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Cue-Reactivity and Smartphone Dependency

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Cue-Reactivity and Smartphone Dependency

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Abstract

Objective: Although Cue-Reactivity was originally developed and used with substance addictions, there has been development and validation of cue-reactivity paradigms with behavioral addictions. Concurrently, there has been a rise of literature and research into Smartphone dependency, a type of behavioral addiction. However, there has not been a study looking into cue-reactivity in conjunction with smartphone dependency. Therefore, the current study was developed to create and test a cue-reactivity paradigm for smartphone addiction to better understand the learning principles behind it. Since most individuals do not realize the severity of their dependence on the device, it is important to have definitive conclusions.

Method: The data from 54 participants was utilized in this study, with 40 participants being included in the physiological analyses. Participants were exposed to both addiction-related and neutral cues and their self-reported craving/urge ratings and EDA reactivity was recorded in response to cue presentation. Then, they were asked to complete a variety of individual difference measures such as the State Trait Anxiety Inventory and the Fear of Missing Out Scale. Other smartphone specific demographics were collected to analyze specific phone usage metrics in correlation to reactivity.

Results: Results indicated that participants had higher self-report craving/urge and physiological arousal to the addiction related cue than the neutral cue overall. Results also showed that the more addicted participants were to their smartphone, as evidenced by scores on the Smartphone Addiction Scale, the more they craved their smartphone. Lastly, results showed that Nomophobia, the fear of being without one’s phone, was predictive of heightened craving/urge to use one’s smartphone.

Conclusions: To the authors' knowledge, this study was the first to test a cue-reactivity paradigm with smartphone dependency. The results showed individuals react to addiction-related cues associated with smartphones in the same way that individuals respond in other cue-reactivity paradigms with other addictions. Therefore, one can infer that classical conditioning is a process that contributes to smartphone dependency.

Cue-Reactivity and Smartphone Dependency

It has previously been established that most behavioral addictions share several similarities with drug addictions (e.g., Griffiths & Smeaton, 2002; Reuter, 2005; Roberts & Priog, 2012). For the proposed study, the shared characteristic of focus will be craving, specifically, how addiction-related cues become associated with the addiction and in turn increase addiction seeking behavior. This phenomenon has been studied widely using *cue-reactivity.* While cue-reactivity has been studied with different behavioral addictions (e.g., Ko et al., 2013; Sodano & Wulfret, 2010), to my knowledge, there has not been a study utilizing a cue-reactivity paradigm on smartphone use. Therefore, this paper will examine the existing literature on cue-reactivity and smartphone addiction, and discuss the findings from adapting a cue-reactivity paradigm to study smartphone dependency.

Behavioral Addictions

In the most current version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013), gambling is classified as a behavioral addiction. Although gambling is accepted as a behavioral addiction, it is still up for debate whether or not one can be addicted to other behaviors, such as gaming, overeating, compulsive buying, sex, and most recently the use of smartphones. Drug addiction is defined as a chronic disorder where an individual has difficulty limiting or omitting drug intake, exhibits high motivating to use the drug, continues to use it despite negative consequences, and experiences negative emotional and physiological states when the drug is withheld (Taylor, et al., 2013).

The traditional concept of addiction was founded on a medical model which stated that the ingestion of a substance alters brain pathways, such as the mesolimbic reward pathway (Karim & Chaudhri, 2012). Research has shown that ingesting a psychoactive substance can cause neural changes by pharmacologically taking over the neural reward circuit. However, there is growing evidence that certain behaviors can also alter the neural reward circuit leading to addiction (Potenza, 2008). Grant and colleagues (2010) described this alteration in the mesolimbic reward pathway: Dopamine is released from the ventral striatum during pleasurable situations (eating one's favorite food). Once the dopamine is released it travels to the nucleus accumbens, which is known as the pleasure center of the brain. Dopamine enters the synapse between neurons and the receiving cell takes up all that is needed. When there is dopamine left over, the excess is taken back up by the sending cell. Then surrounding nerve cells release gamma-amino butyric acid (GABA) to inhibit the receiving cell from being over-stimulated. When addictive substances or behaviors are introduced, the amount of dopamine in the synapses increases. Consequently, the increase of dopamine initiates sensations of pleasure and signals the brain to release additional dopamine. When the substance is used or behavior performed repeatedly, the normal balance of dopamine is overthrown. Due to this excess release of dopamine, the brain reduces or stops the natural production of dopamine. This means that in order to feel pleasure, an addicted individual must participate in the addictive behavior (Grant et al., 2010).

This process has been demonstrated with alcohol-dependent individuals when processing monetary rewards (Wrase et al., 2007). When individuals with alcohol addictions were provided with monetary rewards, their ventral striatum was significantly less activated compared to when alcohol-associated rewards were presented. This effect has also been shown in individuals with pathological gambling disorder. When engaging in simulated gambling, fMRI recordings of individuals with gambling addiction showed less activation in the mesolimbic reward system compared to controls (Reuter, 2005). These studies show that in response to constantly using a drug or partaking in a behavior, neuroadaptations in the mesolimbic reward system occur. These findings help explain why individuals addicted to a substance or behavior find it difficult to focus on other types of rewards and continue to engage in the addictive behavior.

The similarities between behavioral and substance addictions have also been found in many other key areas of addiction, such as the recurrent pattern to engage in a behavior despite the harmful consequences which could interfere with other areas of life (Roberts & Priog, 2012). Similar to substance addictions, financial and martial problems are present when assessing behavioral addictions. A study looking at illegal behavior related to gambling addiction found that individuals with pathological gambling disorder would frequently commit illegal acts (e.g., theft, embezzlement) to their fund their addiction or cope with the consequences of their behavior. The individuals who self-reported engaging in illegal actions were also found to have more severe lifetime and recent gambling disorder symptoms and maintained the severity during treatment (Ledgerwood et al., 2007). These findings demonstrate that individuals addicted to gambling will maintain their addiction during treatment despite negative consequences.

Griffiths (1995 & 2000) concluded that behavioral addictions display what are considered to be the core components of addiction: salience, euphoria, tolerance, withdrawal symptoms, and craving. Many individuals with pathological gambling, kleptomania, and compulsive buying report that in order to achieve the same level of satisfaction and positive mood experienced after engaging in the behavior, the intensity needs to increase each time (Blanco et al., 2001; Grant et al., 2006; Grant & Potenza, 2008). While the above studies used self-report measures, Griffiths (1993) objectively demonstrated tolerance in regular gamblers (i.e., those who played at least once a week). Results showed that after engaging in gambling, regular gamblers' heart rates decreased suddenly, while non-regular gamblers heart rates did not change significantly.

Griffiths (1993) postulated that regular gamblers would need to participate more often or in faster increments to experience the same arousal as non-regular gamblers. Similarly and colleagues (2014) found that problem gamblers were hyposensitive to win outcomes, demonstrated by lower electrodermal activity (EDA). In both studies, researchers provided analogous rationale for the findings: repeated engagement in gambling built-up tolerance for the activity/wins making them less salient and meaningful.

Withdrawal is another core feature of addiction present in behavioral addictions. In contrast with substance withdrawal, withdrawal from behavioral addictions has been found to be primarily psychologically based (e.g., producing irritability and anxiety). Despite the difference in symptom presentation, self-report measures show these psychological withdrawal symptoms are present in both gambling and internet gaming disorder (Griffiths & Smeaton, 2002; Kaptsis et al., 2016).

Along with the overlap in clinical aspects and neurocircuitry of addiction, both behavioral and substance addiction have a common way of forming - learning and memory (Hyman, 2005). Cravings for a drug or behavior are elicited by stimuli surrounding the activity, which over time are learned to be associated with it. These stimuli can include mood states, locations, smells, people, situations, or any other stimuli that becomes associated with the addictive behavior (Drummond, 2000). These associated stimuli can act as cues that provoke an individual to engage in the addictive behavior. These conditioned responses are tested using cue-reactivity and has been shown in both substance and behavioral addictions (e.g., Cooney et al., 1997; Sharpe et al., 1995). The similar findings from cue-reactivity paradigms illustrate the overlap of the learning mechanisms behind substance and behavioral addictions.

Cue–reactivity

In 1973, Wikler developed a theory that cues related to drugs produce withdrawal symptoms; this theory was the foundation of the first conditioning model of addiction known as the “conditioned withdrawal model”. However, many years later it was suggested that drug-related cues might elicit expectancies of the drug, which could in turn drive drug seeking behavior (Stewart, deWit, & Eikelboom 1984). These authors postulated that when individuals addicted to a substance or behavior are presented with addiction-related cues, they have heighted responses in three areas: subjective, physiological, and behavioral (Drummond, 2000). While these three components are distinct, they are often correlated with one another (Glautier & Drummond, 1994).

The cue-reactivity model is derived from a classical conditioning framework, which suggest that through repeated pairing, what was once a neutral stimulus becomes associated with the addictive behavior and elicits a craving for the addiction (Carter & Tiffany, 1999). Furthermore, it is proposed that these associated stimuli can in turn elicit internal responses that are similar to partaking in the addictive behavior. These heightened internal responses can be attributed to the positive reinforcing effects the addictive behavior produces. Together these physiological and craving responses serve as the motivational basis for drug-seeking behavior (Stewart et al., 1984).

As mentioned previously, there are two types of craving responses that have been shown to be affected when addiction-related cues are presented. The first response that can be measured is subjective craving. Subjective responding is usually measured with a questionnaire that examines an individual’s desire/urge to partake in the addiction. In many paradigms, these questionnaires are given to participants after being exposed to relevant cues. The second type of measure is physiological. These measures are typically recorded while the participant is exposed to the stimuli. Such measures can include heart rate, skin conductance, skin temperature, salivation, and neuroimaging of regional changes in brain activity. A review on cue-reactivity literature by Carter and Tiffany (1999) showed that both physiological response and self-reported craving increased when individuals are exposed to drug-related stimuli. These same findings were demonstrated in a meta-analysis on cue-reactivity in behavioral addictions (Starke et al., 2018). Measures of mood/affect are another type of dependent measure collected following exposure to cues (Carrigan & Lisman, 1998). The last measure is behavioral, which is the least studied. This measure consists of latency to some sort of addiction related behavior, such as lighting a cigarette (Drummond, 2000).

In the current literature, cue-reactivity paradigms vary. While all models involve some combination of exposure to addiction related and neutral cue(s) and observation/measurement of responses, there are various types of cues that can be presented. There are two main types of cues. The first type is exteroceptive, which is the most commonly studied (Drummond, 2000). This type of cue comes from the outside world, such as sight, smell, or taste. Exteroceptive cues are commonly visual, meaning that the cue is presented directly to the participant. The presented stimuli can include people, environments, and objects and can come through videos or in-person presentations. However, sometimes it is unethical or impractical to present salient cues to an individual with addiction in a lab setting, so guided imagery provides an alternative means of referencing these cues (Cooney et al., 1997). The second type of cue is interoceptive, or cues that originate within the individual, including cognitions and affective states. It is thought that since the majority of relapses occur when individuals are in a negative mood state (Cooney et al., 1997), the negative affect also becomes a cue to, for instance, drink alcohol.

Cue characteristics such as intensity and valance, as well as individual factors (e.g., degree of dependence) can affect the level of reactivity. Temporal characteristics of the cues can also have an effect. These are factors such as the time of day which the cues are presented in correlation to when they are naturally encountered outside of laboratory settings. Typically, higher reactivity is observed in connection with individuals who are more dependent, and with cues presented in vivo (Drummond, 2000).

Cue-reactivity studies also differ in their design. Some studies compare two groups of subjects who differ in their history and dependence on the drug (i.e., between subjects). In this design, participants receive either a neutral or addiction-related cue. The different reactivity levels demonstrate the differential conditioning effects due to individual experiences. In other words, it shows those who have a longer history with the addiction, have longer conditioning histories and therefore produce greater reactivity to addiction-related cues. Other paradigms present both neutral and addiction-related cues to each subject (i.e., within-subjects). Using a within-subject design allows researchers to show the addiction-related cue has become associated with the unconditioned addiction effects (e.g., euphoria). A within-subjects design also allows for a more direct comparison between both stimuli.

Findings from studies utilizing cue-reactivity paradigms have provided knowledge in many areas of addiction. Such studies have identified conditioned reactions to be useful in explaining the development and maintenance of addiction. Developing cue-reactivity models for various addictions has shown that the underlying learning process between substance and behavioral addictions are parallel. These models have also been helpful in explaining and predicting relapse, which is thought to occur when individuals come in contact with addiction-related cues (Niaura et al., 1988). Findings from this relapse research has aided in the development of new treatment methods for individuals with addiction (i.e., cue exposure; Drummond, 2000).

Cue-reactivity with behavioral and substance addictions

Although cue-reactivity was developed and used with substance addictions, there has been development of cue-reactivity paradigms with behavioral addictions. It is assumed that behavioral addictions begin from the effects of positive reinforcement, which then produce excitement and physiological arousal (Sodano & Wulfret, 2010). Over time the desire for these internal and affective states increases, which produces the urge to participate in the behavior again. Similar to drug addiction, aspects surrounding the addictive behavior become classically conditioned to elicit craving. This has been showed in gambling (e.g., Sharpe et al., 1995), compulsive buying (Trotzke et al., 2014), and internet/computer gaming (e.g., Ko et al., 2011; Thalemann et al., 2007).

Sharpe and colleagues (1995) looked at the difference in subjective craving and physiological arousal between problem gamblers compared to high-and low-frequency gamblers when exposed to gambling cues. Results demonstrated that problems gamblers experienced greater arousal across various gambling stimuli compared to social gamblers. Findings from this study also showed that the skin conductance level (SCL) measure was able to gather additional readings that the other physiological measures did not (i.e., heart rate). Across all gambling cues (i.e., personally relevant and general gambling scenarios), skin conductance levels (SCL) levels for problem gamblers were significantly higher compared to social gamblers.

In a more recent study, Sodano and Wulfret (2010) found similar results. The cues consisted of two gambling scenarios, one winning and one losing, and a control stimuli of a rollercoaster ride. Pathological gamblers reported significantly greater urges to gamble across all gambling and neutral cues compared to recreational gamblers. It was suggested that the feelings the rollercoaster brought forth were similar to the rush from gambling. Heart rate was also recorded but there was no significant difference found between the two groups. The two studies showed that individuals with gambling addiction exhibited heightened subjective and physiological reactivity to gambling related cues.

In a 2018 meta-analysis on cue-reactivity with behavioral addictions, the authors reported that eight out of the nine gaming studies included, utilized fMRI as their main measure of reactivity (Starke et al., 2018). Ko and colleagues (2013) found that brain regions which showed increased activation to gaming cues, were identical to regions represented in a model of substance addiction. Moreover, the participations with current internet gaming addiction (IGA) self-reported stronger urges to play games after being exposed to gaming related cues. These findings suggest that IGA might share similar mechanisms to substance addiction.

The same meta-analysis cited only one study using a cue-reactivity paradigm with pathological buying (Trotzke et al., 2014). Results from this study were congruent with the studies discussed above: Pathological buyers reported a greater urge to buy and had higher skin conductance responses to buying related cues compared to controls. Despite evidence from the studies above, there are still numerous gaps in the current literature on classical conditioning in behavioral addictions, with one area being cue-reactivity models for smartphone dependency.

With past research in mind, I decided to record subjective craving as one dependent measure. Since there were no urge scales created for smartphone dependency, I had to alter one that was used to assess gambling urge. Therefore, two different measures were used to measure subjective craving. I also decided to collect Electrodermal activity, as another dependent variable, since it was found to provide more information over other physiological measures (Sharpe et al., 1995).

Smartphone Dependency

Smartphones have become an integral part of today's society, so much so that for many individuals the mere thought of not having one induces anxiety (Roberts et al., 2014). While smartphones used to serve only the purpose of communication, today a smartphone is equipped to do much more. As the functions of smartphones have increased so has user dependency. The increased dependency has created a culture where constant connectedness is an expectation, making people feel as though they always need to have access to their smartphones (Cheever et al., 2014). Where it used to be an added luxury to own a personal phone, Forgays and colleagues (2014) compared a smartphone to an appendage that individuals cannot envision themselves without.

The constant use of a smartphone has become vastly normalized in today's society, leading most individuals to not realize the severity of their dependency on the device (Roberts et al., 2014). There are various benefits to owning and using a smartphone, such as easy access to information, relationship maintenance, safety, and entertainment. These benefits can be simultaneously emancipating and enslaving: this is what past researchers have called the 'paradox of technology' (Mick & Fournier, 1998).

There are many hypothesized reasons why individuals might become dependent on their smartphone. One belief is that smartphones provide a sense of comfort (Han et al., 2016). For example, being in an unfamiliar social situation one relies on their phone as comfort or when driving somewhere new having the comfort of the GPS to direct you. Another belief is based upon the extended self-theory which proposes that one's possessions become extensions of one's self, even more so when we can exert control over them (i.e., similar to an appendage; McClelland, 1951). Therefore, it is thought that as individuals become skilled in using their phone, they begin to incorporate their phone into their body schema making it harder to stop using it (Clark, 2008). "Fear of Missing Out" (FOMO) is also hypothesized to be a reason individuals become addicted to their smartphone (Przybylski et al., 2013). FOMO is the fear of not being included in other's experiences and the desire to constantly known what others are doing. This leads to individuals checking and using their phone more frequently in order to be "in the know". Nomophobia (i.e., the fear of being without your phone), is an additional reason an individual becomes addicted to their phone (Yildirim & Correia, 2015). Due to fear of being without it, those diagnosed, via the DSM-5 "specific phobias", with Nomophobia cannot fathom being separated therefore they become dependent to the device.

Many researchers have aimed to understand the rise of smartphone dependency, and specific traits and characteristics that are most associated with smartphone dependency. Emotional instability, for example, has demonstrated a direct and positive relationship with smartphone addiction (Roberts et al., 2015). Similar to those who use substances to repair their mood, individuals can use their smartphone as a distraction from their negative mood state. Shyness (Han et al., 2016) and social anxiety (Sapacz & Rockman 2015) are both predictors of smartphone dependency. It is thought that individuals who endorse these traits are more comfortable communicating over the phone than face-to-face making their dependency increase. The same rationale is applied to those with low self-esteem (Bianchi & Phillips, 2005; Hong et al., 2012). Extraversion has also been shown to predict higher smartphone use (Bianchi & Phillips, 2005). It is postulated that extraverted individuals want to connect with others and are constantly using their phone do to that.

Some gender differences have been observed regarding beliefs and behaviors related to smartphone use. Compared to women, men believe that smartphone calls are appropriate in practically all environments, even intimate ones. Men tend to use their phone for more practical and instrumental ways, such as reading the news. Women use it more to socialize and maintain relationships. Women have been found to report more overall smartphone use (Roberts et al., 2014) and have been shown to have higher levels of dependence (Gutierrez et al., 2016).

Addiction has several components that when put together make an extremely complex picture. However, most research investigating smartphone dependency has relied on self-report data; therefore, further studies are needed in order to draw definitive and valid conclusions. More longitudinal and experimental research is needed to gather information on behavioral and neurobiological correlates between smartphone dependency and other established addictions, which is one aim of the current study. While there have been some studies that researched the core components of addiction in relation to smartphone dependency, the findings are scarce. The current understanding of the existing research will be reviewed below.

Smartphone dependency withdrawal research has demonstrated individuals with heavy or moderate amounts of smartphone use have increased levels of anxiety when their smartphones are removed from their possessions (Cheever et al., 2014). Other research has shown that anxiety levels also increase when individuals have restricted use of their smartphones (i.e., unable to check their text messages; Rosen et al., 2013). Sapacz and colleagues (2105) found similar findings: participant’s anxiety increased when their phone was visible but they were unable to use it. Current research shows another similarity between smartphone addiction and the DSM criteria for gambling disorder: partakes in the activity when feeling distressed. Panova and Lleras

(2016) found that the smartphone can be comforting in times of stress, offering a “security blanket” which lowers the negative response to a stressor.

Tolerance to one’s smartphone has been defined as an increase in frequency and duration of phone use to increase satisfaction or the need to own current devices with newer models to increase satisfaction (Yen et al., 2009). However, some authors state that the motivations (i.e., problematic use vs. new relationships or promotion at work) for increasing the use of a smartphone needs to be analyzed in order to deem the increased use as pathological (Panova & Carbonell, 2018). Lin and colleagues (2016) suggested that it is not reasonable to have tolerance as a fundamental aspect for smartphone dependency due to the essential need to use them in the current lifestyle most people live. Another component of addiction is loss of control. It has been shown that questionnaires assessing emotion-based impulsivity and non-planning impulsivity are correlated with self-reported smartphone dependence measures (Billieux et al., 2007). However, this too has not been empirically studied enough to produce a concrete answer whether it occurs or not.

Research has shown that the overuse of one’s smartphone can have various negative effects on achievement, mental and physical health, and relationships. One heavily researched area is the effect on sleep quality, which shows that they are significantly negatively correlated (Sahin et al., 2013). Jenaro and colleagues (2007) found that high cell-phone use was associated with insomnia. Research has also shown significant relationships between the overuse of one’s smartphone and school failure or low GPA, depressive symptomology, anxiety and substance use (Lapieree et al., 2019; Lepp et al., 2014). Smartphone dependency has also been linked to negative physical effects such as muscle pain, auditory illusions, pain/weakness in thumbs and wrists, and ocular afflictions (e.g., blurry vision and irritation; Gutierrez et al., 2016).

Current Study

As the literature on smartphone dependency grows, a number of questions are still unanswered. Some researchers are convinced this addiction is unlike any other and is one of the greatest addictions of the current century (Shambre et al., 2012); however, there is still not enough uniform evidence to support their claims. There is a need for a useful conceptualization and definition of smartphone addiction. The aim of the current study is to provide more information about and evidence for this addiction.

No previous studies to my knowledge have tested a cue-reactivity paradigm for smartphone dependency. Developing such a paradigm will allow for further investigation into the parallels between the processes of smartphone dependency to other established addictions. With the smartphone addiction literature rising, similar to how the gambling research did a short time ago, it seems logical to explore if smartphone dependency fits existing models of addiction. Therefore, the current study will test if smartphone related cues elicit reactivity in individuals in the same manner as previously studied addictions.

In the interest of better understanding smartphone dependency, I conducted a study that exposed participants to both neutral and smartphone related cues, which allowed subjective craving and physiological reactivity to be measured. The within-subjects design allowed for a more direct comparison between the two cues. Several other variables that have been shown to be correlated with high smartphone use (e.g., depression), individual difference factors (e.g., gender) and specific phone usage characteristics (e.g., which apps are used most) were examined in order to assess which variables predict reactivity.

The following hypotheses were tested:

Hypothesis 1. Participants will elicit heighted reactivity to addiction related cues compared to neutral cues.

Hypothesis 1a. Participants will have an increased craving to use their smartphone after being exposed to addiction related cues compared to neutral cues.

Hypothesis 1b. Participants will have an increased skin conductance level when being exposed to addiction related cues compared to neutral cues.

Hypothesis 2. Degree of smartphone dependency (as evidence by scores on the Smart Phone Addiction Scale and time spent on a personal smartphone) will be predictive of reactivity in response to cues.

Hypothesis 3. Fear of Missing Out, Depression, Anxiety, Nomophobia, Alcohol consumption in the last 30 days, average daily smartphone notifications, total phone pickups in a week, gender, race, and age will be predictive of reactivity in response to cues.

Method

Participants

IRB approval was obtained before beginning data collection and the research was conducted following APA guidelines regarding the ethical treatment of research participants.

Participants were recruited through signup.com. Participants consisted of undergraduate students enrolled in Psychology 101. Those who participated in this study received .75 research credits, due to the study taking approximately 45 minutes to complete. The sample of participants was consistent with USC Aiken’s student population, which is majority women, majority Caucasian, and ranging in age from 18-24. Exclusion criteria included students who do not own an iPhone.

iPhones have software embedded in them that collects screen time data, whereas Androids do not. Preliminarily investigations revealed that 90% of students enrolled in Psychology 101 during the semester prior to data collection, owned an iPhone. Since it is not possible to measure their skin conductance without a measurable level, all non-responders have to be excluded (Basden et al., 2016; Kredlow et al., 2018) from the EDA data. Participants who did not exhibit any phasic changes to the first stimuli with a response less than 0.1 µS were considered non-responders and were excluded from the EDA analyses but included in all other analyses.

After data collection, 14 participants were excluded from EDA analysis: eleven were non-responders, three had equipment/user error. The survey data collected on these participants were included in the analysis of those measures. Based on a G-Power analysis the number of participants needed for this study was 34. Data from a total of 54 participants were collected, 40 of which were included in the EDA analysis. There were no significant differences among race and gender between non-responders and responders.

The sample was predominately female ($N = 43$) and predominately White ($N = 35$). The participants ranged in age from 18-41. While the 41 year old was an outlier in age, their scores on the scales and EDA readings were within 2 standard deviations of the mean and the individual was therefore kept in the sample. The sample consisted of mainly freshmen students ($N = 36$).

Participants screen time ranged from 678 minutes to 5581 minutes, daily notifications ranging from 34-462 ($M = 178.08$), total pickups ranged from 87-1739 ($M = 967.21$), and average daily throughout the week pickups ranged from 29-266 ($M = 143.07$). Participants received the most notifications from Snapchat and Messages. The most used apps among participates was Tik Tok, a social media site. The most used categories are as follows: first, Social Networking ($N = 41$), second, Entertainment ($N = 23$), and third Productivity ($N = 11$).

Twenty-two participants placed their phone in their book bag/purse and 16 participants placed it in their pocket. Over half of participants ($N = 30$) owned a smartwatch. Most participants never carry a phone charger with them ($N = 17$). Thirty-one participants reported going 6 or more hours without using their smartphone voluntarily. Participants have owned a smartphone for a range of 4-20 years ($M = 7.48$).

Measures and Materials

Reactivity Measures

Physiological Reactivity. Skin conductance was recorded using Biopac's MP 36 data acquisition system (Goleta, CA). Skin conductance has previously been shown to increase when individuals are presented with addictive related cues (Shape et al., 1995). Therefore, it was collected to determine whether physiological arousal corresponds with the urge to use a smartphone. In order to record skin conductance, two electrodes were attached to the palms of the participants' non-dominate hands (Bach et al., 2010). The electrodes allow information to be relayed back to the Biopac's amplifier.

A baseline measure of 2 minutes was taken prior to cue presentation (Braithwaite, 2013). For each cue type there were two trials. Each trial consisted of the same visual and auditory cue and was the same length of time (10 seconds). Between cue types there was a one minute break to allow participants to return to their baseline. Skin conductance levels were measured while participants were exposed to cues.

For data analysis in AcqKnowledge, participants' phasic EDA was extracted from the raw data. This allowed for the removal of their personal level of skin conductance in order to examine changes in skin conductance level that was associated with the manipulation. Tonic is the slower acting component and background characteristic of the EDA signal or the overall level. Phasic refers to the faster changing elements of the signal or the skin conductance response. When analyzing EDA data, four variables were examined initially: Count, Amplitude, Mean and Median. Skin conductance responses (SCR) are identifiable peaks of skin conductance levels during the times specified in the first paragraph. There are two variables linked to SCR. The Count variable measured participants' amount of SCRs and the Amplitude variable measured the intensity of the SCRs. The Amplitude is the mean of all identified SCRs for a specific time. Some participants did not have identifiable SCRs but still had a fluctuation in their EDA levels; in order to include them in analyses mean and median levels of EDA were also collected. Even though these participants did not have identifiable SCRs, they are not considered non-responders. The mean and median are not associated with SCRs.

Smartphone Craving (Appendix A). This scale was adapted from The Gambling Urge Scale (GUS; Raylu & Oei, 2004). The GUS is a 6-item measure that allows participants to indicate their level of agreement to items that reflect the craving to gamble in the moment on a scale from 0-7, with higher numbers indicating a stronger urge to gamble. In order to capture smartphone craving, the word "gamble" was replaced with "using/use my smartphone". For example, "All I want to do now is gamble" was changed to "All I want to do now is use my smartphone". The GUS was shown to have good internal consistency (.81) previously and was also found to be reliable in the current study ($\alpha = .91$).

Subjective Urge (Appendix B). This scale was used in order to assess participant's current urge to use their smartphone. Participants completed the measure three times; once before cues were presented to establish a baseline and once after each cue presentation. Many cue-reactivity studies utilize a Likert-type rating scale to assess urge (Carter & Tiffany, 1999). The measure is a 10-point scale (1 = *no urge* to 10 = *intense urge*).

Smartphone Characteristics Measures

Phone recorded smartphone use measures (Appendix C). Data was collected directly from each participant's iPhone. Once the setting is enabled, the phone records screen time per day in hour and minute increments. The breakdown of time spent on each app is also provided. Daily phone pickups, the first app to be opened after each pickup, daily notification numbers, and where notifications come from was recorded. This data was collected as another measure of daily use to ensure accurate information. Collecting this data allowed all phone usage metrics to be investigated in order to test which cell phone use behaviors were most associated with cue reactivity.

Phone Usage (Appendix D). To examine how often and for what purposes participants used their smartphone, the Daily Wireless Mobile Device Usage Survey adapted from Cheever et al. (2014) was used. Modifications were made in order to better capture contemporary smartphone use. Two items were revised from the original survey: "listen to music on the radio" was modified to "listen to music" and "watch television" was changed to "watch television and movies". There were also several items added to the questionnaire which are marked with a "*" and can be found in the Appendix. Each item is answered with an amount of time spent doing that activity. Choices range from not at all (0) – more than 10 hours per day (11). Some participant's totals might go over 24 hours per day, since some items represent activities that can be performed simultaneously with each other. This scale was also found to have good internal consistency reliable in the current study ($\alpha = .78$).

Smartphone Addiction. To measure addiction to one's smartphone the Smartphone Addiction Scale (SAS) was used. The current study modified an internet addiction scale (i.e., the term internet was switched to smartphone) crated by Kwon and Colleagues (2013). This scale is

33 items and is comprised of six subscales that are all weighted equally and consist of items scored on a 6-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). The six subscales are: daily-life disturbance (e.g., missing planned work), positive anticipation (e.g., feeling excited about riding stress by using their smart phone), withdrawal (e.g., when not using one's smart phone constantly thinking about it), cyberspace-orientated relationship (e.g., thinking relationships formed through smart phone use are more important than real life ones), overuse (e.g., feeling the urge to use one's smartphone immediately after putting it down) and tolerance (e.g., always trying to control one's smartphone use but failing to do so). When being developed, the internal-consistency test result (Cronbach's alpha) was 0.97. Scores can range from 33-198, where a higher score indicates a stronger smart phone addiction. This scale was also found to be reliable with the sample in the current study (α = .93).

Predictor Variables

Alcohol and Drug Usage (Appendix E). A self-rated alcohol consumption measure was used to assess frequency, quantity, and heavy drinking in the last 30 days. A "drink" was defined as a 12 oz. can or bottle of beer, 4 oz. glass of wine, 12 oz. bottle or can of wine cooler, 12 ounce bottle of malt alternative, or a 1.5 ounce shot of liquor straight or in a mixed drink. The measure was adapted from Musselman and Rutledge (2010). This measure was adapted in order to gather the same information about other types of drugs (e.g., cocaine and marijuana).

Anxiety. The State-Trait Anxiety Inventory (STAI; Spielberger, 1983) was used to assess general anxiety. The STAI has 40 items, with 20 items being allocated to each trait and state anxiety subscales. State anxiety is measuring for the current moment while trait anxiety assesses for frequency of feelings in general. Participants only filled out the trait items. Individuals rated their feelings on a 4-point scale that differs for each item (1 = *not at all* to 4 = *very much*). Scores were added to obtain the total score. Items that are “anxiety absent” were reversed scored. Each subtest scores range from 20-80 with a higher score indicating greater anxiety. Internal consistency for the measure ranges from .86-.95. It has been previously established that smartphone dependency and anxiety are significantly positively correlated (Lepp et al., 2014). Therefore, high scores on the STAI might predict heightened reactivity. This scale was also found to have good internal consistency in the current study ($\alpha = .91$).

Demographics questionnaire (Appendix F). All participants completed a demographics questionnaire that was developed by the present investigator. The questionnaire includes age, race, gender, class status, questions about medications (e.g., “Are you currently taking any prescription medications?”), and questions concerning any diagnoses (e.g., “Have you been diagnosed with an anxiety disorder?”). There are also several demographic questions specific to smartphones (e.g., “How long have you had a personal smartphone?”).

Depression (Appendix G). The Center for Epidemiological Studies Depression Scale **(**CES-D) was used to assess for depression. The CES-D is a 20-item self-report measure that assesses for depressive symptoms occurring within the past week (Radloff, 1997). Participants endorsed items on a Likert Scale (0 = *Rarely or none of the time* to 3 = *Most or all of the time*). Four items focus on positive moods and were reverse scored. Total scores were calculated by summing responses across the set of items and can range from 0-60. Higher scores indicate greater distress. The CES-D has demonstrated good internal consistency on healthy undergraduate students, .88 (Devines et al., 1998). It has been previously established that smartphone dependency and depression are significantly positively correlated (Lapierre, Zaho, & Cuter, 2019). Therefore, high scores on the CES-D might predict heightened reactivity. This scale was also found to have good internal consistency in the current study ($\alpha = .91$).

Fear of Missing Out (Appendix H). Fear of Missing Out (FOMO) is defined as a pervasive apprehension that others might be having rewarding experiences without you (Przybylski et al., 2013). FOMO has been shown to be significantly correlated with problematic smartphone use (Elhai et al., 2018). To assess FOMO, the Fear of Missing Out Scale developed by Przybylski and colleagues (2013) was utilized. The scale contains 10 questions to determine the amount of FOMO an individual experiences. Items are rated on a 5-point Likert scale (1 = *Not true of me at all to* 5 = *Extremely true of me*). Scores can range from 10-50, with a higher score indicating a higher level of FOMO. This scale was also found to have good internal consistency in the current study (α = .87).

Nomophobia (Appendix I). The Nomophobia Questionnaire (NMP-Q) is comprised of 20 items that are rated using a 7-point Likert scale (1 = *Strongly Disagree* to 7 = *Strongly Agree*; Yildirim & Correia, 2015).The scale has four factors: not being able to communicate (6 items), losing connectedness (5 items), not being able to access information (4 items) and giving up convenience (5 items). To calculate total scores, the sum of all questions are added together, making scores range from 20-140. Higher scores indicate greater Nomophobia severity. The questionnaire has been shown to have excellent internal consistency at .95. Each factor also demonstrates good internal consistency .94 (not being able to communicate), .87 (losing connectedness), .83 (not being able to access information), and .814 (giving up convenience). Construct validity was demonstrated by the NMP-Q and smartphone involvement questionnaire (MPIQ) having a correlation of .710. This scale was also found to be reliable with the sample in the current study (α = .93).

Procedure

When signing up for a study time slot, participants were instructed to ensure data on their screen time was being recorded on their phones. Exact instructions can be found in Appendix J. Participants were also asked preliminary questions about the characteristics of their phone in order to know what each participant text tone is (Appendix K). Participants and researchers were required to wear a mask at all times, based on COVID safety guidelines established by the Center of Disease control (CDC). Once they arrived at the lab, participants were given a letter of invitation (Appendix L) and given time to ask any questions about the study. Then the screen time data that was recorded on their phone was collected. During this time, researchers turned the smartphone on airplane mode to ensure that when the cues were presented to participants, they each received the same number of notifications. Smartphones also interfere with the BioPac readings and need to be placed on airplane mode. Before being connected to the Biopac, participants were instructed to fill out the subjective craving measure and smartphone craving scale in a counterbalanced order. Next participants were hooked up to the BioPac and instructed to keep their hand still to ensure accurate readings. A 3-minute baseline measure was collected first (Braithwaite, 2013). During this time, participants watched a neutral video. Then participants were asked to give their personal smartphone to the researcher.

Immediately following baseline collection, the experimenter introduced either the neutral or addiction related cue. When the cell phone (i.e., addiction related cue) was presented, each participant’s personal text tone was played. When the label maker (i.e., neutral cue) was presented, the sound of a label printing was played. Sounds were played on the researcher’s phone through a Bluetooth speaker. Participants were then asked to rate their urge to use their phone and filled out the smartphone craving scale. Participants were then given a 1-minute rest period where they watched the same neural video from baseline. Participants were then presented with the second cue, either the addiction related or neutral cue, whichever they did not receive in the first trial (in a counterbalanced order). For each cue, researchers placed the visual cue on a table in front of participants and played the auditory cue two times, the first after 10 seconds of the visual cue being placed at the table and the second after 20 seconds.

After the cue presentations, participants were detached from the Biopac machine. Participants were asked to fill out the SAS, Daily Wireless Smartphone Usage Scale, Fear of Missing Out Scale, NMP-Q, CES-D, STAI-T, Alcohol and drug engagement questions, and demographic questionnaire through an online survey created on Survey Gizmo. Upon completion, participants' smartphones were returned to them. The researcher e-mailed a list of participants to the Psychology 101 professor and teaching assistants at the end of each semester's data collection, to communicate which students needed to receive credit. Once participants left, the researcher disinfected all surfaces consistent with COVID-19 protocol.

Design

First, a correlation matrix was computed for all variables. Then a repeated measures multivariate analysis of variance was conducted to assess if the amount of craving and/or urge (i.e., dependent variables) changed depending on the type of cue or which order they received them (i.e., independent variables). Then two repeated measures analysis of variance were conducted to assess if the amount of skin conductance responses and EDA response levels (i.e., dependent variables) changed depending on the type of cue, order they received the cue, or the trial number (i.e., independent variables). Following that, four linear regressions were ran to see if the outcome variables of craving, urge, number of skin conductance responses, and EDA response level were predicted by scores on the smartphone addiction scale and time spent using their smartphone. Last, four stepwise linear regressions were conducted to see if several individual difference factors predicted craving, urge, number of skin conductance responses, and EDA response level.

Results

All analyses were conducted using SPSS version 27. An alpha level of .05 was used to determine statistical significance for all tests. Tests with p-vales between .05 and.08 were considered to show marginal significance. Descriptive statistics for participant demographics can be found in Table 1. Descriptive statistics for phone usage characteristics can be found in Table 2. Means, standard deviations and other descriptive statistics for self-reported reactivity, EDA measures, and predicator variables can be found in Table 3.

Descriptive Statistics

Alcohol and drug use. First the number of participants who had used each substance in their lifetime assessed will be presented. Ten participants had used tobacco, 35 have used alcohol, 20 have used cannabis, three have used cocaine, two have used mushrooms, one has used LSD, and one has used methamphetamine. No participants reported using heroin or inhalants. Subsequent analyses only included alcohol due to small numbers of use in the other substances. An independent sample *t* test indicated that the number of times men drank alcohol in the last 30 days ($M = 2.45$, $SD = 4.57$) did not differ from women ($M = 1.77$, $SD = 2.95$; $t(52) = .61$, $p = .54$). An independent sample *t* test indicated that the number of times White participants drank alcohol in the last 30 days ($M = 1.51$, $SD = 3.12$) did not differ from Non-White participants ($M = 2.63$, $SD = 3.59$; $t(52) = -1.19$, $p = .24$).

Anxiety. Scores on the STAI were normally distributed and were all within 2 deviations of the mean. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of anxiety in men ($M = 41.18$ $SD = 8.09$) did not differ from women (*M* = 45.23, *SD* = 11.47; $t(52) = -1.11$, $p = .28$. The amount of anxiety did not differ between White (*M* = 44.40, *SD* = 12.03) and non-White participants (*M* = 44.42, *SD* = 8.83; $t(52) = -.007$, $p = .11$)

Depression. Scores on the CES-D were normally distributed and were all within 2 deviations of the mean. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of depression in men (*M* = 13.45, *SD* = 7.20) did not differ from women (*M* = 18.81, *SD* = 11.48; $t(52) = -.1.47$, $p = .15$.) The amount of anxiety did not differ between White (*M* = 18.06, *SD* = 12.50) and non-White participants (*M* = 17.11, *SD* = 7.41; $t(52) = -.304$, $p = .76$.)

EDA. Amplitude, mean, and median analyses resulted in the same trends. Amplitude only consists of a subset of participants who were highly reactive, cutting the data sample down by more than half. Therefore, analyses from this will not be used but can be inferred by reported findings from mean analysis, which shows the same effect as amplitude but includes all participants. Correlations for the variables are as followed: Amplitude and Mean $r(31) = .965$, $p < .001$, Amplitude and Median $r(31) = .962$, $p < .001$, and Mean and Median $r(31) = 1.00$, $p < .001$. When analyzing time, there was no significant difference between trials by time, therefore time was not included in any subsequent analyses.

The distributions of the data for the number of skin conductance responses were checked and all were significantly different than normal. This is attributed to the nine participants who exhibited no skin conductance responses (SCR). Since the outliers were all within three deviations from the mean, analysis continued without the data being transformed. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of Skin Conductance Responses in men (*M* = 1.45, *SD* = .98) did not differ from women (*M* = 1.55, *SD* = 1.25; *t*(38) = -.23, *p* = .41.) The amount of Skin Conductance Responses did not differ between White (*M* = 1.63, *SD* = 1.25) and non-White participants (*M* = 1.31, *SD* = 1.11; *t*(38) = 7.92, *p* = .43).

The EDA response level variable was normally distributed and all participants responses were all within 2 Standard Deviations of the mean). Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the EDA response level in men (*M* = 18.16, *SD* = 12.29) was marginally significantly higher than women (*M* = 11.16, *SD* = 7.62; *t*(38) = 1.97, *p* = .06) on the addiction-related cue trails. The EDA response level did not differ between White (*M* = 12.71, *SD* = 8.52) and non-White participants (*M* = 11.77, *SD* = 9.44; *t*(38) = 3.2, *p* = .75).

Fear of Missing Out. Scores on the Fear of Missing out Scale were normally distributed and were all within 2 deviations of the mean. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of FOMO in men (*M* = 21.64, *SD* = 7.83) did not differ from women (*M* = 22.37, *SD* = 7.73; *t*(52) = -.28, p = .78). The amount of FOMO was significantly lower in White participants (*M* = 20.74, *SD* = 6.77) compared to non-White participants (*M* = 24.95, *SD* = 8.67; *t*(52) = -1.97, *p* = .05).

Nomophobia. Scores on the NMPQ were normally distributed and were all within 2 Standard Deviations of the mean). Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of Nomophobia in men (*M* = 84.55, *SD* = 26.24) did not differ from women (*M* = 84.23, *SD* = 21.07; *t*(52) = 0.4, *p* = .97). The amount of

Nomophobia was marginally significantly lower in White participants (*M* = 80.34, *SD* = 91.58) compared to non-White participants (*M* = 91.58, *SD* = 16.35; $t(52) = -1.84$, $p = .07$).

Phone usage. There was no significant difference between men (*M* = 3454, *SD* = 1780.56) and women's (*M* = 2621.76, *SD* = 979.66) screen time $t(45) = 1.64$, $p = .11$. Both men and women had social networking as most used category and Tik Tok as their most used app. Non-White participants had higher screen time (*M* = 3428, *SD* = 1220.21) than White participants (*M* = 2442.30, *SD* = 1085.50; $t(45) = -2.53$, $p = .02$. Both White and non-White participants had social networking as their most used category and Tik Tok as their most used app.

Smartphone addiction. Scores on the SAS were normally distributed and were all within 2 deviations of the mean. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of smartphone addiction in men (*M* = 93.18, *SD* = 21.46) did not differ from women (*M* = 101.42, *SD* = 25.03; $t(52) = -.99$, $p = .32$) The amount of smartphone addiction was significantly lower for White participants (*M* = 94.97 *SD* = 24.49) compared to non-White participants (*M* = 108.53, *SD* = 22.64; $t(52) = -1.99$, $p = .05$). Consistent with previous research that indicated smartphone dependence is correlated with anxiety (Lepp et al., 2014), Nomophobia (Yildirim & Correia, 2015), and FOMO (Przybylski et al., 2013) those relationships were also found in the current study. Correlations for the variables are as followed: SAS and anxiety $r(53) = .46$, $p < .001$, SAS and Nomophobia $r(53) = .74$, $p < .001$, and SAS and FOMO $r(53) = .42$, $p < .001$.

Smartphone craving/urge. Smartphone craving and urge were moderately correlated $r(53) = .69$, $p < .00$, therefore they will both be reported. Scores on the craving scale were normally distributed and were all within 2 deviations of the mean. Means and standard deviations are reported in Table 3. An independent samples *t* test indicated that the amount of urge to use their smartphones after being exposed to the addiction related cue in men ($M = 3.64$ $SD = 2.06$) did not differ from women ($M = 3.52$, $SD = 2.09$; $t(51) = .16$, $p = .87$) The amount of urge to use their smartphones after being exposed to the addiction related cue in White participants ($M = 3.29$, $SD = 1.87$) did not differ from non-White participants ($M = 4.0$, $SD = 2.36$; $t(51) = -1.20$, $p = .24$).

An independent samples *t* test indicated that the amount of craving to use their smartphones after being exposed to the addiction related cue in men ($M = 14.18$, $SD = 16.57$) did not differ from women ($M = 16.57$, $SD = 8.36$; $t(51) = -.84$, $p = .41$). The amount of craving to use their smartphones after being exposed to the addiction related cue in White participants ($M = 15.29$, $SD = 7.57$) did not differ from non-White participants ($M = 17.47$, $SD = 9.79$; $t(51) = -.90$, $p = .37$).

Correlation Matrix

The two types of self-reported craving measures were significantly correlated $r(53) = .69$, $p < .001$.The two measures of EDA were also significantly correlated $r(39) = .54$, $p < .001$. When looking at the correlation between the self-report and EDA reactivity measures there was no significance: craving and SCR $r(39) = -.16$, $p = .33$, craving and EDA mean $r(39) = .05$, $p = .75$, urge and SCR $r(39) = .02$, $p = .90$, and urge and EDA mean $r(39) = .11$, $p = .54$. These insignificant correlations show that the two types are reactivity are gathering information of two separate kinds of reactivity; the self-reported is more specific to the smartphone and conscious where the EDA measures are more general and unconscious. The SAS scores and total screen time are marginally significantly correlated $r(47) = .28$, $p = .06$. Since they are not significant, both of them will be used as predictor variables in the regression analyses.

The SAS was significantly correlated with age $r(53) = -.27$, $p = .05$, anxiety $r(53) = .46$, $p < .001$, nomophobia $r(53) = .74$, $p < .001$, and FOMO $r(53) = .41$, $p = .002$. Several predictor variables were significantly correlated with urge: depression $r(53) = .28$, $p = .04$, nomophobia $r(53) = .48$, $p < .001$, and SAS $r(53) = .58$, $p < .001$. Several predictor variables were also significantly correlated with craving: anxiety $r(53) = .27$, $p = .04$, nomophobia $r(53) = .43$, $p < .001$, total screen time $r(53) = .34$, $p = .02$, and SAS $r(53) = .56$, $p < .001$. Lasty, an interesting finding is that total phone pickups and FOMO were significantly correlated $r(47) = .30$, $p = .04$. Refer to Table 3 for the correlation matrix.

Hypothesis Testing

Hypothesis One: Participants will elicit heighted reactivity to cell-phone related cues compared to neutral cues. This hypothesis had two sub-hypotheses. The first sub-hypothesis that participants would have an increased craving to use their smartphone after being exposed to addiction related cues compared to neutral cues was tested with a repeated measures multivariate analysis of variance. Independent variables included type of cue (phone or label) and order (phone cue first or label cue first). Type of cue was a within subject factors and order was a between subject factor. The two dependent variables were smartphone urge and subjective craving.

There was a statistically significant main effect of cue type on smartphone urge, $F(1, 51) = 16.85$, $p < .001$, $\eta_p^2 = .25$. Cue Type also had a statistically significant main effect on subjective craving, $F(1, 51) = 33.73$, $p < .001$, $\eta_p^2 = .40$. In other words, the amount of urge and craving changed depending on the tone type. Neither the main effect for order, nor the interaction between type of cue and order were significant. This means the order of cues received did not impact the level of urge or craving participants felt for each cue. Participants had higher self-reported urge and craving ratings, respectively, after being exposed to the addiction related cue (M = 16.08, SD = 8.41; M = 3.55, SD = 2.06) than the neutral cue (M = 13.19, SD = 6.81; M = 2.57, SD = 1.83). This hypothesis was supported.

The second sub-hypothesis was that participants would have an increased skin conductance level after being exposed to smartphone related cues compared to neutral cues. This hypothesis was tested with two repeated measures analyses of variance. Independent variables included type of cue (phone or label), trial number (1st or 2nd) and order (addiction cue first or neutral cue first). The trial variable refers to the two trials given for each cue type and the order variable refers to which cue type participants received first. Type of cue and trial number were within subject factors and order was a between subject factor. The two dependent variables were the number of specific skin conductance responses (SCRs) following each cue and the EDA response level.

Results revealed a main effect for cue type on the number of SCRs $F(1, 38) = 19.06$, $p < .001$, $\eta_p^2 = .33$. Participants had more SCRs to the addiction cue (M = 1.53, SD = 1.2) compared to the neutral cue (M = .83, SD = 1.0). There was not a significant main effect of order nor a significant interaction with order; this illustrates that participants were more reactive to the smartphone cues than the neutral cues, no matter which cue participants received first, supporting this hypothesis. Similarly, there were no main effects or interactions for trial number indicating that participants responded similarly to both presentations of the cues.

A significant main effect of cue type was not found for EDA response level $F(1, 37) = 1.56$, $p = .22$, $\eta_p^2 = .04$. However, there was a significant interaction effect of cue type and trial number on participants' EDA response level, $F(1,37) = 4.88$, $p = .033$, $\eta_p^2 = .12$. In other words, the impact of cue type on EDA response level depended on the Trial Number. Two post hoc paired samples *t* tests were conducted to compare means between trials for each type of cue. Results of the first *t* test revealed no different between trial 1 of the addiction cue ($M = 11.76$, $SD = 8.23$) and trial 1 for the neutral cue ($M = 11.65$, $SD = 8.28$; $t(39) = .46$, $p = .65$. The second *t* test showed significant difference between trial 2 of the addiction cue ($M = 12.41$, $SD = 8.72$) and trial 2 of the neutral cue ($M = 11.75$, $SD = 8.32$; $t(39) = 2.27$, $p = .03$). This indicates that participants had a higher EDA response level to the addiction related cue compared to the neutral cue, but only during the second trial. Refer to Figure 1.

There was also a significant interaction effect of cue type and which cue participants received first (order) on participants' EDA response level, $F(1,37) = 19.76$, $p < .001$, $\eta_p^2 = .35$. This indicates that the effect of cue type on EDA response level depended on which cue the participants received first. Post hoc paired samples t test results indicated that the EDA response level was significantly different between the addiction related and neutral cue, when participants received the neutral cue first t(20) = 3.57, p < .002. Refer to Figure 2.

Hypothesis 2: Degree of smartphone dependency (as evidence by scores on the Smart Phone Addiction Scale and time spent on a personal smartphone) will be predictive of reactivity in response to cues. This was tested with four linear regression analyses. Predictor variables were the same for each analysis and included SAS and total screen time. The four outcome variables included craving scores, urge scores, SCRs, and EDA response level.

A significant regression equation was found for total screen time and SAS scores on craving scores $F(2, 43) = 9.201$, $p < .001$, with an Adjusted R^2 of .27 and urge scores $F(2, 43) = 9.54$, $p = .001$ with an adjusted R^2 of .28. SAS was the only significant predictor, but total screen time was marginally significant. Total scores on the SAS significantly predicted craving $\beta = .22$, $t(45) = 3.34$, $p = .002$. Total scores on the SAS also explained a significant proportion of variance in urge scores $\beta = .46$, $t(45) = 3.75$, $p < .001$. A significant regression model was not found for screen time and SAS scores on the amount of SCRs $F(2, 31) = .07$, $p = .93$, with an adjusted R^2 of -.60. There was also not a significant regression equation for screen time and SAS scores on EDA response level $F(2,31) = .05$, $p = .95$, with an adjusted R^2 of -.06. Therefore, this hypothesis was partially supported. Refer to Tables 5 and 6 for summaries of the regression analyses.

Hypothesis 3: Fear of Missing Out, Depression, Anxiety, Nomophobia Alcohol consumption, weekly notifications, total phone pickups in a week, gender, race, and age will be predictive of reactivity in response to cues. This was tested with a stepwise linear regression. This determined how heavily predictor variables are correlated with reactivity and which individual difference variables were included in the regression analyses. For a correlation matrix, refer to Table 3. SPSS selects the predictor variables from the computed correlations. The selected predictor variables include Fear of Missing Out Scale, Nomophobia, Depression, Anxiety, alcohol consumption in the last 30 days, weekly number of phone notifications, total phone pick-ups in a week, age, race, and gender. Since there were four different measures of reactivity (i.e., craving, urge, SCRs, EDA response level) four regressions were conducted.

For craving, a significant regression equation was found $F(1, 45) = 9.99$, $p = .003$, with an adjusted R^2 of .16. The only significant predictor variable was nomophobia $\beta = .43$, $t(45) = 3.16$, $p = .003$. For urge, a significant regression was found $F(1,45) = 13.80$, $p < .001$ with an adjusted R^2 of .22. The only significant predictor variable was nomophobia $\beta = .48$, $t(45) = 3.72$, $p < .001$. For SCRs, there were no significant predicator variables. For EDA response level, a significant regression was found $F(1, 32) = 5.03$, $p = .03$ with an adjusted R^2 of .11. The only significant predictor variable was gender $\beta = -.37$, $t(-2.24) = 3.99$, $p = .03$.

Discussion

The purpose of the current study was to use a cue-reactivity paradigm to study smartphone dependency to analyze if the learning mechanisms behind the dependency are similar to other established behavioral addictions. The learning mechanisms demonstrated through cue-reactivity is classical conditioning, where conditioned cues become associated with the addiction and in turn trigger emotional/motivational reactions, which elicits a craving response. The current study utilized two types of reactivity measures: Self-report and EDA. Participants in the study were presented with both addiction related (i.e., their personal smartphone) and neutral cues (i.e., a label maker) and a within subjects design was used in order to a have more direct comparison between the two types of cues.

The first prediction was that participants will show heightened reactivity to cell-phone related cues compared to neutral cues and was split into two sub-predictions. The first was that participants would have an increased self-reported craving to use their smartphone after being exposed to smartphone related cues compared to neutral cues. Results indicated that participants had a higher self-reported craving and urge to use their smartphone after being exposed to their personal smartphone compared to a label maker. Results also indicated that this was consistent between groups (i.e., which cue type they received first) and the order of the cues did not affect participants craving and urge amounts. This is consistent with previous research with pathological gamblers who reported significantly greater urge to gamble after being exposed to gambling related cues (Sharpe et al., 1995; Sodano & Wulfret, 2010). Further, this has also been seen with individuals with internet gaming addiction (Ko et al., 2011) and heavy smokers (Litvin & Brandon, 2010) who had a higher urge to play games and smoke, respectively, after being exposed to addiction related cues.

The second part was that participants would have an increased skin conductance level after being exposed to smartphone related cues compared to neutral cues. Results demonstrated that participants had a higher number of Skin Conductance Responses to their smartphone than the label maker, no matter which cue they received first. This is also consistent with previous research, which showed problem gamblers having higher skin conductance levels when exposed to gambling cues (Sodano & Wulfret, 2010). When considering participants' overall EDA response levels two interaction effects showed that participants had an increased EDA response level to the smartphone compared to the label maker in the second trial and that this was especially evident in those who received the label maker first. Since reactivity was stronger during the second trial, it could be inferred that perhaps participants need a certain level of saliency of the cue in order to have heightened reactivity (i.e., the second trial). Another reason that could explain why there was no difference between cues on the first trial, is that both responses during the first trial were startle responses. Reactivity to the label maker did not increase over time, suggesting participants were less aroused to the stimulus over trials rather than more aroused as seen with the smartphone.

Taken together participants' self-reported urge/craving and physiological data provide evidence that the cue-reactivity phenomena is exhibited in smartphone dependency. Moreover, the results provide evidence for classical conditioning. Therefore, classical conditioning seems to be a contributing factor for why individuals become dependent on their smartphone. To further explain, before conditioning takes place the neutral stimulus (NS) is the text tone and phone, which could elicit no response. During conditioning, the NS remains the same but is repeatedly paired with the unconditioned stimulus, social interaction through the phone, which elicits the unconditioned response of positive emotional reactions and physiological arousal. After conditioning occurs the NS because the conditioned stimulus which then elicits the conditioned response of heightened craving and physiological arousal.

Additionally, the study posited, that smartphone dependency, as evidenced by scores on the Smartphone Addiction Scale and time spent on their smartphone, would be predictive of reactivity in response to cues, for both self-report and EDA. Total screen time was not predictive of any outcome variable, which indicates that more time using applications on one's phone does not increase craving or physiological reactivity. Scores on the SAS were predictive of urge and craving, meaning the more "dependent" a participant reported being on their smartphone the higher their urge and craving was to use it. This is consistent with previous research on IGA that found individuals who were currently addicted had a higher urge to play games than individuals who were in remission or the control group (Ko et al., 2011). However, scores on the SAS were predicative of any EDA variable, which means participants physiological reactivity was not accounted for by their level of dependence on their smartphone. This could be due to the small EDA sample size, that EDA arousal is not specific to the smartphone and the reactivity could have been due to other stimuli, and both EDA variables were slightly correlated with FOMO and anxiety, indicating the sample was somewhat anxious, leading to higher arousal but not to the smartphone cues.

Finally, I explored whether other individual difference factors would account for a significant amount of variance in both self-report and EDA reactivity. Nomophobia, or the fear of being without one's smartphone, was the only significant predictor variable for self-reported craving/urge. Gender was the only significant predictor variable for EDA response level. There were no significant predicators for the number of SCRs. This could be due to the 9 participants who exhibited no SCRs. The sample size could account for the lack of predicator variables for EDA due to low power. Although the predictor variables were not predictive or correlated with the physiological reactivity, the variables were correlated with the other measures of craving (Table 3).

Previous research found that women tend to have higher screen time compared to men, there were no significant difference in the current study (Roberts et al., 2014). Also, previous research showed that women had higher reported dependency than men (Gutierrez et al., 2016), there was no significant difference in the current sample. Further, previous research stated that men used their smartphone for more practical and instrumental ways, but the current sample showed that men primarily use their phone for social networking (Roberts et al., 2014). One potential reason this study sample differs from past studies could be because several years have passed since those studies were conducted and usage characteristics have evolved since then. Lastly it was indicated that non-white participants had significantly more smartphone dependence than White participants.

While previous research reported FOMO (Przybylski et al., 2013) and negative mood states (e.g., anxiety and depression; Lepp et al., 2014) to be highly correlated to smartphone dependence, they were not predicative of self-reported or EDA reactivity. Although not predictive, SAS was significantly correlated with anxiety and FOMO. Nomophobia, also previously shown to be correlated with smartphone dependency (Yildirim & Correia, 2015) was predictive. However, participants in the current sample did not report high depression levels.

Strengths/Limitations

The study had several strengths such as utilizing two different measures of reactivity: self-report and physiological, each providing more information than one could have alone. The study adapted the Gambling Urge Scale to measure smartphone usage urge, which was showed good internal consistency with the current sample. This means that future researchers could examine the psychometric properties further and other researchers can utilize this as a means to gauge urge to use a smartphone. Another strength is that the participants actual screen time data was recorded from their phones. This provided precise and accurate data, that the participants were not able to manipulate leading to more valid results. While participants can report aspects of their phone usage, the amount of information gathered from the embedded software (e.g., phone pickups, notifications, etc.) would not be possible to collect without the phone keeping track.

The study also had many limitations that should be taken into consideration. First, the sample was predominately white and female, which is not an adequate representation of the general population, meaning that findings are not going to be highly generalizable. Future studies should aim to obtain a sample that is equal across gender and race. Future studies should also aim to have a larger sample for EDA data, as more participants could lead to more power.

The self-reported craving and urge scores were relatively low which could be due multiple factors. Refer to Table 3 for means of Craving and Urge. Participants were not without their phone in their possession for a long period of time, before the cue presentation participants did not use their phone for roughly 3-4 minutes. Future research could deprive participants of their smartphone for a longer period to induce heightened craving (Cheever et al., 2014). Some participants could have known that their phone was on silent, meaning that they knew they were not actually receiving a text message. While the visual and auditory cue still served as conditioned stimuli, having all participants believe they were truly receiving a text could have made the cue stronger. Further, participants were presented with the cues and craving/urge measures close together. If there was more time in between cue presentations, participants' craving/urge could have increased more. Lastly, participants were instructed to hand the researcher their craving/urge measures once completed. This could make the participant feel pressure to answer a certain way. For example, participants may have not wanted to seem dependent and downplayed their craving or they may have thought the researcher wanted to see high scores and answered in that trend. Lastly, there was no behavioral measure of craving, which could be looked at in future studies.

Future research could also examine how distracting participants' craving/urge is from completing a specific task, to help assess individuals focus in the classroom once exposed to the stimuli. This would be beneficial in assessing the educational implications of receiving smartphone cues. Additionally, future research could alter the type of cues given. Other types of cues could be videos or true notifications on participants' phone screen. Participants could be given the option to hold or touch their phone or the option to use their smartphone. Having the participant do these behaviors could provide a more salient cue, since they typically engage in the behavior when they have an urge to use it. Previous research has asked heavy smokers to hold a cigarette before rating their craving (Livitin & Brandon, 2010).

Since scores on the SAS and total screen time were not significantly correlated, future research could look at what specific smartphone activities are correlated with more smartphone dependency. Also, since nomophobia was a significant predictor of craving and urge and the scale has four subscales, future studies could investigate which subscales are predictive.

Implications and Conclusions

The current study extended the research on smartphone dependency by utilizing a paradigm well known and utilized the in addictions field. To my knowledge, this was the first study to utilize cue-reactivity with smartphone dependency. Results were consistent with prior research on cue-reactivity showing that exposure to addiction related cues elicits heightened arousal and craving to engage in the behavior. This provided more experimental evidence that smartphone dependency has similar characteristics to other behavioral and substance addictions. This paradigm can be altered and used in future studies with smartphone dependency. This research is important due to most individuals not realizing the severity of their dependency on their device. The level of dependency and possible distracting nature of individuals urge and craving could be harmful in class, at work, and when attempting to complete tasks. The level of dependency and possible distracting nature could also be dangerous when driving.

References

Bach, R. D., Flandin, G., Friston, J. K., & Dolan, J. R. (2010). Modelling event-related skin conductance responses. *International Journal of Psychophysiology, 75*(3), 349-356. https://doi.org/10.1016/j.ijpsycho.2010.01.005

Basden L. S., Orr P. S., Otto, W. M. (2016). Impaired de novo fear conditioning in opiate-dependent outpatients. *Cognitive Therapy and Research*, *40*(6):824–830. https://doi.org/10.1007/s10608-016-9786-9.

Barnes, J. S., Pressey, D. A., Scornavacca, E. (2018). Mobile ubiquity: Understanding the relationship between cognitive absorption, smartphone addiction and social network services, *Computer in Human Behavior, 90*(2019), 246-258. https://doi.org/10.1016/j.chb.2018.09.013

Bianchi, A., & Phillips, G. J. (2005). Psychological predictors of problem smartphone use. *Cyberpsychology & Behavior, 8*(1), 39-51. http://doi.org/10.1089/cpb.2005.8.39.

Billieux J., Linden Van der, M., d'Acremont M., Ceschi G., & Zermatten A. (2007) Does impulsivity relate to perceived dependence and actual use of the mobile phone? *Applied Clinical Psychology, 21*(4):527–37. https://doi.org/10.1002/acp.1289

Braithwaite, J. J., Watson, G. D., Jones, R., & Rowe, M. (2010). A guide for analyzing electrodermal activity (EDA) & skin conductance responses for psychological experiments. University of Birhingam, UK. https://www.biopac.com/wp-content/uploads/EDA-SCR-Analysis.pdf

Carter, L. B., & Tiffany, T. S. (1999). Meta-analysis of cue-reactivity in addiction research. *Addiction, 94*(3), 327-340. https://doi.org/10.1046/j.1360-0443.1999.9433273.x

Carrigan, M. H., & Lisman, S. A. (1998, November). Examination of a new questionnaire to measure urge to drink in a cue reactivity study. Paper presented at the annual meeting of the Association for the Advancement of Behavior Therapy, Washington, DC.

Cheever, A. N., Rosen, D. L., Carrier, L. M., & Chavez, A. (2014). Out of sight is not out of mine: The impact of restricting wireless mobile device use on anxiety levels among low, moderate, and high users. *Computers in Human Behavior, 37,* 290-297. https://doi.org/10.1016/j.chb.2014.05.002

Clayton, B. R. (2015). The extended iself: The impact of iPhone separation on cognition, emotion, and physiology, *Journal of Computer-Mediated Communication, 20,* 119-135. https://doi.org/10.1111/jcc4.12109

Drummond, C. D. (2000). What does cue-reactivity have to offer clinical research? *Addiction, 95,* 129-144. https://doi.org/10.1046/j.1360-0443.95.8s2.2.x

End, M. C., Worthman, S., Mathews, B. M., & Wetterau, K. (2010). Costly smartphones: The impact of smartphone rings on academic performance, *Teaching of Psychology*, 37(1), 55-57.

Grant, E. J., Potenza, N. M., Weinstein, A., Gorelick, A. D. (2010). Introduction to behavioral addictions. *American Journal of Drug and Alcohol Abuse, 36*(8), 233-241. https://doi.org/10.3109/00952990.2010.491884

Griffiths, M. D. (1996). Gambling on the internet: a brief note. *Journal of gambling studies* 12 471-473.

Griffiths, M. (1993). Tolerance in gambling: An objective measure using the psychophysiological analysis of male fruit machine gamblers. *Addictive Behaviors, 18*, 365-372.

Griffiths M. D., & Smeaton M. (2002).Withdrawal in pathological gamblers: a small qualitative study. *Social Psychological Review, 4*(1), 4-13.

Gutierrez, J., Eodriguez de Fonseca, F., & Rubio, G. (2016). Cell-phone addiction: A review. *Frontiers in Psychiatry. Addictive Disorders, 7.* https://doi.org/10.3389/fpsyt.2016.00175

Han, L., Geng, J., Jou, M., Gao, F., & Yang, H. (2017). Relationship between shyness and smartphone addiction in Chinese young adults: Mediating roles of self-control and attachment anxiety. *Computer in Human Behavior, 76,* 363-371. https://doi.org/10.1016/j.chb.2017.07.036

Holden, C. (2001). Compulsive behaviors: "Behavioral" addictions: Do they exist? *Science, 394*(5544), 980-982. http://doi.org/ 10.1126/science.294.5544.980

Hong, F-Y., Chiu, S-I., Huang, D-H. (2012). A model of the relationship between psychological characteristics, smartphone addiction and use of smartphones by Taiwanese university female students. *Computers in Human Behavior, 28,* 2152-2159. https://doi.org/10.1016/j.chb.2012.06.020

Hyman, S. E. (1005). Addiction: A disease of learning and memory. *American Journal of Psychiatry, 162*(8), 1414-1422. https://doi.org/10.1176/appi.ajp.162.8.1414

Jenaro, C., Flores, N., Gomez-Vela, M., Gonzalez-Gil, F., & Caballo, C. (2007) Problematic Internet and cell-phone use: psychological, behavioral and health correlates. *Addiction Research & Theory, 15*(3), 309–20. https://doi.org/10.1080/16066350701350247

Kaptsis D., King D. L., Delfabbro P. H., Gradisar M. (2016). Withdrawal symptoms in internet gaming disorder: a systematic review. *Clinical Psychology Review, 43*, 58–66. https://doi.org/10.1016/j.cpr.2015.11.006

Karim, R., & Chaudhri, P. (2012). Behavioral addictions: An overview. *Journal of Psychoactive Drugs, 44*(1), 5-17. https://doi.org/10.1080/02791072.2012.662859

Kim, H. J., Min, J. Y., Him, H. J., Min, K. B. (2019). Association between psychological and self-assessed health status and smartphone overuse amount Korean college students. *Journal of Mental Health, 28*(1), 11-16. http://doi.org/10.1080/09638237.2017.1370641

Ko, C. H., Liu, G. C., Hsiao, S., Yen, J. Y., Yang, M. J., & Lin, W. C. (2009). Brain correlates of craving for online gaming under cue exposure in subjects with internet gaming addiction and in remitted subjects. *Addiction Biology, 18*(3), 559-569. https://doi.org/10.1111/j.1369-1600.2011.00405.x

Kredlow, A. M., Pineless, L. S., Inslicht, S. S., Marin, M-F., Milad, R. M., Otto, W. M., & Orr, P. S. (2018). Assessment of skin conductance in African American and Non-African American participants in studies of conditioned fear. *Psychophysiology, 54*(11), 1741-1754. https://doi.org/10.1111/psyp.12909

Kwon, M., Lee, JY., won, WY., Park, JW., Min, JA., Hahn, C., Gu, X., Choi, JH., & Kim, DJ. (2013). Development and validation of a smartphone addiction scale (SAS). *Public Library of Science, 8*(2).

Lapierre, A. M., Zhao, P., & Custer, E. B. (2019). Short-term longitudinal relationships between smartphone use/dependency and psychological well-being among late adolescents. *Journal of Adolescent Health, 65*(5), 607-612. https://doi.org/10.1016/j.jadohealth.2019.06.001

Ledgerwood, M. D., Weinstock, J., Morasco, J. B., & Petry, M. N. (2007). Clinical features and treatment prognosis of pathological gamblers with and without recent gambling-related illegal behavior. *Journal of the American Academy of Psychiatry and the Law, 35*, 294-301.

Lepp, A., Barkley, E. J., & Karpinski, C. A. (2014). The Relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students. *Computers in Human Behavior, 31,* 343-350. https://doi.org/10.1016/j.chb.2013.10.049

Litvin, B. E. & Brandon, H. T. Testing the influence of external and internal cues on smoking motivation using a community sample. *Experimental and Clinical Psychopharmacology, 18*(1), 61-70. https://doi.org/10.1037/a0017414

Lole. L., Gonsalvez, j. C., Barry, J. R., & Blaszcynski, A. (2014). Problem gamblers are hyposensitive to wins: An analysis of skin conductance during actual gambling on electronic gaming machines. *Psychophysiology, 51*(6), 566-564. https://doi.org/10.1111/psyp.12198

Mick, G. D., & Fournier, S. (2010). Paradoxes of technology: Consumer cognizance, emotions, and coping strategies. *Journal of Consumer Research, 25*(2), 123-143. https://doi.org/10.1086/209531

Morrill, B. T., Jones, M. R., & Vaterlaus, M. J. (20113). Motivations for text messaging: gender and age differences among young adults. *North American Journal of Psychology, 15*(1).

Musselman, R. B. J., & Rutledge, C. P. (2010). The incongruous alcohol-activity association: Physical activity and alcohol consumption in college students. *Psychology of Sport and Exercise, 11*(6), 609-618. https://doi.org/10.1016/j.psychsport.2010.07.005

Niaura, S. R., Rohsenow, J. D., Binkoff, A. J., Monti, M. P., Pedraza, M., & Abrams, B. D. (1988). Relevance of Cue Reactivity to understanding alcohol and smoking relapse. *Journal of Abnormal Psychology, 97*(2), 133-152. https://doi.org/10.1037/0021-843X.97.2.133

Panova, T., & Lleras, A. (2016). Avoidance or boredom: Negative mental health outcomes associated with use of information and communication technologies depend on users' motivations. *Computers in Human Behavior, 58*, 249–258. https://doi.org/10.1016/j.chb.2015.12.062

Panova, T., & Carbonell, X. (2018). Is smartphone addiction really an addiction? *Journal of Behavioral Addictions, 7*(2), 252-259. https://doi.org/10.1556/2006.7.2018.49

Przybylski, A. K., Murayama, K., DeHaan, C. R., & Gladwell, V. (2013). Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior, 29*(4), 1841–1848.

Potenza, N. M. (2008). The neurobiology of pathological gambling and drug addiction: an overview and new findings. *Philosophical Transactions of the Royal Society B, 363,* 3181-3189. https://doi.org/10.1098/rstb.2008.0100

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurements,* 1, 385-401.

Raylu, N. & Oei, P. S. T. (2004). The Gambling Urge Scale: Development, confirmatory factor validation, and psychometric properties. *Psychology of Addictive Behaviors, 18*(2), 100-105. https://doi.org/10.1037/0893-164X.18.2.100

Reuter, J., Raedler, T., Rose, M., Hand, I., Glascher, J., & Buchel, C. (2005). Pathological gambling is linked to reduced activation of the mesolimbic reward system. *Nature Neuroscience, 8,* 147-148. http://doi.org/ 10.1038/nn1378

Roberts, J. A. & Pirog, III, S. F. (2012). A preliminary investigation of materialism and impulsiveness as predictors of technological addictions among young adults. Journal of Behavioral Addictions, 2(1), 56–62. http://doi.org/ 10.1556/JBA.1.2012.011

Roberts, A. J., Yaya, P. H. L., & Manolis, C. (2014). The invisible addiction: Cell-phone activities and addiction among male and female college students. *Journal of Behavioral Addictions, 3*(4), 254-265. http://doi.org/ 10.1556/JBA.3.2014.015

Sahin, S., Ozdemir, K., Unsal, A., & Temiz, N. (2013). Evaluation of mobile phone addition level and sleep quality in university students. *Pakistan Journal of Medical Sciences, 29*(4), 913-918.

Sapacz, A., & Rockman, J., C. (2015). Are we addicted to our smartphones? *Computers in Human Behavior, 57,* 153-159. https://doi.org/10.1016/j.chb.2015.12.004

Sharpe, L., Tarrier, N., Schotte, D., & Spence, S. H. (1995). The role of autonomic arousal in problem gambling. *Addiction, 90*(11), 1529-1540. https://doi.org/10.1046/j.1360-0443.1995.9011152911.x

Sodano, R., & Wulfert, E. (2010). Cue reactivity in active pathological, abstinent pathological, and regular gamblers. *Journal of Gambling Studies, 26,* 53-65. http://doi.org/10.1007/s10899-009-9146-8

Spielberger, C. D. (1983). Manual for the State–Trait Anxiety Inventory (Form Y). Palo Alto, CA: Mind Garden.

Starke, K., Antons, S., Trotzke, P., & Brand, M. (2018). Cue-reactivity in behavioral addictions: A meta-analysis and methodological consideration. *Journal of Behavioral Addictions, 7*(2), 227-238. https://doi.org/10.1556/2006.7.2018.39

Stewart, J., deWitt, H., & Eikelboom, R. (1984). The role of unconditioned and conditioned drug effects in the self-administration of opiates and stimulants. *Psychological Review, 91*251-268. https://doi.org/10.1037/0033-295X.91.2.251

Taylor, B. S., Lewis, R. C., & Olive, F. M. (2013). The neurocircuitry of illicit psychostimulant addiction: acute and chronic effects in humans. *Substance Abuse and Rehabilitation, 4,* 29-43. https://doi.org/10.2147/SAR.S39684

Tiffany, T. S., & Wray, M. J. (2012). The clinical significance of drug craving. *Annals of the New York Academy of Sciences, Addiction Review,* 1-17. http://doi.org/ 10.1111/j.1749-6632.2011.06298.x

Trotzke, P., Starcke, K., Pedersen, A., & Brand, M. (2014). Cue-induced craving in pathological buying: Empirical evidence and clinical implications. *Psychosomatic Medicine, 76*(9), 694-700. http://doi.org/ 10.1097/PSY.0000000000000126

Wikler, A. (1948). Recent progress in research on the neurophysiological basis of morphine addiction. *American Journal of Psychiatry, 105*, 329-338. https://doi.org/10.1176/ajp.105.5.329

Wrase, J., Schlagenhauf, F., Kienast, T., Wustenberg, T., Burmpohl. F., Kahnt, T., Beck, A., Strohle, A., Juckle, G., Kunston, B., & Heinz, A. (2007). Dysfunction of reward processing correlates with alcohol craving in detoxified alcoholics. *Neuroimage, 35*, 787-794. https://doi.org/10.1016/j.neuroimage.2006.11.043

Yen C. F., Tang T. C., Yen J. Y., Lin H. C., Huang C. F., Liu S. C., Ko, H. C. (2009). Symptoms of problematic cellular phone use, functional impairment and its association with depression among adolescents in Southern Taiwan. *Journal of Adolescence, 32*(4):863–73. https://doi.org/10.1016/j.adolescence.2008.10.006

Yildirim, C. & Correia, AP. (2015). Exploring the dimensions of Nomophobia: Development and validation of a self-reported questionnaire. *Computers in Human Behavior, 48,* 130-137. https://doi.org/10.1016/j.chb.2015.02.059

Table 1

Descriptive Statistics for Participants

Variables	*N*	%
Gender		
Male	11	20.4
Female	43	79.6
Race		
White	35	64.8
Non-White	19	35.2
Class		
Freshmen	36	66.7
Sophomore	11	20.4
Junior	7	13
Order		
Addiction	28	50.9
Neutral	26	45.5

Note. *N* = 54, group is which cue participants received first, age can be found in Table 3

Table 2

Phone Usage Characteristics for Participants

Variables	*N*	%
1. Time w/o phone		
6+ hours	31	56.4
4-5 hours	14	24.5
2-3 hours	7	12.7
1 hour	1	1.8
2. Social Networking	41	74.5
3. Entertainment	23	41.8
4. Productivity	11	20.0
5. App 1		
Tik Tok	18	32.7
Snapchat	9	16.4
Instagram	5	9.1
6. Smartwatch		
Yes	21	44.4
No	33	55.6
7. Phone during class		
Backpack/purse	22	40.0
Pocket	16	29.5
Desk/lap	16	29.5
8. Carrying Charger		
Never	17	30.9
Rarely	20	36.4
Some of the time	9	16.4
Most of the time	4	7.3
Always	4	7.3
9. App w/ most Not.		
Snapchat	21	38.9
Messages	20	27

Table 3
Correlation Matrix between all Reactivity Measures and Predictor Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. SCRs	--															
2. EDA res.	.54**															
3. Urge	.02	.11														
4. Craving	-.16	-.05	.69**													
5. Gender	.04	-.30	.12	-.02												
6. Race	-.13	-.05	.13	.17	-.11											
7. Age	-.23	-.22	-.10	-.11	-.01	-.11										
8. Weekly Notifications	.15	-.16	-.09	.06	-.15	.18	.05									
9. Total Pickups	.17	.02	.02	.07	-.01	-.03	.15	.60**								
10. Alcohol Consumption	-.06	.11	.20	.07	-.09	.16	.004	-.12	.03							
11. Depression	.02	.11	.28*	.24	.20	-.04	.22	.24	.11.	.46						
12. Anxiety	.20	.24	.22	.29*	.15	.001	-.15	.19	.10	-.09	.79**					
13. Nomophobia	.03	.18	.48*	.43*	-.01	.25	-.31*	.09	.20	.25	.19	.30*				
14. FOMO	.27	.27	.16	.14	.04	.26	-.17	.40**	.31*	.09	.21	.39**	.47**			
15. Total Screen Time	.06	.06	.29	.34*	-.24	.35*	-.11	.34*	.33	-.03	.04	.12	.18	.17		
16. Smartphone Addiction	.02	.04	.58**	.56**	.14	.27	-.27*	.14	.12	.12	.25	.46**	.74**	.42**	.28	--
M	1.53	12.41	16.08	3.55	--	--	19.22	221.83	967.21	1.91	17.72	44.41	84.30	22.22	2786.28	99.74
SD	1.20	8.72	8.41	2.16	--	--	3.18	325.45	370.45	3.30	10.91	10.93	21.95	7.68	1206.51	24.52
Range	0-5	31.04-1.34	6-39	0-8	--	--	18-41	34-2319	87-1739	0-15	1-49	22-77	23-127	10-45	678-5581	52-157

Note. *. Correlation is significant at the 0.05 level
**. Correlation is significant at the 0.01 level

Table 4

Summary of Regression Analysis Predicting Craving and Urge (Hypothesis 2)

	Model 1					Model 2				
Variable	B	SE B	β	*t*	*p*	B	SE B	β	*t*	*p*
Total Screen Time	.000	.000	.22	1.65	.11					
Smartphone Addiction	.04	.01	.44	3.34	.002					
Total Screen Time						.001	.001	.15	1.12	.27
Smartphone Addiction						.17	.04	.50	3.75	.001

Note. Model 1 dependent variable = craving Model 2 dependent variable = urge

Table 5

Summary of Regression Analysis Predicting SCRs and Mean (Hypothesis 2)

	Model 1					Model 2				
Variable	B	SE B	β	*t*	*p*	B	SE B	β	*t*	*p*
Total Screen Time	4.38	.000	.04	.22	.83					
Smartphone Addiction	.002	.01	.04	.19	.85					
Total Screen Time						.000	.001	.06	.29	.06
Smartphone Addiction						.000	.07	-.001	-.005	.99

Note. Model 1 dependent variable = count Model 2 dependent variable = mean

Table 6

Summary of Regression Analysis Predicting Craving and Urge (Hypothesis 3)

	Model 1					Model 2				
Variable	B	SE B	β	*t*	*p*	B	SE B	β	*t*	*p*
NMPQ	.04	.01	.43	3.16	.003					
NMPQ						.19	.05	.48	3.72	.001

Note. Model 1 dependent variable = craving, Model 2 dependent variable = urge

Figure 1

Interaction between cue type and trial number

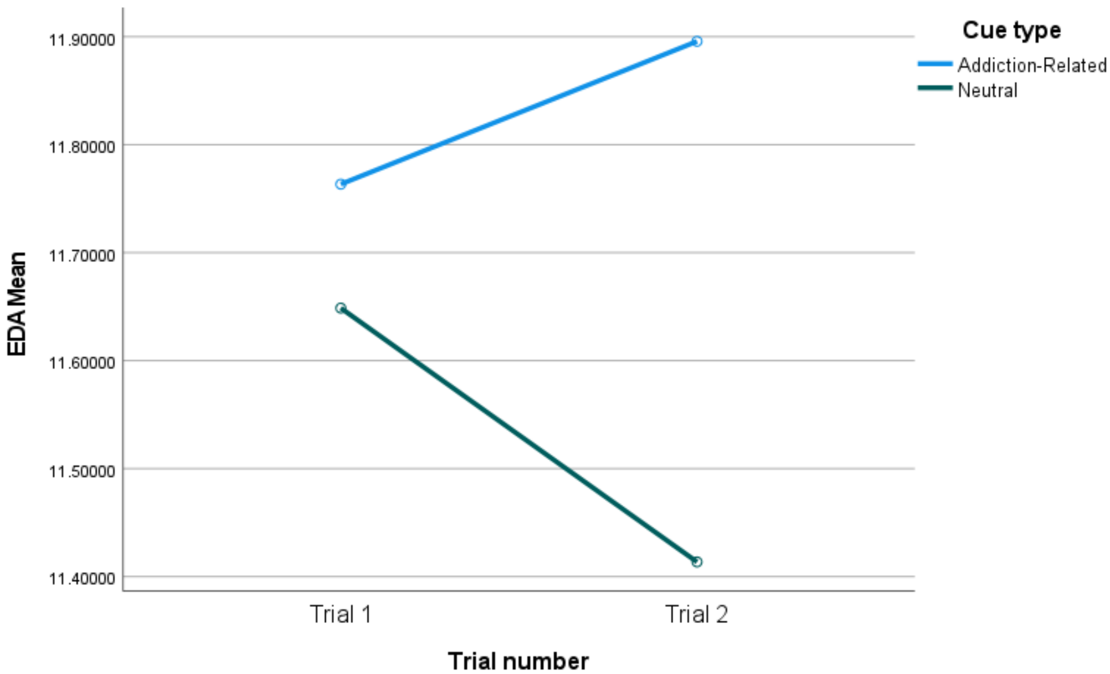
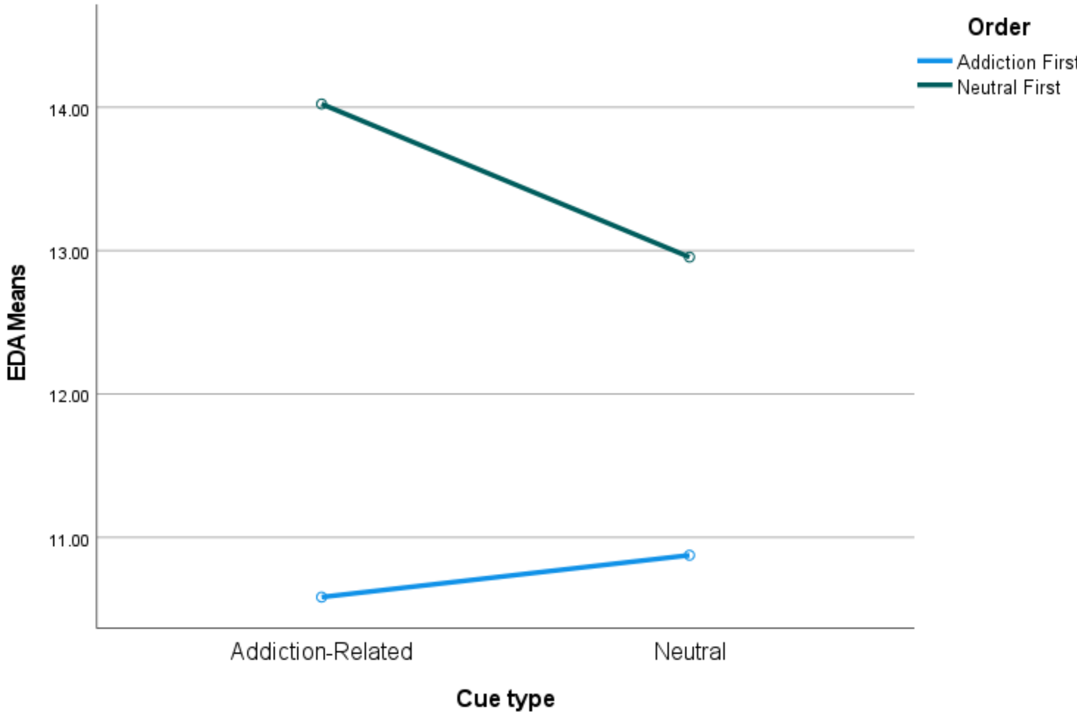


Figure 2

Interaction between cue type and order



Appendix A

Smartphone Craving Scale

Please indicate how much you agree or disagree with each statement using the following scale:

1- Strongly Disagree
2- Disagree
3- Somewhat Disagree
4- Neither Agree or Disagree
5- Somewhat Agree
6- Agree
7- Strongly Agree

1. All I want to do now is use my smartphone.
2. It would be difficult to turn down using my smartphone at the moment.
3. Using my smartphone now would make things seem just perfect.
4. I want to use my smartphone so bad that I can almost feel it.
5. Nothing would be better than using my smartphone right now.
6. I crave using my smartphone right now.

Appendix B

Subjective Craving Scale

Please rate your urge to use your smartphone at this moment by circling a number on the scale below, with 0 being no urge and 10 being intense urge.

0	1	2	3	4	5	6	7	8	9	10

Appendix C

Phone recorded smartphone use measures

Total screen time day: Weekly average: Total:

- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday

Most used category (list numbers next to)

- Social networking
- Creativity
- Productivity
- Reading and reference
- Entertainment
- Education
- Health and Fitness
- Other (list in the other)

7 most used apps:

1.
2.
3.
4.
5.
6.
7.

Weekly Average phone pickups: Most pickups: Total pickups:

Apps first used after a pickup:

Notifications weekly average: Most notifications in a day:

Top 4 places notifications are from:

Appendix D

Daily wireless mobile device usage

Please rate how much time you spend doing each activity on your phone daily:

1. Send and receive emails
2. Participate in instant message conversation or participate in online chats
3. Talk on the phone
4. Send and receive text messages
5. Play video games
6. Listen to music
7. watch television or movies
8. watch videos*
9. read books or magazines
10. go on social media accounts*
11. facetime*
12. read news stories*
13. Journal*
14. Use for exercising purposes*
15. Take photos*

Answer choices:

Not at all (0)

Less than one h per day (.5)

1 h per day (1)

2 h per day (2)

3 h per day (3)

4-5 h per day (4.5)

6-8 h per day (7)

9-10 h per day (9.5)

More than 10 h per day (11)

Appendix E

Alcohol and Drug Engagement

1. In your life, which of the following substances have you ever used? Circle Y if you have used and N if you have not.
    a. Tobacco products Y | N
    b. Alcoholic beverages Y | N
    c. Cannabis (Marijuana) Y | N
    d. Cocaine Y | N
    e. Stimulants Y | N
    f. Inhalants Y | N
    g. Sedatives/hypnotics Y | N
    h. Hallucinogens Y | N
    i. Opioids Y | N
    j. Other drugs Y | N
2. How many times did you use ____ in the past 30 days?
    a. Once in the past 30 days
    b. 2-3 times in the past 30 days
    c. Once or twice a week
    d. 3-4 times a week
    e. 5-6 times a week
    f. Nearly everyday
    g. Every day
3. In the past 30 days, when you drank, how many drinks did you usually have on any one occasion?
    a. 1 drink
    b. 2 drinks
    c. 3 drinks
    d. 4 drinks
    e. 5 drinks
    f. 6 drinks
    g. 7 drinks
    h. 8 drinks
    i. 9 drinks
    j. 10 drinks
    k. 11 drinks
    l. 12 drinks
    m. 13 or more drinks
4. In the past 30 days how many times have you had five or more drinks in a single sitting?
    a. Once in the past 30 days
    b. 2-3 times in the past 30 days
    c. Once or twice a week
    d. 3-4 times a week
    e. 5-6 times a week
    f. Nearly everyday

   g. Every day
5. How many times did you use _____ in the past 30 days?
   a. Once in the past 30 days
   b. 2-3 times in the past 30 days
   c. Once or twice a week
   d. 3-4 times a week
   e. 5-6 times a week
   f. Nearly everyday
   g. Every day

   REPEAT QUESTIONS FOR EVERY DRUG THEY ENDORSE?

Appendix F

Demographics

Age:

Gender:

Race:

Class status:

Did you consume any caffeinated substances before coming to this study? If so, when and what?

Did you consume any alcohol before coming to this study? If so, when and how much?

Are you currently taking any prescription medications? If so, please list them.

Are you currently using any illegal substances? If so, please list them.

Are you currently taking any non-prescription medications? If so, please list them.

Have you been diagnosed with an Anxiety disorder?

Smartphone related demographics:

What percentage of the time do you carry a smartphone charger with you?

Do you own a smart watch? If so, what percentage of the time do you wear your watch? What type of notifications come to your smartwatch?

How many years have you have a personal phone?

What is the longest amount of time you have gone without using your smartphone?

What is the longest amount of time you have gone without your smartphone in your possession?

Where do you put your smartphone during class?

Appendix G

CES-D

Rate each statement with what best describes how often you felt or behaved this way- during the past week

Rarely or none of the time (less than one 1 day) 0

Some or a little of the time (1-2 days) 1

Occasionally or a moderate amount of time (3-4 days) 2

Most or all of the time (5-7 days) 3

1. I was bothered by things that usually don’t bother me
2. I did not feel like eating; my appetite was poor
3. I felt that I could not shake off the blues even with help from my family or friends
4. I felt that I was just as good as other people
5. I had trouble keeping my mind on what I was doing
6. I felt depressed
7. I felt that everything I did was an effort
8. I felt hopeful about the future
9. I thought my life had been a failure
10. I felt fearful
11. My sleep was restless
12. I was happy
13. I talked less than usual
14. I felt lonely
15. People were unfriendly
16. I enjoyed life
17. I had crying spells
18. I felt sad
19. I felt that people disliked me
20. I could not get ‘going’

Appendix H

Fear of Missing Out Scale

Please rate how much each statement relates to you:

Not at all true of me = 1

Slightly true of me = 2

Moderately true of me = 3

Very true of me = 4

Extremely true of me = 5

1. I fear others have more rewarding experience than me
2. I fear my friends have more rewarding experiences than me
3. I get worried when I find out my friends are having fun without me
4. I get anxious when I don't know what my friends are up to
5. It is important that I understand my friends "in jokes"
6. Sometimes, I wonder if I spend too much time keeping up with what is going on
7. It bothers me when I miss an opportunity to meet up with friends
8. When I have a good time, it is important for me to share the details online (e.g., updating status)
9. When I miss out on a planned get-together it bothers me
10. When I go on vacation, I continue to keep tabs on what my friends are doing

Appendix I

Nomophobia Questionnaire (NMP-Q)

Please indicate how much you agree or disagree with each statement using the following scale:

1- Strongly Disagree
2- Disagree
3- Somewhat Disagree
4- Neither Agree or Disagree
5- Somewhat Agree
6- Agree
7- Strongly Agree

1. I would feel uncomfortable without constant access to information through my smartphone.
2. I would be annoyed if I could not look information up on my smartphone when I wanted to do so
3. Being unable to get the news (e.g., happenings, weather, etc.) on my smartphone would make me nervous
4. I would be annoyed if I could not use my smartphone and/or its capabilities when I wanted to do so.
5. Running out of battery inn my smartphone would scare me
6. If I were to run out of credits or hit my monthly data limit, I would panic
7. If I did not have an data signal or could not connect to Wi-Fi, then I would constantly check to see if I had signal or could find a Wi-Fi network
8. If I could not use my smartphone, I would be afraid of getting stranded somewhere
9. If I could not check my smartphone for a while, I would feel a desire to check it

If I did not have my smartphone with me,

10. I would feel anxious because I could not instantly communicate with my family and/or my friends
11. I would be worried because my family and/or friends could not reach me
12. I would feel nervous because I would not be able to receive text messages and calls
13. I would be anxious because I could not keep in touch with my family and/or friends
14. I would be nervous because I could not know if someone had tried to get ahold of me
15. I would feel anxious because my constant connection to my family and friends would be broken
16. I would be nervous because I would be disconnected from my online identity
17. I would be uncomfortable because I could not stay up-to-date with social media and online networks
18. I would feel awkward because I could not check my notification for updates from my connections and online networks

19. I would feel anxious because I could not check my email messages
20. I would feel weird because I would not know what to do

Appendix J

Smartphone screen time recording instructions.

Before coming to the lab, please ensure your screen time is being recorded on your iPhone. To do this, click on your settings icon first. Then in the second box (under do not disturb) click the “screen time” tab. Once in there you should see a button that says, “turn on screen time”, once clicked a screen will come up that list what you can do with this feature. Please click the “continue” button and then the “this is my iPhone” button. A screen will come up that shows a daily average grid and options to choose. This indicates your phone is collecting your screen time data. Please leave this on until you come to the lab to complete the study. We will be collecting data from the information provided in this feature. If you arrive with it not activated, you will be asked to reschedule.

Thank you in advance.

Appendix K

1. What is your service provider?
2. What model IPhone do you have?
3. What is your text tone sound, if you do not know please go into the settings app and select “sounds and Haptics” and look at “text tone”?
4. What color is your IPhone?
5. How long have you had this IPhone?

Appendix L

Dear USCA Student,

My name is Collytte Cederstrom. I am a graduate student in the Psychology Department at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Clinical Psychology, and I would like to invite you to participate. This study is sponsored by the Psychology Department.

I am studying smartphone dependency and the effect of being exposed to cues. If you decide to participate, you will be asked to allow screen time data from your phone to be recorded, your phone to be taken you're your possession for a short amount of time in order to be used in the study, connected to a BioPac machine through electrodes attached to your palms in order to record your electrodermal activity (e.g., sweat conductivity), and answer several questionnaires both on paper and on the computer, and watch a video on the computer screen.

In particular, you will be asked questions about your cell phone usage, anxiety, depression, Fear Of Missing out, and alcohol/drug use. You may feel uncomfortable answering some of the questions. You do not have to answer any questions that you do not wish to answer. The meeting will take place in the Science 312 on USCA's campus and should last about 45 minutes.

Participation is confidential. Study information will be kept in a secure location at the University of South Carolina Aiken. All information provided on the computer will be password protected. The results of the study may be published or presented at professional meetings, but your identity will not be revealed.

You will receive .75 research credits for participating in the study.

Participation, non-participation or withdrawal will not affect your grades in any way. If you begin the study and later decide to withdraw, you will still receive research credit *(or)* there are other research credit opportunities available to satisfy your research requirement.

We will be happy to answer any questions you have about the study. You may contact me at Collytte@usca.edu or my faculty advisor, Dr. Maureen Carrigan at MaureeC@usca.edu, or The University of South Carolina's Office of Research Compliance (803) 777-6670. Thank you for your consideration. If you would like to participate, please open your phone to the screen recorded data to be recorded by the researcher.

With kind regards,

Collytte Cederstrom

Collytte Cederstrom

Collytte@usca.edu