even stronger support for the plasticity of mindfulness. Perhaps the most commonly evaluated subcomponent of mindfulness is sustained attention. Brief meditation training with
novice meditators has also yielded superior performance relative to active controls on the Stroop (Allen et al., 2012; Wenk-Sormaz, 2003) and a computer-adaptive n-back test (Zeidan et al., 2010). Among adolescents aged 13-15, a year of concentrative meditation training yielded better performance, compared to demographically-matched controls, on the Alerting subscale of the Attention Network Test (ANT) (Baijal, Jha, Kiyonaga, Singh, & Srinivasan, 2011), which also in part measures the capacity for sustained attention.

Studies have also demonstrated that mindfulness training can enhance performance on measures of attention switching. Novice meditators performed superior to a control group on the Internal Switching Task following a ten-day intensive meditation retreat (Chambers, Lo, & Allen, 2008) and participants in MBSR performed better than control on the Orienting subscale of the ANT (Jha, Krompinger, & Baime, 2007). Lastly, brief mindfulness training has shown increased performance on the Conflict Monitoring subscale of the ANT, which measures attention switching, in a number of studies (Ainsworth, Eddershaw, Meron, Baldwin, & Garner, 2013; Tang et al., 2007; Zylowska et al., 2007), including meditative interventions targeting adolescents (Baijal et al., 2011).

Other studies have measured the effects of mindfulness training on the capacity for attention without interference from elaborative processing or the filters of preconceived notions (i.e., with an accepting awareness). Superior performance among those receiving brief mindfulness training was found on an Emotional Interference Task (Ortner et al., 2007), and an object detection task (Anderson, Lau, Segal, & Bishop, 2007). Zanesco, King, Maclean, and Saron (2013) also found significant improvement on response inhibition task performance following a month of intensive mindfulness
training. While the aforementioned studies provide support for our model of mindfulness, evidence for the relationship between mindfulness training and attentional functions is mixed. For example, while Anderson et al. (2007) found improvements in object detection (awareness) following eight weeks of mindfulness training, they did not find improvements in attention switching.

Studies in neuroscience have also demonstrated that neural systems and structures can be modified as a result of training, with increases in gray matter signaling improved functioning in a given area (Hölzel et al., 2011). For example, studies of experienced meditators have shown increased cortical thickening in brain regions implicated in attention, including the prefrontal cortex and right interior insula (Lazar et al., 2005) and the dorsal anterior cingulate cortex (ACC; Grant, Courtemanche, Duerden, Duncan, & Rainville, 2010). Increased activation in the ACC (implicated in detecting and processing attentional conflicts by Van Veen and Carter, 2002) has been found after five days of mindfulness training (Tang et al., 2009) as well as increased white matter integrity (Tang et al., 2010). A normal course of MBSR has also been shown to increase gray matter concentration in the hippocampus (Hölzel et al., 2011).

Some recent studies of MBTs not only show that they have a positive impact on mindfulness and other outcomes, but also that increases in mindfulness are related to the positive effects of the MBT. For example, the previously mentioned Brown et al. (2011) study of adolescents receiving outpatient MBSR not only showed post-training increases on the MAAS-A, but also that these increases were related to higher self-esteem, lower perceived stress, anxiety, and SCL-90-R (Derogatis, 1977) psychological symptoms. Shapiro et al. (2008) found that participation in MBSR increased MAAS scores relative
to active and waitlist controls, and that increases in self-report mindfulness mediated decreases in perceived stress and rumination. By tracking mindfulness (FFMQ) and perceived stress weekly throughout an MBSR intervention, Baer, Carmody, and Hunsinger (2012) showed that significant improvement in mindfulness began in the 2nd week, but significant reductions in perceived stress were not found until the 4th week. Change in mindfulness in the first three weeks predicted the amount of change in perceived stress over the course of the intervention. Kiken et al. (2015) found that MBSR participants varied in their trajectories of state mindfulness (TMS) over the course of the intervention and that individuals with greater rates of increase in state mindfulness increased more in trait mindfulness (FFMQ) and decreased more in psychological distress, as measured by the SCL-90-R. According to a recent meta-analysis of MBSR and MBCT, there is moderate, consistent evidence for mindfulness as a mediator (Gu, Strauss, Bond, & Cavanagh, 2015).

Together, evidence from self-reports, objective measures of mindfulness components, and a growing amount of neurological studies all corroborate our supposition that mindfulness is plastic and that a purposeful increase in trait mindfulness through consistent behaviors and environmental supports (e.g., intervention) is possible, with some of these studies demonstrating that these increases in mindfulness mediate the other positive impacts of mindfulness-based treatments. It follows, then, that trait mindfulness could also be decreased by certain behaviors. We argue that experiential avoidance and automatic reactivity are two potential mechanisms by which this could occur. Attempts at suppressing or avoiding aversive thoughts, feelings, or experiences are quite literally the opposite of mindful engagement in the moment. Rather than sustaining
attention on the aversive thought or feeling, while avoiding rumination and preconceived notions, the “experiential avoider” suppresses their awareness and redirects attention elsewhere. If reacting to unpleasant thoughts and feelings in this way occurs regularly, experiential avoidance can become an automatic reaction. Shapiro et al. (2006) observed that reperceiving, a shift in perspective that comes from regular mindfulness practice, enabled individuals to be less apt to react automatically to uncomfortable situations. Deikman (1963) called this reduction of automatic responding deautomization. In short, the regular practice of engaging in an accepting awareness of the moment through self-regulation of attention increases ones capacity to do so. It follows, then, that regularly avoiding awareness and reacting automatically could make engaging this capacity more difficult, especially under stressful circumstances.

**Adolescence as a Sensitive Period for Increased Malleability of Mindfulness**

Assuming that the capacity for mindfulness can be decreased, we argue that it then follows that adolescents, in the midst of rapid development and changes within the brain, may be more vulnerable to this decrease. Although we are not aware of any direct studies of the development of mindfulness through adolescence, there are a number of studies that demonstrate that aspects of mindfulness are developing during this time. McKay et al. (1994) demonstrated that the capacity for sustained attention shows significant growth between age 11 and adulthood, indicating that this capacity is still developing during late adolescence. Given the prefrontal cortex (PFC) is not structurally mature until young adulthood (Huttenlocker & Dabholkar, 1997), the capacity for top-down attentional control, which is, in part, dependent on functions of the PFC (Hölzel et al., 2011), would also continue to develop into late adolescence. Reaction time on tests
such as the ANT continue to improve during this time because of maturation and the
development of more efficient connectivity between the anterior cingular cortex and
other brain areas (Rothbart & Posner, 2015).

In a review of brain imaging studies, Blakemore and Choudhury (2006) observed
that there are more changes occurring in the PFC, which is implicated in attention
switching and response inhibition, than in other parts of the brain throughout
adolescence. These increased changes during adolescence in synaptogenesis
(Huttenlocher & Dabholkar, 1997), gray matter reduction (Sowell, Thompson, Holmes,
Jernigan, & Toga, 1999), and myelination (Giedd et al., 1999), along with increases in
volume of white matter up until age 20 (Klingberg, 2008) within the PFC suggest that the
capacity for mindfulness may still be developing. Both Booth et al. (2003) and Luna,
Padmanabhan, and O’Hearn (2010) have corroborated this supposition by finding both
developmental differences in the prefrontal cortex and performance differences in
attention switching and response inhibition tasks between mid-adolescents and young
adults. Given pruning and neural growth are happening at high rates during mid-
adolescence (Thompson et al., 2000), this period of development is believed to be
optimal for mental training to promote greater attentional control (Bajjal et al., 2011;
Wass, Scerif, & Johnson, 2012). If these capacities are still developing across
adolescence and may be especially amenable to positive mental training, then it stands to
reason that physiologically, they could also be especially vulnerable to behaviors that
may decrease the capacity for mindfulness, such as regular smartphone use.
Impact of Smartphone Use on Mindfulness

The literature addressing the potential impacts of smartphone use, particularly as it relates to mindfulness, is lacking in volume and limited by the difficulty in keeping up with rapid advances in technology. The majority of extant studies on the impact of use focus on what is essentially a qualitatively different device: the mobile phone. Even studies conducted in the smartphone era have used measures of self-report use that primarily asked participants to estimate the frequency or amount of phone calls and texts (e.g. Bayer et al., 2015; Billieux, Van der Linden, d’Acremont, Ceschi, & Zermatten, 2007; Walsh, White, & Young, 2010). This is a severely limited conceptualization for today’s smartphone use, as they have so rapidly advanced in speed, functionality, and potential uses beyond that of a traditional mobile phone. In a survey of over 5,900 smartphone users published in 2016, GfK MRI found that only 44% of time spent on smartphones is used for calling and texting. There are a limited number of studies, such as Lee et al. (2013), that have tried to overcome this limitation by incorporating objectively measured smartphone use, using unobtrusive apps.

Smartphones are able to provide users with consistent, salient, and instant rewards, which based on operant conditioning, can reinforce more usage, particularly among those with less ability to self-regulate (LaRose, Lin, & Eastin, 2003). This instant gratification can lead to unconscious triggering of goal-seeking behaviors, such as compulsive checking of the phone. In one of the few extant studies addressing smartphone use and mindfulness, Bayer et al. (2015) found automatic use (in this case, texting) to be negatively associated with awareness. When an action is consistently rewarded, that behavior begins to be automatically triggered with an expectation of
subsequent reward (Neal, Wood & Quinn, 2006). Over time, such a repeatedly triggered behavior can become a habit. The immediately accessible, highly salient rewards offered by smartphones, such as access to social networks, communication, news, and other online content, promote such automated behavior (Harwood, Dooley, Scott, & Joiner, 2014). An increase in this kind of habit implies an increase not just in use, but also the level of involvement.

In the era before the ubiquity of smartphones, researchers argued that, while mobile phone use had a negative impact, the degree of individuals’ cognitive and behavioral involvement with their phones was a key predictor of the extent to which use has deleterious effects on functioning (Walsh, White & Young, 2010). In their survey of Australian youth aged 15-24, 85% reported moderate-to-highly involved use. Involvement, which was only moderately correlated ($r = .30$) with use, captures how people use their phones and ways in which the devices impact their cognition and behavior, even when they are not actively being used. Highly involved users are defined by a preoccupation during other tasks because they are thinking about their phones (Walsh et al., 2010), persistent, unconscious and/or compulsive phone checking behaviors (Atchley & Warden, 2012; Lee et al., 2014), and a need to know where their phone is at all times (Atchley & Warden, 2012). Hartanto and Yang (2016) found that such cognitive preoccupation with smartphones could result in short term deficits in attention switching and inhibitory control. They found that users who were separated from their smartphones experienced heightened anxiety, which mediated an adverse effect on these functions.
What researchers have identified as high involvement may indicate a higher susceptibility to the negative impact of smartphone use on their state of mindfulness. As Walsh et al.’s conception of involved use was based on a much less sophisticated and simpler device being used on concomitantly less advanced and slower networks, the construct must be expanded to not only encompass automatic, mindless use, but also experientially avoidant use. The newer capabilities of smartphones that go far beyond texting and calling (i.e. social media apps, internet access, online games) have exponentially expanded its potential for use to avoid boredom or other aversive feelings. The conceptual model we have developed is based on the proposition that much as engaging in regular mindfulness practice enhances one’s capacity for mindfulness, it follows that the more one regularly engages in the automatic, compulsive cognitions and experiential avoidance associated with high smartphone involvement, the more likely it will have a detrimental effect on that capacity.

For example, Billieux et al. (2007) found that those who reported both higher levels of use of their mobile phones and higher perceived dependence on their phones showed lower ability to deliberately suppress these automatic responses, resulting in difficulty postponing their use in unsafe or inappropriate conditions, and a lower capacity for sustaining concentration on a tedious or difficult task, as measured by the Urgency and Perseverance subscales (respectively) of the UPPS Impulsive Behavior Scale (Van der Linden et al., 2006). Moreover, those who are more distracted by automatic cognitions and experiential avoidance with their phones engage in more frequent task-switching (having to return their attention to the task at hand after distraction). Those individuals who frequently switch attention in this way were found to be less able to
sustain attention in the presence of irrelevant stimuli and less able to switch attention back once distracted (Ophir, Nass, & Wagner, 2009). Research has also shown that those who frequently task-switch not only exhibit inferior performance when performing the same tasks but also take longer to finish them (Fox, Rosen, & Crawford, 2009). Poldrack and Foerde (2008) found that people, when distracted by another activity, had a harder time learning new things. Using fMRI, they found that undistracted learners engaged the hippocampus, which is critical in processing and storing information. Task-switchers, however, did not engage the hippocampus, but rather the striatum, which has been implicated in performing habitual tasks. Participants in another fMRI study showed less cortical activation when asked to perform tasks concurrently than when asked to perform these tasks successively (Just et al., 2001). This research shows that the brain learns and functions differently when distracted, operating in a manner less associated with flexible application of knowledge and creative problem solving. These findings are in direct contrast to the results on similar tasks by those with mindfulness-based training previously reviewed.

**Adolescent Vulnerability to Highly Involved Smartphone Use**

As adolescents are likely more vulnerable to outside influences on their state and trait mindfulness, it follows that they are also likely more vulnerable to the characteristics of smartphones that facilitate high involvement. Developmental changes in the brain during adolescence, particularly in the processing of social information, have been linked to changes in social behavior in adolescence, notably in the increased salience of social experiences and ties to peers (Nelson, Leibenluft, McClure, & Pine, 2004). This increased salience can lead to difficulties balancing competing social demands and
meeting social expectations of constant connectivity. That is, friends and peers are highly influential for adolescents (Smetana, Campione-Barr, & Metzger, 2006) and using phones to stay in contact with them functions to satisfy this need for increased social inclusion and connectedness (Walsh, White, & Young, 2008). In a study of American undergraduates, Ames (2013) found that smartphone users were attempting to reconcile two conflicting desires: on one hand, to be available to respond to friends, family or extended network members that might contact them, and on the other, to be present in the moment and giving attention to their immediate surroundings. In addition, participants reported feeling anxiety and guilt in regard to not being able to check for and return messages, but also feeling guilty about checking their phone in class or in social situations. Students reported that if they did not remain “tethered” to their phones then they faced social consequences, with many reporting that being connected less than their friends expected them to be had caused problems in those relationships.

Walsh et al. (2010) found that the majority of a sample of 15-24 year-olds reported psychological distress if they were unable to access their phones, or even simply at the thought of not having access to their phones. Most, however, reported preventing this distress by making sure the phone was always available. These in-group norms about availability are an especially salient influence on phone-related behavior among young people. Studies have shown positive views of phone use held by an adolescent’s social group to be an influence on an individual’s frequency of use (Cassidy, 2006; Smetana et al., 2006).
Smartphone Use and Adolescents’ Day-to-Day Mindfulness

Research has repeatedly demonstrated that smartphone use adversely affects adolescents in important areas of functioning including academic achievement, and physical health and safety. Although evidence of the role of mindfulness in these relations is scant, it’s clear that the capacity to sustain attention while in class or while walking or driving, inhibiting one’s attention from being pulled to your smartphone, is a vital, adaptive ability. In an extreme example, having one’s attention focused on a smartphone while driving could, and too often does, lead to death or injury of the driver or others.

Academics. In a study of first-year university students, over two-thirds used electronic media (including cell phones) while in class, studying, or doing homework (Jacobsen & Forste, 2011). In turn, Rosen, Carrier, and Cheever (2013) found that middle school, high school, and university students all typically became distracted by smartphone content such as texting or Facebook in less than 6 min after initiating a studying session. Similarly, in a national study conducted by The Pew Internet and American Life Project, 64% of teens who have phones text in class and 23% access social network sites in class on their phones (Lenhart, Purcell, Smith, & Zickuhr, 2010). Aligned with research on the negative impact of task-switching, these interruptions come at a cost. Numerous studies have demonstrated the negative impact of smartphone-related task-switching on academic performance (e.g., Junco & Cotton, 2011; Wood et al., 2012). For example, Ellis, Daniels, and Jauregui (2010) compared students allowed to use their phones during a lecture with those who were not allowed and found students with phone access scored significantly lower on subsequent exams than students with no
access, even after controlling for GPA and gender. Similarly, Wei, Wang, & Klausner (2012) found that students who texted during class showed decreased ability to self-regulate and decreased capacity to sustain attention to tasks in the classroom.

**Physical Health and Safety.** Use of smartphones has been shown to interfere with sleep and even pose physical dangers. A recent study of Swiss adolescents between the age of 12 and 17 found that levels of electronic media use were associated with reduced sleep duration and increased sleep difficulties (Lemola, Perkinson-Gloor, Dewald-Kaufman, & Groh, 2014). Bedtime use of mobile phones has also been associated with reduced time in bed (Punamaki, Wallenius, Nygård, Saarni, & Rimpelä, 2007), increased tiredness (Van den Buick, 2007), and significant reductions in weekday sleep duration (Arora, Broglio, Thomas, & Taberi, 2014).

Adolescents are also likely to be more vulnerable to dangerous distraction due to their heightened sensitivity to the incentives offered by smartphones coupled with a relatively immature capacity for cognitive and emotional regulation (Somerville, Jones & Casey, 2010). That is, research has demonstrated that the presence of affective cues from peers increases adolescents’ risky behavior (Chein et al., 2011), and adolescents have more difficulty identifying when they need to switch off emotionally or socially rewarding experiences, such as those provided by the smartphone, and focus on the task at hand, even if ignoring that task is threatening to their safety. For example, a 2013 survey of UK adolescents by RoadSafe found that 25% of 11-12 year olds and 34% of 13-14 year olds reported that they have been distracted when crossing a road by personal mobile technology. In the US, Nasar and Troyer (2013) found that those between the ages of 16 and 25 are most at risk for phone-related injuries while walking. Pedestrians using
their phones were found to walk slower and disregard other pedestrians (Sultan, 2014) and even hands-free phone conversation has been shown to be a significant distractor for undergraduate pedestrians in a virtual walking environment (Stavrinos, Byington, & Schwebel, 2011).

Texting and driving has also become a prominent public health concern, with 43 states passing laws banning the practice and 12 of them prohibiting the use of any handheld phone while driving (National Highway Traffic Safety Administration (NHTSA), 2014). The National Safety Council (2012) estimates that nearly one-third of all automobile crashes are due to drivers using mobile phones with texting and driving shown to be 5–6 times as dangerous as drunk driving (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). Automobile crashes are the leading cause of death in younger adults (Centers for Disease Control and Prevention, 2014). Over 95% of recently surveyed young/teen drivers reported that they text and drive (Atchley, Atwood, & Boulton, 2011). Younger drivers report that they know texting and driving is a risky behavior and that texting-related crashes are more preventable than crashes preceded by drunk driving or talking on a mobile phone yet they engage in the behavior at an alarmingly high rate despite the risk (Atchley, Hadlock, & Lane, 2012).

While research on the relation between mindfulness and smartphone use is scant, three recent studies have linked mindfulness with texting while driving. Feldman, Greeson, Renna, and Robbins-Monteith (2011) found that undergraduates who reported lower levels of mindfulness reported significantly more texting while driving. In addition, those reporting texting while driving were significantly more likely to report texting as experiential avoidance of negative emotional states. Also, undergraduate drivers who
reported more intrusive thoughts related to their phones reported more near accidents related to using their phones while driving (Terry & Terry, 2015). In the same study, drivers who scored higher on two aspects of the Five Factor Mindfulness Questionnaire – acting with awareness and nonjudging of inner experience - reported fewer phone-related near accidents. Lastly, Bayer and Campbell (2012) found that, after controlling for reported levels of texting frequency and other known predictors (such as norms and attitudes about texting while driving and perceived behavioral control of texting while driving), habitual/automatic texting (i.e., high levels of involvement) was a uniquely significant predictor of reading and sending texts while driving.

The Present Research

Together, the research reviewed above provides the foundation to support the premise that smartphone use negatively impacts mindfulness, with this effect strengthening as cognitive and behavioral involvement with the smartphone increases. Much as mindfulness training has been shown to increase the inherent capacity for mindfulness, we argue that the use of smartphones, especially in a cognitively and behaviorally involved way, could decrease it, with the still developing capacity of adolescents being particularly vulnerable to this effect.

In the present study, we evaluate the impact that smartphone use has on mindfulness, and the effect of smartphone involvement on this relation among undergraduates aged 18-20, using both self-report and objective measures of smartphone use and mindfulness. This dissertation is the first empirical test of hypotheses derived from the conceptual model (see Figure 1.1). We hypothesize that smartphone use affects trait mindfulness, but in degrees based on the user’s level of involvement. Our model
conceives of smartphone involvement acting as a moderator of the relation between smartphone use and mindfulness. There is, however, a plausible, alternate conception in which smartphone involvement acts as the mechanism, or mediator, of the effect of smartphone use’s effect on mindfulness. In light of this, we also conduct a post-hoc, exploratory analysis that tests smartphone involvement as a mediator of this relation. In our conception of highly involved use as akin to the opposite of mindfulness training, there is an implication that the effect could intensify over time. The measurement of smartphone involvement used herein is a measure of the current level of involved use only, and does not allow us to measure participants’ history of smartphone involvement. However, to account for possible effects of how long they have owned smartphones, years of smartphone ownership are included in the model as a covariate.

It is expected that a better understanding of the relations among these variables will help to illuminate the mechanisms by which smartphones could impact mindfulness among older adolescents. This understanding could then facilitate the design of methods aimed at lessening the potential negative impacts of smartphone use. In the current study, we limit the focus to the relations among smartphone use, smartphone involvement, and mindfulness, due to the unknown nature of said relations. It is hoped that, by focusing on and elucidating these constructs, a clearer framework for studying their relations to psychological well-being and other indicators of positive adaptation can be discovered.

The present research is composed of two studies that test the proposed relations between smartphone use, involvement, and mindfulness. For Study 1, hypotheses are tested using student self-report data. Study 2 also uses objective measures to improve measurement precision. These objective measures are incorporated using a planned
missingness design (described fully in Chapter 3), which allows for these measures to be given to a subset of the larger sample used in Study 1.

**Hypotheses**

*Bivariate Relations Hypotheses*

**Hypothesis 1:** Controlling for duration of smartphone ownership, smartphone use will be positively correlated with smartphone involvement.

**Hypothesis 2:** Controlling for duration of smartphone ownership, smartphone use will be a significant, negative predictor of mindfulness.

**Hypothesis 3:** Controlling for duration of smartphone ownership, smartphone involvement will be a significant, negative predictor of mindfulness.

*Moderation Hypothesis*

**Hypothesis 4:** Controlling for duration of first smartphone ownership, smartphone involvement will moderate the association between smartphone use and mindfulness, such that a higher level of smartphone involvement will be associated with a stronger negative prediction of mindfulness by smartphone use.
Figure 1.1. Conceptual Model.
Figure 1.2. Working Definition of Mindfulness.
CHAPTER 2

STUDY 1

Study 1 was an observational, cross-sectional study whose major purpose was to test the above hypotheses using self-report data from a large sample of undergraduates aged 18-20. We assessed the relations among smartphone use, smartphone involvement, and mindfulness, including an exploratory relation whereby smartphone involvement mediates the effect of smartphone use on mindfulness.

Method

Participants

Participants in Study 1 included 668 undergraduates aged 18-20 recruited from the University of South Carolina (USC) (See Table 2.1 for demographic characteristics). Recruitment took place in the Fall, 2015, semester through a posting on USC’s Department of Psychology Participant Pool website (https://sc.sona-systems.com), postings on Facebook pages for undergraduates at USC, contacting professors of large psychology classes (over 100) at USC and asking them to offer extra credit, and contacting deans of other schools at USC and asking them to forward the information to their students. Participants who were psychology majors received course credit for participation and all participants who participated the study were entered into a drawing to win a 16GB Apple iPad Air.

Participants were required to: be aged 18-20; be a student at USC; have owned and used an Android smartphone or an iPhone version 5 or later for at least the previous 3
months; have normal or corrected-to-normal vision, and; speak English fluently. The demographics entry page of the online test asked the participants to indicate whether they meet these inclusion criteria before they were asked to give informed consent.

**Procedure**

We collected data through an online survey during the Fall of 2015, using SoGoSurvey (https://www.sogosurvey.com/). The University’s Institutional Review Board approved the study before data collection began, and ethical procedures were followed throughout the study. Before beginning the survey, we asked participants questions on the inclusion criteria (age, USC student, phone ownership, English-speaking, etc.). 95 individuals who did not meet the criteria were taken directly to an exit page that thanked them for their willingness to participate but explained that they did not fit the criteria for participation. We obtained electronic informed consent for Study 1 (see Appendix C) from each participant prior to beginning the online survey. The informed consent specified details of the study, the rights of the participants, and contact information for the researcher and the researcher’s faculty mentor. It also specified that all data provided would be kept confidential and that we would be asking some participants to participate in another phase of data collection, which they could decline to do without penalty. Those who read and acknowledged understanding of the informed consent moved on to the study self-report measures.

The study self-report measures were presented in the following order: demographics (age, race, ethnicity, gender), mindfulness, smartphone use, smartphone involvement, and psychological well-being. Each page of the survey was designed to require each item to be completed before the participant could move on to the next page.
After participants completed the measures, we invited them to contact the researcher or faculty mentor if they had any questions or concerns regarding the study. We also asked for their consent to be contacted to participate in Study 2. 633 out of the initial 670 participants (94.5%) gave consent to be contacted to participate in Study 2. If they so indicated, we then asked that they provide their email address. Those who did not consent to be contacted for Study 2 were directed to a separate Google document page where they were able to enter their email address in order to be included in the drawing.

**Measures**

We asked all study participants to complete questions regarding inclusion criteria (see Appendix D), a brief demographic questionnaire and consent to be contacted for Study 2 (see Appendix E), the Mindfulness Attention Awareness Scale (MAAS; see Appendix F), questions about their smartphone use and ownership (see Appendix G), an adapted version of the Mobile Phone Involvement Questionnaire (MPIQ; see Appendix H), a set of supplementary questions about smartphone use compiled by the researcher (see Appendix I), a supplementary measure not used in the present dissertation project (see Appendix J), and a restatement of the previous question regarding daily smartphone use, in a different form, in order to check validity (see Appendix K). In addition, we recorded the time required for each participant to complete the measures, in order to screen for participants who completed the measure much more quickly than others.

**Mindfulness.** We measured mindfulness using the Mindfulness Attention Awareness Scale (MAAS) (Brown & Ryan, 2003), a 15-item self-report scale designed to measure trait mindfulness. This scale focuses on measuring the capacity for attention to and awareness of the present moment. The items each have 6 response options ranging
from 1 (*almost always*) to 6 (*almost never*), with higher scores reflecting more mindfulness. Examples of items are “I find it difficult to stay focused on what’s happening in the present,” and “It seems I am ‘running on automatic,’ without much awareness of what I’m doing.” Brown and Ryan (2003) noted that the items reflect mindlessness rather than mindfulness because mindless states are more common than mindful states. Their initial study found a strong single-factor solution, as well as evidence that mindfulness, as measured by the MAAS, is distinct from self-awareness. The internal consistency (coefficient alpha) for their sample of 327 university students was .82. Subsequent studies using college samples corroborated the validity and factor structure of the MAAS (e.g., MacKillop & Anderson, 2007). Numerous studies have shown that participants involved in interventions designed to increase mindfulness show significant increases in MAAS scores versus active control (e.g., Cohen-Katz et al., 2005; Shapiro, Brown, & Biegel, 2007).

**Smartphone Use.** Participants were asked to estimate how long they use their smartphone each day and at what age they first owned a smartphone. The estimated length of time that they have owned a smartphone was included in the analyses as a covariate.

**Smartphone Involvement.** We measured smartphone involvement using a modified version of the Mobile Phone Involvement Questionnaire (MPIQ) and a supplemental questionnaire developed by the author. Walsh, White, & Young (2010) developed the MPIQ to measure cognitive and behavioral involvement with phones. The MPIQ is an 8-item measure of the cognitive energy people devote to their phones even when not using them; the extent of their automatic, mindless use; and use that negatively
impacts other activities. The item responses are scored on a 7-point ordinal scale, 1
(\textit{strongly disagree}) to 7 (\textit{strongly agree}). Because we were exclusively interested in
smartphone use, “mobile phone” was changed to “smartphone” in all items. Examples of
items are: “I often think about my smartphone when I am not using it,” and “I interrupt
whatever else I am doing when I am contacted on my smartphone.” Initial validation
using a sample of Australians aged 16-24 showed a single-factor solution with moderate
reliability ($\alpha = .78$). Correlation with frequency of phone use was significant, but modest
($r = .37, p < .001$), suggesting that phone involvement is a distinct construct from phone
use.

As discussed in the introduction, we conceive of smartphone involvement as a
continuous construct, with users falling along a continuum. The developers of the MPIQ
(Walsh et al., 2010) initially reported their results as dichotomous, with respondents
designated as highly involved if they passed an arbitrary threshold. Because of this, we
altered the responses from a scale measuring agreement with the statement (\textit{strongly
disagree to strongly agree}) to responses that allow for reporting of the frequency of
engaging in activities described by the items (\textit{almost never to almost always}) as a way to
better measure responses along the continuum. These responses were on a 5-point scale
rather than the originally used 7-point scale, as five distinct response anchors were
conceptually identified as meaningful.

The MPIQ addresses, in part, the type of involved use that we theorize could
contribute to decreased mindfulness. It has items related to using the phone “for no
particular reason,” “los(ing) track of how much” the phone is used, and interrupting other
activities if an alert is received (Walsh et al., 2010). These items address automatic,
compulsive use, but not use for the purpose of avoiding uncomfortable feelings and/or thoughts (i.e., experiential avoidance). Excluding the latter would give an incomplete assessment of an individual’s level of cognitive and behavioral involvement. As described in the introduction, the MPIQ was developed before the ubiquity of smartphones and at a time when the technology of the phones, the networks, and the apps were not nearly as advanced. Today’s smartphone user has easier and more available access to vastly more content and reward for potential experiential avoidance than at the time of the initial study. This necessitates the inclusion of items designed to capture this type of use.

Therefore, we formed a pool of 7 items inquiring about the frequency of experientially-avoidant smartphone use and use in potentially dangerous situations, also based on a 5-point ordinal scale for consistency with the MPIQ items. These items were based on aspects of the type of highly involved use that could negatively impact mindfulness that are not adequately covered on the MPIQ and other validated scales measuring problematic smartphone use (e.g., Mobile Phone Problem Use Scale (MPPUS; Bianchi & Phillips, 2005; Problematic Mobile Phone Use Questionnaire (PMPUQ; Billieux, Van der Linden, 2008)). Several graduate students and PhD-level researchers assisted by evaluating the initial pool of questions for clarity, and some questions were rephrased or edited. Examples of items are: “I use my smartphone when I feel awkward or uncomfortable.” and “I use my phone while I’m walking for texting, email, reading, or social media.” We hypothesized that the MPIQ and these questions together measure a unidimensional factor of smartphone involvement.
Supplementary Measure. We also administered one additional self-report measure, the General Well-Being Index (GWBI; McKenna & Hunt, 1992), after the completion of the primary measures. This measure of psychological well-being is not included in the present dissertation project, but was included in order to be able to test further hypotheses relating to the proposed model. The GWBI is a 22-item measure of psychological well-being with six subscales: positive well-being (e.g., How cheerful have you felt?), self-control (e.g., Have you seriously thought you might be losing control over your thoughts and actions?), anxiety (e.g., Have you been under any stress or pressure?), depression (e.g., I felt downhearted and blue during the past month), vitality (e.g., How active and vigorous have you felt?), and general health (e.g., How have you been feeling in general?). Participants were asked to rate, on a 6-point scale, how they’ve been feeling over the previous month, with lower scores indicating a higher level of psychological well-being. Across a number of studies, the measure has consistently scored high on internal consistency and test-retest reliability, and the discriminant, concurrent, and construct validity of the overall measure has also been supported (Gaston & Vogl, 2005; Hopton, Hunt, Shiels, & Smith, 1995; McKenna, Hunt, & Tennant, 1993). One item (Have you felt depressed during the past month?) has a response choice that indicates recent suicidal ideation. Because this study design does not facilitate being able to intervene with participants that indicate such, this item was excluded from the current project. Although this could weaken measurement of the depression subscale, the impact on the measurement of the factor of psychological well-being is expected to be minimal.
Results

Power Analysis

Based on parameter estimates and relationships from the theoretical model, we performed a power analysis using G*Power (release 3.1.9.2; Faul, Erdfelder, Lang, & Buchner, 2007). These analyses indicated that the present study had statistical power (1-β) of .80 to detect an incremental $R^2$ of 0.012 (relative to an $R^2$ of 0.5 for the restricted model) for the hypothesized moderation effect with $N=668$. Because it was treated as an interaction effect, the moderation effect was the most difficult to detect. Power to detect main effects was higher.

Data Preparation

Descriptive statistics for smartphone ownership and use are found in Table 2.2, with bivariate correlations shown in Table 2.3. The age reported for first owning a smartphone ranged from 10 to 19 ($M = 14.4$, $SD = 1.7$), with a mean duration of smartphone ownership of 4.4 years ($SD = 1.7$). Finally, in estimating their daily smartphone use, our sample reported a range of 0.5 hours to 18 hours of use per day ($M = 5.7$, $SD = 3.5$). Before analysis began, we checked the collected data for validity. In the online survey, we asked participants at two separate points in the survey to estimate their daily smartphone usage, once by estimating total time of use per day, once by selecting from a list of ranges (an hour or less, 1-3 hours, 3-5 hours, 5-7 hours, more than 7 hours). We checked each participant’s answers and two participants were excluded from analysis because the estimated time of usage given in their first response did not fall within $+/-$ one range of their second response (e.g. one excluded respondent first reported using their phone 8 hours a day then chose 3-5 hours when asked the second time). The site
used for the online survey, SoGoSurvey, provided the time taken by each participant to complete the survey. The distribution of these data showed no secondary mode of short durations. Extremely short times could have indicated that participants were paying little attention to the questions and not being compliant with the protocol, but no participants had response times under five minutes.

We also checked the data for univariate outliers, calculating skew then examining histograms for individual outliers. Skew for hours of smartphone use per day was 1.20 (SE = 0.09). Visual examination of the histogram for individual outliers raised no cause for concern, so no log transformation was calculated. For the ordinal items, we also examined the distributions for possible strong ceiling or floor effects. We found asymmetry among some of these responses, with four of the smartphone involvement and two of the mindfulness items having modes at an extreme. Due to the significant computational difficulties inherent in the alternative approach of treating this large number (30) of indicators as ordinal with our moderate sample size, ordinal items were treated as continuous.

**Analytical Procedures**

All data analyses were conducted using *Mplus* v7.4 (Muthén & Muthén, 2015). We used confirmatory factor analysis (CFA), a hypothesis-driven form of factor analysis, in order to test the factor structures of the latent variables smartphone involvement and mindfulness, using maximum likelihood estimation with robust standard errors (MLR). We chose CFA to test whether the observed data were consistent with the measurement model hypothesized based on the previous research and theory cited above. MLR’s handling of missing data has been shown to yield more precise and less biased parameter
estimates compared to those using listwise deletion or other \textit{ad hoc} approaches. Due to
the design of the online survey and no participants leaving the survey incomplete, there
were no missing data in Study 1. All confidence intervals reported herein were derived
using percentile bootstrapping with 3000 draws. Bootstrapping was used in order to
estimate potentially asymmetric confidence intervals, reflecting the fact that products of
coefficients (indirect effects) have asymmetric sampling distributions. Bootstrapped
confidence intervals were not calculated for the hypothesized moderation effects because
the normally distributed sampling distribution allows for accurate calculation of
confidence intervals using the standard error.

\textbf{Measurement Model}

The first step in analysis was evaluating the fit of our Study 1 measurement
model. This model included the adapted MPIQ and supplementary questions to measure
smartphone involvement and the MAAS to measure self-report mindfulness. To assess
reliability, we calculated coefficient omega for the MAAS and our smartphone
involvement measure. We chose to use coefficient omega rather than alpha because
omega has less restrictive assumptions (alpha assumes tau-equivalence), does not
increase with mere scale length, is more sensitive to multidimensionality, and allows for
generation of confidence intervals. Both the MAAS (\( \omega = .82 \), bootstrap corrected [BC]
95\% CI [.80, 85]) and the hybrid smartphone involvement measure (\( \omega = .90 \), [BC] 95\%
CI [.89, 91]) showed adequate reliability.

\textbf{Evaluating Model Fit.} All items loaded significantly onto their respective factors
(loadings ranging from .37 to .72 on the MAAS and .41 to .69 on the hybrid SI scale –
see Table 2.4). We assessed model fit for our theorized structural model using multiple
goodness-of-fit statistics: chi-square test of fit ($\chi^2$), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Residual (SRMR). The chi-square value for the overall model fit was significant, ($\chi^2$ (426) = 874.90, $p < .001$) suggesting a lack of fit between the hypothesized model and the data. However, due to the sensitivity of $\chi^2$ to small degrees of mis-fit, other fit indices are emphasized (Kline, 2010). For the other fit statistics, Hu and Bentler (1999) recommend the following thresholds to indicate good model fit: CFI > .95, TLI > .95, RMSEA < .06, and SRMR < .08. Examination of these indices showed mixed results regarding model fit, with CFI = .93, TLI = .92, RMSEA = .039, 95% CI [0.035, 0.042], and SRMR = .043. While the RMSEA and SRMR meet the recommended thresholds, the CFI and TLI values are slightly below the recommended cutoffs. These values both depend on the size of the correlations in the measured variables, which in the case of this dataset low, particularly on the MAAS. Rather than attempting post hoc modification of this established measure, we will accept marginal fit and interpret our estimates with caution.

**Hypothesis Testing**

For the sake of clarity, we tested Hypotheses 1-3 in the context of a single structural equation model (results shown in Figure 2.1) including years of smartphone ownership as a predictor of mindfulness, smartphone use, and smartphone involvement. Because this model is structurally saturated using the measurement model established in the CFA, then acceptable fit for that model also indicates acceptable fit for this model. Two of the three bivariate hypotheses were supported. Regarding Hypothesis 1, there was a significant positive correlation between the latent variables smartphone use and
smartphone involvement, $r = .37, p < .001$. Hypothesis 2, which stated that smartphone use would a significant negative predictor of mindfulness, was not supported ($b = 0.00$, [BC] 95% CI [-0.01, 0.01], $z = 0.18, p = .861$). Hypothesis 3, which posited smartphone involvement as a significant negative predictor of mindfulness, was supported ($b = -0.43$, [BC] 95% CI [-0.58, -0.31], $z = 5.99, p < .001$). To test the moderation hypothesis 4, we used the Mplus function XWITH to create a latent product term from the latent smartphone use variable and the latent smartphone involvement variable. XWITH uses a latent moderated structural equations (LMS) method to estimate multiple latent interactions, which has been shown to provide efficient parameter estimates and unbiased standard errors (Klein & Moosbrugger, 2000). The coefficient for mindfulness regressed on this latent product term in the structural equation model was not significant ($b = 0.01$, 95% CI [-0.01, 0.03], $z = 0.72, p = .48$), indicating no support for Hypothesis 4 (see Figure 2.2).

Exploratory Analysis. Although it is hypothesized that smartphone involvement is a moderator of the effect of smartphone use on mindfulness, it is also plausible that smartphone involvement, instead of moderating this effect, is a mechanism by which the effect occurs. Therefore, we also explored this potential mediation, testing the model shown in Figure 2.3. Examination of fit indices again showed mixed results regarding model fit, $\chi^2 (484) = 1005.19, p < .001$, CFI = .92, TLI = .91, RMSEA = .040, 95% CI [0.037, 0.044], SRMR = .043. We found a statistically significant product of coefficients ($a*b = -0.02$, [BC] 95% CI [-0.03, -0.01]), indicating support for the possible indirect effect.
Table 2.1. Demographic Characteristics of Study 1 Sample and Study 2 Subsample

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study 1 Number</th>
<th>Study 1 Percentage</th>
<th>Study 2 Number</th>
<th>Study 2 Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>304</td>
<td>45.5</td>
<td>21</td>
<td>38.2</td>
</tr>
<tr>
<td>19</td>
<td>209</td>
<td>31.3</td>
<td>8</td>
<td>14.5</td>
</tr>
<tr>
<td>20</td>
<td>155</td>
<td>23.2</td>
<td>26</td>
<td>47.3</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>520</td>
<td>77.8</td>
<td>50</td>
<td>86.1</td>
</tr>
<tr>
<td>Male</td>
<td>148</td>
<td>22.2</td>
<td>5</td>
<td>13.9</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, Not Hispanic</td>
<td>545</td>
<td>81.6</td>
<td>40</td>
<td>72.7</td>
</tr>
<tr>
<td>African American, Not Hispanic</td>
<td>55</td>
<td>8.2</td>
<td>8</td>
<td>14.5</td>
</tr>
<tr>
<td>Multiracial, Not Hispanic</td>
<td>18</td>
<td>2.7</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Asian or Pacific Islander</td>
<td>16</td>
<td>2.4</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>4</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Hispanic</td>
<td>30</td>
<td>3.7</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Note. Study 1 N = 668; Study 2 N = 55. *Sample and subsample sizes of fewer than 5 individuals are masked to reduce the risk of deductive disclosure.
Table 2.2. Descriptive Statistics for Smartphone Ownership and Use

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age First Smartphone Ownership (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study 1 (minus Study 2 sample, N = 618)</td>
<td>10</td>
<td>19</td>
<td>14.3</td>
<td>1.7</td>
<td>14</td>
</tr>
<tr>
<td>Study 2 (N = 55)</td>
<td>10</td>
<td>18</td>
<td>14.8</td>
<td>1.9</td>
<td>15</td>
</tr>
<tr>
<td><strong>Duration Smartphone Ownership (years)</strong></td>
<td>&lt;1</td>
<td>8</td>
<td>4.4</td>
<td>1.7</td>
<td>4</td>
</tr>
<tr>
<td>Study 1 (minus Study 2 sample, N = 618)</td>
<td>&lt;1</td>
<td>8</td>
<td>4.4</td>
<td>1.7</td>
<td>4</td>
</tr>
<tr>
<td>Study 2 (N = 55)</td>
<td>2</td>
<td>8</td>
<td>4.3</td>
<td>1.8</td>
<td>4</td>
</tr>
<tr>
<td><strong>Self-Reported Smartphone Use (hours/day)</strong></td>
<td>0.5</td>
<td>18</td>
<td>5.7</td>
<td>3.5</td>
<td>5</td>
</tr>
<tr>
<td>Study 1 (minus Study 2 sample, N = 618)</td>
<td>0.5</td>
<td>18</td>
<td>5.6</td>
<td>3.4</td>
<td>5</td>
</tr>
<tr>
<td>Study 2 (N = 55)</td>
<td>1</td>
<td>15</td>
<td>6.3</td>
<td>3.4</td>
<td>6</td>
</tr>
</tbody>
</table>

*Note: N = 668.*
Table 2.3. Study 1 Bivariate Correlations

<table>
<thead>
<tr>
<th></th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SUSELF</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. YOWN</td>
<td>.11*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. SI</td>
<td>.37*</td>
<td>.24*</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mindfulness</td>
<td>.18*</td>
<td>.08</td>
<td>.49*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5. SUSI</td>
<td>.31*</td>
<td>.20*</td>
<td>.84*</td>
<td>.43*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. N = 668. SUSELF = Self-reported smartphone use; YOWN = Self-reported years of smartphone ownership; SI = Smartphone involvement; SUSI = Latent interaction term for smartphone use and smartphone involvement. *p < .05.
<table>
<thead>
<tr>
<th>Item</th>
<th>Standardized Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smartphone Involvement</strong></td>
<td></td>
</tr>
<tr>
<td>1. I lose track of how much I am using my smartphone.</td>
<td>.56</td>
</tr>
<tr>
<td>2. I use my smartphone while waiting in line.</td>
<td>.63</td>
</tr>
<tr>
<td>3. I use my smartphone while out at dinner with friends or family.</td>
<td>.60</td>
</tr>
<tr>
<td>4. I have been unable to reduce my smartphone use.</td>
<td>.69</td>
</tr>
<tr>
<td>5. I think about my smartphone when I'm not using it.</td>
<td>.56</td>
</tr>
<tr>
<td>6. I need to know exactly where my smartphone is.</td>
<td>.65</td>
</tr>
<tr>
<td>7. I interrupt whatever else I am doing when I receive an alert on my</td>
<td>.48</td>
</tr>
<tr>
<td>8. Arguments have arisen with others because of my smartphone use.</td>
<td>.67</td>
</tr>
<tr>
<td>9. I use my smartphone while walking for texting, email, reading or</td>
<td>.67</td>
</tr>
<tr>
<td>10. The thought of being without my smartphone makes me feel</td>
<td>.69</td>
</tr>
<tr>
<td>11. I use my smartphone when I'm feeling bored.</td>
<td>.62</td>
</tr>
<tr>
<td>12. I use my smartphone in class for purposes other than schoolwork.</td>
<td>.53</td>
</tr>
<tr>
<td>13. I use my smartphone while driving for texting, email, reading,</td>
<td>.41</td>
</tr>
<tr>
<td>14. I use my smartphone in social situations where I feel</td>
<td>.57</td>
</tr>
<tr>
<td>15. I use my smartphone for no particular reason.</td>
<td>.69</td>
</tr>
<tr>
<td>16. I feel connected to others when I used my smartphone.</td>
<td>.53</td>
</tr>
<tr>
<td><strong>Mindfulness</strong></td>
<td></td>
</tr>
<tr>
<td>1. I could be experiencing some emotion and not be conscious of it</td>
<td>.37</td>
</tr>
<tr>
<td>2. I break or spill things because of carelessness, not paying</td>
<td>.47</td>
</tr>
<tr>
<td>3. I find it difficult to stay focused on what’s happening in the</td>
<td>.57</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4.</td>
<td>I tend to walk quickly to get where I’m going without paying attention to what I experience along the way.</td>
</tr>
<tr>
<td>5.</td>
<td>I tend not to notice feelings of physical tension or discomfort until they really grab my attention.</td>
</tr>
<tr>
<td>6.</td>
<td>I forget a person’s name almost as soon as I’ve been told it for the first time.</td>
</tr>
<tr>
<td>7.</td>
<td>It seems I am “running on automatic,” without much awareness of what I’m doing.</td>
</tr>
<tr>
<td>8.</td>
<td>I rush through activities without being really attentive to them.</td>
</tr>
<tr>
<td>9.</td>
<td>I get so focused on the goal I want to achieve that I lose touch with what I’m doing right now to get there.</td>
</tr>
<tr>
<td>10.</td>
<td>I do jobs or tasks automatically, without being aware of what I'm doing.</td>
</tr>
<tr>
<td>11.</td>
<td>I find myself listening to someone with one ear, doing something else at the same time.</td>
</tr>
<tr>
<td>12.</td>
<td>I drive places on ‘automatic pilot’ and then wonder why I went there.</td>
</tr>
<tr>
<td>13.</td>
<td>I find myself preoccupied with the future or the past.</td>
</tr>
<tr>
<td>14.</td>
<td>I find myself doing things without paying attention.</td>
</tr>
<tr>
<td>15.</td>
<td>I snack without being aware that I’m eating.</td>
</tr>
</tbody>
</table>

*Note. N = 668. Smartphone involvement measured by adapted Mobile Phone Involvement Questionnaire (MPIQ) and mindfulness measured by Mindfulness Attention Awareness Scale (MAAS). All factor loadings significant, *p < .05.*
Figure 2.1. Structural Model for Study 1 test of Hypotheses 1, 2 & 3. Correlation and unstandardized factor loadings (standard errors) shown. Disturbances not shown.
Figure 2.2. Structural Model for Study 1 Hypothesis 4a (Moderation). Unstandardized factor loadings (standard errors) shown. Disturbances not shown.
Figure 2.3. Structural Model, Study 1 Mediation. Note. Indirect effect was significant (a*b) = -0.02, [BC] 95% CI [-0.03, -0.01]. Unstandardized factor loadings (standard errors) shown. Disturbances not shown.
CHAPTER 3

STUDY 2

Study 2 was an observational, cross-sectional study whose major purpose was to test the above hypotheses using the self-report data from Study 1 augmented with objective measures of two of the three latent variables (smartphone use and mindfulness) in a two-method planned missingness design, in order to improve measurement precision. We again assessed the relations between smartphone use, smartphone involvement, and mindfulness, including an exploratory relationship whereby smartphone involvement mediates the effect of smartphone use on mindfulness.

Method

Participants

Participants in Study 2 included 55 participants from Study 1 who were among those who provided an email address and consented to be contacted to participate in Study 2 (See Table 2.1 for demographics). Beginning with the first eight participants in Study 1, we numbered each group of eight consecutive participants 1 to 8, in order of completion. SAS 9.4 (SAS Institute, Cary NC) was used to generate a random number from 1 to 8. If the participant corresponding to that number had given consent, we invited them to participate in the Study 2. If that person had not consented to be contacted or declined to participate in Study 2, we chose an alternate from that group. This process continued until there was one participant from each group of eight (unless all eight participants from a given group either declined consent to be contacted or declined to
participate in Study 2). In total, we invited 350 Study 1 participants to take part in Study 2, with 214 (61.1%) not responding, 81 (23.1%) declining to participate, and 56 (16.0%) agreeing to participate, of whom one did not meet their appointment for Study 2 and did not respond to follow up contact. Of the 55 who participated in Study 2, our compliance rate was 100%, and all participants in Study 2 were iPhone users.

**Procedure**

In Study 2, we used a planned missingness design to improve the measurement of mindfulness and smartphone use. This design, similar to that described by Graham, Taylor, Olchowski, and Cumsille, (2006), is described in more detail in the following Planned Missingness Design subsection of the Results section.

We invited the participants who agreed to take part in Study 2 to come into the laboratory, where we then asked them to give informed consent for participation in the two phases of Study 2 (called Phases 2 & 3 in Appendix L). This consent form addressed the two phases of Study 2 separately and allowed participants to consent to take part in each phase separately. In the first part of Study 2, participants completed two tasks designed to measure aspects of mindfulness. The primary researcher administered the tasks in random order (decided by a coin flip), using an iPad Air, giving a standardized set of instructions for each task immediately prior to completion. Participants responded to information presented visually on the iPad screen, using apps downloaded from the Apple Store.

At the completion the first part of Study 2, we asked those who agreed to participate in the second phase to download a free app to their smartphones (Moment for iPhones) that records how long they use their phones each day. We explained how the
app works, what permissions were required, and the privacy policy of the app. We asked participants to enable Moment to run in the background, invisibly tracking the amount of time their phone is being actively used. We informed them that this information will only be visible to them, with no data being transferred to the researcher from the app at any time, shared with any third party by the app, or accessible by any other installed app. In order to more accurately track usage, Moment needs to be able to access the smartphone’s location information. This information cannot be accessed by other installed apps or any third party. Location and GPS data are only stored on the device and never shared with anyone, including the app developers. A researcher then contacted participants every eight days for the next thirty-two days by email and asked them to forward only the number of minutes that they used their phones each day for the previous eight days. The Moment app contains a feature that allowed participants to easily forward daily total usage since the installation of the app.

Measures

In order to objectively measure sustained attention and attention switching, we used, respectively, the Sustained Attention Response Task (SART; Robinson et al., 1997) and the Trail Making Test (TMT; Army Individual Test Battery (AITB), 1944). We chose these measures because they allow for valid measurement of these aspects of mindfulness with a minimal time investment from the participants.

**Sustained Attention.** The SART (Robinson et al., 1997) is a continuous performance paradigm requiring response to frequently presented non-targets and a withholding of the response for occasional targets. Participants are shown 225 single digits for 250ms each, with a 900ms mask, and are asked to tap the iPad screen in
response to every digit other than “3.” If a “3” appears, they are instructed to not respond. This task is designed to require continuous attention to response, be sensitive to brief lapses in attention, and have minimal demands on other cognitive processes (e.g., memory, planning, and general cognitive effort). The SART places demands on maintaining attentional focus in two ways: by having long and unpredictable intervals between targets, and requiring continuous performance over the duration of the 225-trial/4.3min task. Testing by Robertson et al. (1997) showed SART performance predicted self and informant reports of everyday attentional failures. Further study has demonstrated that the SART measures sustained attention performance, as opposed to simple response inhibition (Manly, Robertson, Galloway & Hawkins, 1999). We used the number of omission errors on the SART as the indicator for the latent variable of sustained attention (Manly et al., 1999).

**Attention Switching.** To objectively measure attention-switching ability, we used the two-part Trail Making Test (TMT; AITB, 1944. This test was initially published as part of the Army Individual Test Battery (1944) as a paper and pencil test but has been adapted for use with the touchscreen of the iPad. Part A (TMT-A) requires connecting numbers 1-25 with a single line as quickly as possible while still maintaining accuracy, while part B (TMT-B) requires drawing a similar line connecting alternating numbers and letters in order (i.e., 1-A-2-B-3-C etc.). The score recorded for each part is the time required to complete each “trail,” or connecting line. A recent comprehensive review and validation of the TMT provides strong support to the initial assumptions, that attentional switching ability is the primary variable accounting for variance in B-A difference scores (Sánchez-Cubillo et al, 2009). Mayr and Keele (2000) demonstrated that the shifting from
one task-set to the other requires not just a shift of attentional focus, but also inhibition of
attention to the currently irrelevant task-set, indicating that B-A difference scores provide
a relatively clear measure of the capacity for attention switching.

**Smartphone Use.** The variable of interest in this study, minutes of smartphone
use per day, was measured using the Moment app. A previous study by Lee et al. (2013)
used a similar, self-developed app to unobtrusively monitor smartphone use. They found
significantly different levels of use in the first 2 days of monitoring as compared with the
rest of the study, so they excluded those days. Accordingly, we also excluded the first
two days of monitoring.

**Analytical Procedures**

All data analyses were conducted using the software and methods described in
detail in the Analytical Procedures section of Study 1 found in Chapter 2.

**Results**

**Data Preparation**

Descriptive statistics for Study 2 measures are found in Table 3.1 and correlations
are shown in Table 3.2. Additionally, we examined the objectively measured hours of
smartphone use, finding a skew of 0.20, Based on previous literature, there was no reason
to expect non-normality on either the SART or TMT, but we examined this data visually
in order to screen for outliers and calculated skew for each to be 1.98 and 1.58,
respectively.

**Planned Missingness Design**

We measured two of the three latent variables (smartphone use and mindfulness)
using the two-method, planned missingness design as described in Graham et al. (2006).
In this design, “inexpensive” (in terms of money, resources, and/or time) measures are given to the full sample (Study 1), while more “expensive” measures are used on a portion of respondents to facilitate more precise measurement (Study 2). In a planned missingness context, having multiple measures of latent constructs allows for better construct measurement and more power than with the inexpensive measures alone (Graham et al., 2006). It also allows for better modeling of the error structures of said measures (e.g., Kaplan, Johnson, & Bailey, 1988). This is accomplished because the more expensive measures are used to help model the response bias of the less expensive measures. With mindfulness, we accomplished this by using a second order factor model, in which items on the MAAS load onto a single MAAS factor, which, in turn, is the third indicator of mindfulness, along with the two expensive measures, the SART and TMT. Because there was only one self-report (i.e., inexpensive) indicator of smartphone use, we could not explicitly model the response bias; however, we expected that having the other two objective, expensive indicators would improve the measurement of this latent variable.

Among participants in Study 2, correlations between the inexpensive and expensive measures ranged from moderate to close to zero. Smartphone use as measured by the Moment app showed a moderate correlation with self-reported smartphone use, \( r = .38, p < .001 \). Our participants tended to overestimate their smartphone use, reporting in Study 1 that they used their phones an average of 6.4 hours a day (\( SD = 3.4 \)), while the Moment app found that participants averaged 3.8 hours of use each day (\( SD = 1.3 \)). The two objective measures of mindfulness did not significantly correlate with MAAS (\( r = .01, p = .508 \) for the TMT B-A score and \( r = .15, p = .207 \) for SART omissions). The
A score was also not significantly correlated with SART omissions, \( r = .24, p = .081 \).

**Measurement Model**

The first step in analysis was evaluating the fit of our study 2 measurement model. All of the following analyses were also conducted using *Mplus* v7.4 (Muthén & Muthén, 2015).

**Evaluating Model Fit.** All items loaded significantly onto their respective factors aside from the TMT B-A score (\( b = 0.87, SE = 1.45, z = 0.60, p = .549 \)). Due to the small standardized loading (.09) of TMT B-A on mindfulness, this measure was removed post-hoc from our CFA and hypothesis testing. Fit indices of the revised measurement model (see Figure 3.1) showed mixed results regarding model fit: \( \chi^2 (517) = 1056.99, p < .001, \) CFI = .92, TLI = .91, RMSEA = .038, 95\%CI [0.035, 0.041], SRMR = .079. As with the Study 1 CFA, the RMSEA and SRMR meet the recommended thresholds, while the CFI and TLI values are below the recommended cutoffs. We again chose to accept marginal fit and interpret our estimates with caution, rather than attempting post hoc modification of this established measure.

**Hypothesis Testing**

In Study 2, we tested the same hypotheses that were tested in Study 1, with the objective measures included. Hypotheses 1-3 were again tested in the context of a single structural equation model (see Figure 3.2) including all covariates as predictors of mindfulness, smartphone use, and smartphone involvement. As in Study 1, this model is structurally saturated using the measurement model established in the CFA, and acceptable fit for that model also indicates acceptable fit for this model. Our results
demonstrated support for two of the three bivariate hypotheses. Regarding Hypothesis 1, there was a significant positive correlation between the latent variables smartphone use and smartphone involvement, $r = .61, p < .001$. Hypothesis 2, which stated that smartphone use would be a significant negative predictor of mindfulness, was not supported ($b = 0.03, [BC] 95\% CI [-0.51, 1.13], z = 0.12, p = .90$). There was support for Hypothesis 3, which posited smartphone involvement as a significant predictor of reduced mindfulness ($b = -0.83, [BC] 95\% CI [-1.97, -0.51], z = 4.30, p < .001$). To test the moderation hypothesis (Hypothesis 4), we again used the Mplus function XWITH to create a latent product term from the latent smartphone use variable and the latent smartphone involvement variable in the model shown in Figure 3.3. The coefficient for mindfulness regressed on this latent product term in the structural equation model was not significant ($b = -0.42, 95\% CI [-1.08, 0.37], z = 1.04, p = .30$), indicating no support for Hypothesis 4.

**Exploratory Analysis.** As with Study 1, we also explored the potential mediation of the effect of smartphone use on mindfulness by smartphone involvement. Examination of fit indices indicated marginal model fit: $\chi^2 (548) = 1115.54, p < .001$, CFI = .91, TLI = .91, RMSEA = .039, 90\% CI [0.036, 0.043], SRMR = .080. We found a significant product of coefficients ($a*b = -0.25, [BC] 95\% CI [-0.70, -0.05]$, as shown in Figure 3.4), indicating support for the possible indirect effect.
Table 3.1. Descriptive Statistics for Study 2 Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone Use (mean hrs/day)</td>
<td>0.75</td>
<td>7.35</td>
<td>3.83</td>
<td>1.31</td>
<td>3.73</td>
</tr>
<tr>
<td>TMT B-A (sec)</td>
<td>6.9</td>
<td>42.1</td>
<td>23.3</td>
<td>9.3</td>
<td>21.7</td>
</tr>
<tr>
<td>SART omissions (no. of missed targets)</td>
<td>0</td>
<td>7</td>
<td>1.02</td>
<td>1.38</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. N = 55. Smartphone use measured by Moment smartphone application. TMT B-A = Difference in secs between TMTA and TMTB completion.
Table 3.2. Study 2 Bivariate Correlations

<table>
<thead>
<tr>
<th></th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SU</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YOWN</td>
<td>.19*</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>.62*</td>
<td>.24*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Mindfulness</td>
<td>.39*</td>
<td>.11</td>
<td>.64*</td>
<td>1.00</td>
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Note. \( N = 55 \) SUSELF = Self-reported smartphone use; YOWN = Self-reported years of smartphone ownership; SI = Smartphone involvement. \(^*p < .05.\)
Figure 3.1. Standardized Factor Loadings for Study 2 Confirmatory Factor Analysis. SI1-SI16 from adapted smartphone involvement scale. M1-M15 from Mindfulness Attention Awareness Scale (MAAS). SART = Sustained Attention Response Task (omission errors). All factor loadings significant, $p < .05$. 
Figure 3.2. Structural Model for Study 2 Hypotheses 1, 2 & 3. Unstandardized factor loadings (standard errors) and correlation shown. Disturbances not shown.
Figure 3.3. Structural Model for Study 2 Hypothesis 4b (Moderation). Unstandardized factor loadings (standard errors) shown. Covariates and disturbances not shown.
Figure 3.4. Structural Model for Testing Study 2 Mediation. Indirect effect was significant (a*b) = -0.25, [BC] 95% CI [-0.90, -0.05]. Unstandardized factor loadings (standard errors) shown. Disturbances not shown.
CHAPTER 4
GENERAL DISCUSSION

The present study was designed to test our theoretical model, which hypothesizes relations among smartphone use, smartphone involvement and mindfulness, in a sample of undergraduates aged 18-20. Importantly, the findings were essentially the same for Study 1, using self-report data only, as for Study 2, which added objective data in a planned missingness design in order to improve the measurement of our latent constructs.

The main findings supported the hypothesis that the use of smartphones in a behaviorally and cognitively involved manner is significantly associated with lower levels of trait mindfulness. In addition, findings from exploratory analyses suggested that this behavioral and cognitive involvement could explain the relation between smartphone use and mindfulness. This gives support to the idea that the manner in which young adults use their smartphones is more important than how much they use them, in relation to trait mindfulness. Because a higher capacity for mindfulness is linked with so many positive outcomes, these results are an important and novel link between it and the use of these ubiquitous devices among young adults. While a great deal of research has been devoted to increasing mindfulness and its correlates, increasing our understanding of the impact of smartphones on mindfulness may help identify relevant areas for interventions to reduce any deleterious effects of smartphone use, particularly among adolescents.

While our understanding of the impact of smartphones on developing capacities for attention and awareness is limited, there exists a small but growing foundation of
studies examining smartphone use and mindfulness. The current results are consistent with past studies that demonstrated, among younger adults, that signs of high smartphone involvement (e.g. texting while driving, anxiety when separated from phone) are associated with lower levels of present moment awareness (Bayer et al., 2015), lower capacity for sustained attention (Billieux et al., 2007), lower trait mindfulness (Feldman et al., 2011), decreased abilities for attention switching and distraction inhibition (Hartanto & Yang, 2016) and more distractibility while driving (Terry & Terry, 2015). Our results were also consistent with Walsh et al. (2010), who found smartphone use and smartphone involvement to be moderately correlated but quantitatively distinct constructs.

Although the present study builds on previous literature on phone use and involvement, the rapid advancement of technology means that we studied a qualitatively different device than many previous studies. Much of the past research on the effects of phone use quantified use as frequency of texting and calling, which recent research has shown to constitute less than half of the bulk of smartphone use (GfK MRI, 2016). Therefore, many of these previous studies may significantly underestimate the potential impact of smartphone use.

Another significant aspect of the current study is that we build on and improve on the aforementioned self-report-only studies by using the Moment smartphone app to objectively measure smartphone use and the SART to objectively measure mindfulness. That we found only a moderate correlation between estimated daily use and daily use measured objectively highlights the importance of including such measures in smartphone research. Notably, participants in both studies tended to overestimate their
daily smartphone use as compared with objectively measured use. The small correlation between the SART and the MAAS in our sample highlights the importance of continued refinement of our understanding of the construct of mindfulness and how to best measure it.

The present study extended prior work by being the first to demonstrate that cognitive and behavioral involvement is significantly associated with trait mindfulness, and by providing evidence of a possible mechanism of action for the effect of smartphone use on mindfulness. Our hybrid smartphone involvement measure includes items related to automatic reactivity (e.g. “I interrupt whatever else I am doing when I receive an alert on my smartphone.”) and experiential avoidance (e.g. “I use my smartphone in social situations where I feel awkward or uncomfortable”). These processes are essentially the opposite of mindful action and awareness and can be compared to parallel but inverse processes that occur in mindfulness training where participants learn to act mindfully, with intent, rather than to react reflexively, and to allow themselves to experience uncomfortable thoughts, feelings, and experiences when appropriate. Therefore, it follows logically that in the same way purposefully practicing engaging in state mindfulness increases trait mindfulness, consistent practice with avoiding state mindfulness would reduce this capacity. The results of our post hoc exploratory analyses provide the first empirical evidence that this may be the process by which smartphone use impacts mindfulness.

This study also extends the literature by integrating a measure of how long participants have been smartphone users. In both studies, duration of smartphone ownership was not significantly associated with mindfulness, but was significantly
associated with both smartphone use and smartphone involvement. This indicates that participants who have used a smartphone longer tend to use them more each day and also tend to use them in a more cognitively and behaviorally involved manner. The relation between duration of use and other study variables was not a focus of this study, but these findings are consistent with our argument that smartphone design elicits more use and more involved use, as levels of both smartphone use and involvement increased with increased duration of ownership.

There are several limitations with the current study that should be noted. First, the use of a cross-sectional design limits our ability to make inferences about temporal relationships among variables. This is especially notable, as our model makes specific assertions regarding temporal relationships, namely that smartphone involvement can negatively impact mindfulness. While we have evidence supporting their significant association, prospective, longitudinal studies will be helpful to find evidence of the direction of their relation, as experimental studies would not be possible with smartphone involvement. It is likely that such studies may find reciprocal effects between mindfulness and smartphone involvement. While our model focuses on the potential impact of smartphone involvement on mindfulness, it seems apparent that one’s capacity for mindfulness could be an indication of potential vulnerability to highly involved use. It will be important, therefore, to ascertain whether purposeful increases in mindfulness could decrease smartphone involvement and/or protect against its potential negative impacts.

Second, all of these results come from structural models that showed less-than-ideal fit. As mentioned, we chose to move forward and interpret results with marginal fit
rather than make post hoc adjustments to the MAAS, an existing measure whose low
inter-item correlation is a potential culprit for lowered fit indices in both studies. While
our use of a planned missingness design yielded the same results for our hypotheses as
analyses conducted using only self-report data, there were issues with the objective
measures of mindfulness. The low correlation of the TMT B-A with the MAAS and
resulting low factor loading on mindfulness resulted in its exclusion from analyses. The
mixed results regarding objective measures and self-report measures of mindfulness is
not uncommon in the literature (e.g. Anderson et al., 2007) and points to a continuing
need for refinement of our understanding and measurement of mindfulness.

Third, the undergraduate sample (ages 18-20) used in the present study is both a
strength and a limitation. This sample is drawn from among the first generational cohorts
to have availability of smartphones since early adolescence and is still in the age range
that shows ongoing development of the brain regions implicated in attentional control
(Huttenlocker & Dabholkar, 1997) and thus, is more vulnerable to the salient, instant, and
always available rewards of smartphone use (LaRose, Lin, & Eastin, 2003). However,
this use of an undergraduate convenience sample may limit generalizability of the results
while also missing those who are likely most vulnerable to this potential effect – young
adolescents. Nonetheless, these results are useful as they provide evidence of the relation
between smartphone use and mindfulness in an at-risk age group. They are also useful
because they provide insight about a developmentally unique cohort – young adults who
may be living away from home for the first time and who are expected to take on
increased levels of personal responsibility. For example, there are more likely to be
external restrictions on smartphone use during class in high school than in college, when there is more expectation of self-regulation.

Despite these caveats, these results offer preliminary support for our theoretical model. While we conceived of the level of involvement as increasing or decreasing the effect of smartphone use on mindfulness, we instead found evidence for the plausible alternative of involvement as a mediator of this relation. There are some fundamental tenets of this model that have not been previously studied, to our knowledge, and were not directly addressed herein. The first is that trait mindfulness is not only malleable but that it can be decreased. While there is ample support for the increase of trait mindfulness, measured both subjectively (e.g. Levy et al., 2013) and objectively (e.g. Chambers, Lo, & Allen, 2008), we found no extant studies demonstrating decreases in the capacity for mindfulness. The second is that adolescents may be especially vulnerable to this potential detrimental effect of smartphone use on mindfulness, although the evidence does suggest that this capacity continues to develop across adolescence and they have been shown to be less capable of self-regulating behavior in general (LaRose, Lin, & Eastin, 2003).

Future studies, in order to address these gaps, will need to be prospective and best begun at an age before participants have acquired smartphones. Studies that simply follow adolescents and track the development of mindfulness into early adulthood would be a welcome addition to the mindfulness literature. In order to test the suppositions of this theory, this development would need to be measured both objectively and subjectively along with objective measures of smartphone use and smartphone involvement. For comparison, it would be best to include among the cohort adolescents
who do not use smartphones or at least do not acquire them until late adolescence. Only by following all three over time can the temporal and developmental relations of these constructs be elucidated.

The significant relations found between duration of smartphone ownership, use, and involvement also highlight the need for study of the evolution of smartphone use over time and its potential effects. Given the immediate, ubiquitous availability of rewards via smartphone use, it is possible that habituation over time leads to increased levels of use and especially increased automatic use. This could also be true for the rewarding experience of avoiding aversive thoughts, feelings, or situations through smartphone use. If highly involved smartphone use is indeed akin to the opposite of mindfulness training, the impact of such could also increase over time.

The present results indicate a need for further research of the study variables, their relation to well-being, and subsequent implications for prevention and clinical recommendations. We discussed herein some of the extensive evidence for the link between higher levels of mindfulness and greater well-being. Future studies of the potential impact of smartphone use on mindfulness should examine how the study variables relate to well-being. Mindfulness as a protective factor against smartphone involvement, and against potential impacts of such on well-being, should be explored. In conclusion, the present study provides initial evidence that individual differences in cognitively and behaviorally involved smartphone use are associated with lower level of trait mindfulness among young adults. The study also suggests that this cognitive and behavioral involvement may be the mechanism by which smartphone use impacts mindfulness. These novel findings suggest that the constructs of smartphone use,
smartphone involvement, and mindfulness deserve further attention from researchers interested in understanding the development of mindfulness and how modern technology impacts that development.
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APPENDIX A

CONSENT FOR PHASE ONE

PURPOSE AND BACKGROUND:
You are being asked to volunteer for a research study conducted by Darren Woodlief. I am a doctoral candidate in the Psychology Department at the University of South Carolina. This research is sponsored by the University of South Carolina. The purpose of this study is to study how smartphone use relates to mindfulness. You are being asked to participate in this study because you are a smartphone user aged 18 to 20. This phase of the study is being conducted online and will involve approximately 300 volunteers. This form explains what you will be asked to do if you decide to participate in this study. Please read it carefully and feel free to contact Mr. Woodlief at woodlied@email.sc.edu or his faculty mentor Nicole Zarrett at zarrettn@mailbox.sc.edu to ask questions before you make a decision about participating.

PROCEDURES:
If you agree to be in this study, you will be asked to complete questionnaires about demographic information, mindfulness, smartphone use, and general well-being. Some participants may be contacted and asked to participate in a second phase of the study. You can decline to do so without penalty.

DURATION:
Participation in the study will take about 20-25 minutes.

RISKS/DISCOMFORTS:
Loss of Confidentiality: There is the risk of a breach of confidentiality, despite the steps that will be taken to protect your identity.

BENEFITS:
Taking part in this study is not likely to benefit you personally. However, this research may help us understand the relation between smartphone use and mindfulness.

COSTS:
There will be no costs to you for participating in this study.

PAYMENT TO PARTICIPANTS:
Participants in Phase 1 will not be paid for participating in this study, but you will be entered into a random drawing for an 16 GB Apple iPad Air. The winner will be chosen once data collection is complete.
**USC STUDENT PARTICIPATION:**
Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. You participation, non-participation and/or withdrawal will not affect your grades or your relationship with your professors, college(s), or the University of South Carolina. If extra credit or research credit is required for a course, other alternative means for obtaining research credits or extra credit are available and you may discuss these options with your instructor.

**CONFIDENTIALITY OF RECORDS:**
Any information that is obtained in connection with this study will remain confidential and will be disclosed only with your express written permission, unless required by law. The information will be securely stored in locked files and on password protected computers. The results of the study may be published or presented at seminars, but the report will not include your name or other identifying information about you.

**VOLUNTARY PARTICIPATION:**
Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the researcher or his faculty mentor.

If I have any questions about my participation in this study, I may contact Darren Woodlief at 803-404-9785 or email: woodlied@email.sc.edu or Nicole Zarrett at email: zarrettn@mailbox.sc.edu.

If I have any questions, problems, or concerns, desire further information or wish to offer input, I may contact Lisa Marie Johnson, IRB Manager, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-7095 or email: LisaJ@mailbox.sc.edu. This includes any questions about my rights as a research subject in this study.

I agree to participate in this study. I will print a copy of this form for my own records if I so choose. If you wish to participate, please indicate below that you have read and understood the above information.

_ I have read and I understand the above information. I wish to participate in this study.

_ I decline to participate in this study.
APPENDIX B

INCLUSION CRITERIA

1. Do you speak English fluently?
   a. Yes
   b. No

2. Do you have normal vision or vision that is corrected to normal with glasses and/or contact lenses?
   a. Yes
   b. No

3. Do you currently own and use an iPhone (iOS) or Android smartphone?
   a. Yes
   b. No

4. What kind of smartphone do you currently use?
   a. iPhone 5 or later (5, 5S, 5C, 6, 6 Plus, 6s, or 6s Plus)
   b. iPhone 4 or earlier
   c. Android
   d. Other (Please specify)

5. Have you owned and used a smartphone for at least 3 months?
   a. Yes
   b. No

6. How old are you?
   a. 17 or younger
   b. 18
   c. 19
   d. 20
   e. 21 or older
APPENDIX C

DEMOGRAPHICS AND OPT-IN FOR PHASES 2 AND 3

1. What is your gender?
   a. Male
   b. Female
   c. Other (please specify)
   d. Choose Not to Answer

2. Please specify your ethnicity.
   a. Hispanic or Latino
   b. Not Hispanic or Latino
   c. Choose Not to Answer

3. Please specify your race, choosing all that apply.
   a. American Indian or Alaska Native
   b. Asian
   c. Black or African American
   d. Native Hawaiian or Other Pacific Islander
   e. White
   f. Other (please specify)
   g. Choose Not to Answer

4. Please enter your email address if we can contact you with an invitation to take part in the next phase. Some participants will be asked to voluntarily take part in future phases, for which compensation may be offered.
APPENDIX D

MINDFUL ATTENTION AWARENESS SCALE

Items are rated:

1 – Almost Always 2 – Very Frequently 3 – Somewhat Frequently 4 – Somewhat Infrequently 5 – Very Infrequently 6 – Almost Never

1. I could be experiencing some emotion and not be conscious of it until some time later.
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.
3. I find it difficult to stay focused on what’s happening in the present.
4. I tend to walk quickly to get where I’m going without paying attention to what I experience along the way.
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.
6. I forget a person’s name almost as soon as I’ve been told it for the first time.
7. It seems I am “running on automatic” without much awareness of what I’m doing.
8. I rush through activities without being really attentive to them.
9. I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.
10. I do jobs or tasks automatically, without being aware of what I’m doing.
11. I find myself listening to someone with one ear, doing something else at the same time.
12. I drive places on “automatic pilot” and then wonder why I went there.
13. I find myself preoccupied with the future or the past.
15. I snack without being aware that I’m eating.
APPENDIX E

SMARTPHONE USE AND OWNERSHIP ITEMS

1. As accurately as possible, please estimate the total amount of time you spend using your smartphone each day. Please consider all uses except listening to music. For example, consider calling, texting, Facebook, Twitter, Instagram, Vine, e-mail, sending photos, gaming, surfing the Internet, watching videos, and all other uses driven by apps.

2. As accurately as possible, please estimate how old you were when you first owned and regularly used a smartphone.
APPENDIX F

ADAPTED MOBILE PHONE INVOLVEMENT QUESTIONNAIRE

Items are rated:

1 – Hardly Ever 2 – Occasionally 3 – Sometimes 4 – Frequently 5 Almost Always

1. I think about my smartphone when I am not using it.
2. I use my smartphone for no particular reason
3. Arguments have arisen with others because of my smartphone use.
4. I interrupt whatever else I am doing when I receive an alert on my smartphone.
5. I feel connected to others when I use my smartphone.
6. I lose track of how much I am using my smartphone.
7. The thought of being without my smartphone makes me feel distressed.
8. I have been unable to reduce my smartphone use.
APPENDIX G

SUPPLEMENTARY SMARTPHONE INVOLVEMENT QUESTIONNAIRE

Items are rated:

1 – Hardly Ever 2 – Occasionally 3 – Sometimes 4 – Frequently 5 Almost Always

1. I use my smartphone while driving for texting, email, reading, or social media.
2. I use my smartphone while waiting in line.
3. I use my smartphone while out at dinner with friends or family.
4. I need to know where my smartphone is.
5. I use my smartphone in class for purposes other than schoolwork.
6. I lose track of how much I am using my smartphone.
7. I use my smartphone when I feel awkward or uncomfortable.
8. I use my smartphone when I’m feeling bored.
APPENDIX H

PSYCHOLOGICAL GENERAL WELL-BEING INDEX

1. How have you been feeling in general during the past month?
   a. In excellent spirits
   b. In very good spirits
   c. In good spirits mostly
   d. I have been up and down in spirits a lot =
   e. In low spirits mostly
   f. In very low spirits

2. How often were you bothered by any illness, bodily disorder, aches or pains during the past month?
   a. Every day
   b. Almost every day
   c. About half of the time
   d. Now and then, but less than half the time =
   e. Rarely
   f. None of the time

3. Have you been in firm control of your behavior, thoughts, emotions or feelings during the past month?
   a. Yes, definitely so
   b. Yes, for the most part
   c. Generally so
   d. Not too well
   e. No, and I am somewhat disturbed
   f. No, and I am very disturbed

4. Have you been bothered by nervousness or your "nerves" during the past month?
   a. Extremely so - to the point where I could not work or take care of things
   b. Very much so
   c. Quite a bit
   d. Some - enough to bother me
   e. A little
   f. Not at all
5. How much energy, pep, or vitality did you have or feel during the past month?
   a. Very full of energy - lots of pep
   b. Fairly energetic most of the time
   c. My energy level varied quite a bit
   d. Generally low in energy or pep
   e. Very low in energy or pep most of the time
   f. No energy or pep at all - I felt drained, sapped

6. I felt downhearted and blue during the past month.
   a. None of the time
   b. A little of the time
   c. Some of the time
   d. A good bit of the time
   e. Most of the time
   f. All of the time

7. Were you generally tense or did you feel any tension during the past month?
   a. Yes - extremely tense, most or all of the time
   b. Yes - very tense most of the time
   c. Not generally tense, but did feel fairly tense several times
   d. I felt a little tense a few times
   e. My general tension level was quite low
   f. I never felt tense or any tension at all

8. How happy, satisfied, or pleased have you been with your personal life during the past month?
   a. Extremely happy - could not have been more satisfied or pleased
   b. Very happy most of the time
   c. Generally satisfied - pleased
   d. Sometimes fairly happy, sometimes fairly unhappy
   e. Generally dissatisfied or unhappy
   f. Very dissatisfied or unhappy most or all the time

9. Did you feel healthy enough to carry out the things you like to do or had to do during the past month?
   a. Yes - definitely so
   b. For the most part
   c. Health problems limited me in some important ways
   d. I was only healthy enough to take care of myself
   e. I needed some help in taking care of myself
   f. I needed someone to help me with most or all of the things I had to do
10. Have you felt so sad, discouraged, hopeless, or had so many problems that you wondered if anything was worthwhile during the past month?
   a. Extremely so - to the point that I have just about given up
   b. Very much so
   c. Quite a bit
   d. Some - enough to bother me
   e. A little bit
   f. Not at all

11. I woke up feeling fresh and rested during the past month.
   a. None of the time
   b. A little of the time
   c. Some of the time
   d. A good bit of the time
   e. Most of the time
   f. All of the time

12. Have you been concerned, worried, or had any fears about your health during the past month?
   a. Extremely so
   b. Very much so
   c. Quite a bit
   d. Some, but not a lot
   e. Practically never
   f. Not at all

13. Have you had any reason to wonder if you were losing your mind, or losing control over the way you act, talk, think, feel or of your memory during the past month?
   a. Not at all
   b. Only a little
   c. Some - but not enough to be concerned or worried about
   d. Some and I have been a little concerned
   e. Some and I am quite concerned
   f. Yes, very much so and I am very concerned

14. My daily life was full of things that were interesting to me during the past month.
   a. None of the time
   b. A little of the time
   c. Some of the time
   d. A good bit of the time
   e. Most of the time
   f. All of the time
15. **Did you feel active, vigorous, or dull, sluggish during the past month?**
   a. Very active, vigorous every day  
   b. Mostly active, vigorous - never really dull, sluggish  
   c. Fairly active, vigorous - seldom dull, sluggish  
   d. Fairly dull, sluggish - seldom active, vigorous  
   e. Mostly dull, sluggish - never really active, vigorous  
   f. Very dull, sluggish every day

16. **Have you been anxious, worried, or upset during the past month?**
   a. Extremely so – to the point of being sick or almost sick  
   b. Very much so  
   c. Quite a bit  
   d. Some – enough to bother me  
   e. A little bit  
   f. Not at all

17. **I was emotionally stable and sure of myself during the past month.**
   a. None of the time  
   b. A little of the time  
   c. Some of the time  
   d. A good bit of the time  
   e. Most of the time  
   f. All of the time

18. **Did you feel relaxed, at ease or high strung, tight, or keyed-up during the past month?**
   a. Felt relaxed and at ease the whole month  
   b. Felt relaxed and at ease most of the time  
   c. Generally felt relaxed but at times felt fairly high strung  
   d. Generally felt high strung but at times felt fairly relaxed  
   e. Felt high strung, tight, or keyed-up most of the time  
   f. Felt high strung, tight, or keyed-up the whole month

19. **I felt cheerful, lighthearted during the past month.**
   a. None of the time  
   b. A little of the time  
   c. Some of the time  
   d. A good bit of the time  
   e. Most of the time  
   f. All of the time
20. I felt tired, worn out, used up, or exhausted during the past month.
   a. None of the time
   b. A little of the time
   c. Some of the time
   d. A good bit of the time
   e. Most of the time
   f. All of the time

21. Have you been under or felt you were under any strain, stress, or pressure during the past month?
   a. Yes - almost more than I could bear or stand
   b. Yes - quite a bit of pressure
   c. Yes, some - more than usual
   d. Yes, some - but about usual
   e. Yes - a little
   f. Not at all
APPENDIX I

VALIDITY CHECK AND DRAWING ENTRY

1. Were your responses on the previous page highly influenced by a recent health issue or life event?
   a. Yes
   b. No
   c. Prefer not to answer

2. On an average day, how many hours do you spend using your smartphone (other than listening to music)? For example, consider calling, texting, Facebook, Twitter, Instagram, Vine, e-mail, sending photos, gaming, surfing the Internet, watching videos, and all other uses driven by apps.
   a. An hour or less
   b. 1-3 hours
   c. 3-5 hours
   d. 5-7 hours
   e. More than 7 hours

3. If you did not enter your email previously and would like to be entered into the drawing to win a 16 GB Apple iPad Air, please copy and paste this link into a new browser window and enter your email address BEFORE answering "Okay" below. If you don't wish to do so, simply choose "No thanks" below:
   https://docs.google.com/spreadsheets/d/1Ywh-ooCQuixvG8hReQy1ST2JXOLddjfxm1sDot_Gek/edit?usp=sharing
   a. Okay
   b. No thanks
APPENDIX J

CONSENT FOR PHASES 2 AND 3

PURPOSE AND BACKGROUND:
You are being asked to volunteer for a research study conducted by Darren Woodlief. I am a doctoral candidate in the Psychology Department at the University of South Carolina. This research is sponsored by the University of South Carolina. The purpose of this study is to study how smartphone use relates to mindfulness. You are being asked to participate in this study because you are a smartphone user aged 18 to 20. Phase 2 of the study is being conducted in our lab. This phase will involve approximately 75 volunteers. This form explains what you will be asked to do if you decide to participate in this phase of the study. Please read it carefully and feel free to contact Mr. Woodlief at woodlied@email.sc.edu or his faculty mentor Nicole Zarrett at zarrettn@mailbox.sc.edu to ask questions before you make a decision about participating.

PROCEDURES:
If you agree to be in this study, the following will happen:

1. In Phase 2, you will be asked to complete two attention tasks here in the lab.
2. In Phase 3, we will ask you to download a free app to your phone (for iOS, Moment and for Android, Phone Usage Time) that will run in the background for the next 30 days, recording how long you use your phone each day. This information will only be visible to you, on your phone, and will not be shared by the app with any third party, including the researchers.
3. The iOS app Moment requires the user to give permission to run in the background and track how long the screen is unlocked and in use each day, with this information only visible to them, not shared by the app with any third party, or accessible by any other installed app. In order to more accurately track usage, Moment will need to be enabled to access the smartphone’s location information. This information cannot be accessed by other installed apps or any third party. Location and GPS data is only stored on the device and never shared with anyone, including the app developers.
4. The Android app Phone Usage Time requires permission to run in the background and access Device and app history. This information will also be only visible to the participant and shared with no other apps or third parties.
DURATION:
Participation in Phase 2 will take 1 visit to the lab, lasting about 20 minutes total. Participation in Phase 3 will require you download and setup the appropriate app on your phone while in the lab and to send emails to the researcher over the next 30 days to report only the amount of your daily smartphone usage. You will receive an email each time reminding you to do so.

RISKS/DISCOMFORTS:
Loss of Confidentiality: There is the risk of a breach of confidentiality, despite the steps that will be taken to protect your identity.

BENEFITS:
Taking part in this study is not likely to benefit you personally. However, this research may help us understand the relation between smartphone use and mindfulness.

COSTS:
There will be no costs to you for participating in this study.

PAYMENT TO PARTICIPANTS:
If you participate in Phase 2, you will receive an additional (to the one received for Phase 1) entry into a random drawing for a 16 GB Apple iPad Air. Participation in both Phases 1 and 2 will give you a 1 in 375 chance of winning, approximately. The winner will be chosen once data collection is complete.

If you participate in Phase 3, you will receive a $10 Amazon gift card as compensation for participating in this study and will receive another (in addition to the two received for Phases 1 & 2) entry into a random drawing for a 16 GB Apple iPad Air. Participation in Phases 1, 2 and 3 will give you a 1 in 250 chance of winning, approximately. The winner will be chosen once data collection is complete.

USC STUDENT PARTICIPATION:
Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. You participation, non-participation and/or withdrawal will not affect your grades or your relationship with your professors, college(s), or the University of South Carolina. If extra credit or research credit is required for a course, other alternative means for obtaining research credits or extra credit are available and you may discuss these options with your instructor.

CONFIDENTIALITY OF RECORDS:
Any information that is obtained in connection with this study will remain confidential and will be disclosed only with your express written permission, unless required by law. The information will be securely stored in locked files and on password protected computers. The results of the study may be published or presented at seminars, but the report will not include your name or other identifying information about you. The downloaded smartphone app will not share any information with the researcher or other third party.
VOLUNTARY PARTICIPATION:
Participation in this study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the Principal Investigator.

___ I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, I may contact Darren Woodlief at 803-404-9785 or email: woodlied@email.sc.edu or Nicole Zarrett at email: zarrett@mailbox.sc.edu. If I have any questions, problems, or concerns, desire further information or wish to offer input, I may contact Lisa Marie Johnson, IRB Manager, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-7095 or email: LisaJ@mailbox.sc.edu. This includes any questions about my rights as a research subject in this study.

___ I agree to participate in this study. I have been given a copy of this form for my own records.

If you wish to participate in Phase 2, you should sign below.

__________________________  ______________  __________________________  __________
Signature of Person Obtaining Consent    Date     Signature of Participant      Date

I agree to participate in this study. I have been given a copy of this form for my own records.

If you wish to participate in Phase 3, you should sign below.

__________________________  ______________  __________________________  __________
Signature of Person Obtaining Consent    Date     Signature of Participant      Date