This study uniquely examined the effects on self, cognition, anxiety, and physiology when iPhone users are unable to answer their iPhone while performing cognitive tasks. A 2 x 2 within-subjects experiment was conducted. Participants (N = 40 iPhone users) completed 2 word search puzzles. Among the key findings from this study were that when iPhone users were unable to answer their ringing iPhone during a word search puzzle, heart rate and blood pressure increased, self-reported feelings of anxiety and unpleasantness increased, and self-reported extended self and cognition decreased. These findings suggest that negative psychological and physiological outcomes are associated with iPhone separation and the inability to answer one’s ringing iPhone during cognitive tasks. Implications of these findings are discussed.

Keywords: Cell Phone Separation, Extended Self, Cognition, Anxiety, Physiology.

doi:10.1111/jcc4.12109

Cell phone use has become a ubiquitous part of everyday life, and the cell phone has become one of the most popular devices for communicating with others. Consistent with the primary social functions of the household/landline telephone, mobile communication via the smart phone helps strengthen bonds among family members (Wei & Hwei-Lo, 2006) while also expanding the user’s “psychological neighborhoods” and facilitating “maintenance of symbolic proximity” (Wei & Hwei-Lo, 2006). While
these devices continue to facilitate relationship maintenance, the physical and emotional attachments humans have developed with cell phones have simultaneously increased (Srivastava, 2005). Indeed, recent research indicates that such attachments are associated with greater feelings of anxiety when users are distanced from their smart phone devices, specifically for heavy smartphone users (Cheever, Rosen, Carrier, & Chavez, 2014).

However, research has not shown how iPhone separation affects physiological responses during cognitively demanding tasks. For the current study, we ask the hypothetical questions, what physiological responses occur when students are taking a test and are unable to answer their ringing iPhone? Does anxiety from not being able to answer one's iPhone affect performance on the test? Or, for another example, when sitting in a conference meeting when one is unable to answer his or her iPhone, what physiological responses are induced? Thus, the goal of this study is to examine the effects of iPhone separation on cognitive and physiological outcomes during such daily occurrences (i.e., when a cell-phone user is unable to answer his or her nearby ringing iPhone). Before discussing the results of the study we will review the psychosocial role of the smart phone, the Extended-Self Theory, and the Embodied Motivated Cognition framework.

**Psychosocial Role of the Smart Phone**

In explaining the phenomenon of *mobilization*, Harkin (2003), who draws on the seminal work of Brown, Green, and Harper (2001) and Katz and Aakhus (2002), explains that mobile technologies are capable of being incorporated in the fabric of economies, social lives, and communications. Harkin (2003) proposes that mobile technologies are important to the modern sense of self because they “function as comfort objects, antidotes to the hostile terrain of wider society,” (p. 9), and have become entities so intimately a part of us that they are capable of representing “an extension of our physical selves – an umbilical cord, anchoring the information society's digital infrastructure to our very bodies” (Harkin, 2003, p. 16). Indeed, such propositions are reflected by the sheer amount of time, on average, users are spending with their mobile devices. For instance, young adults aged 18–24 send an average of 109.5 text messages per day, or roughly 3,200 texts each month, while also checking their cell phones 60 times a day (Brenner, 2012; Roberts & Pirog III, 2013). Moreover, Srivastava (2005) found that smart phone users use their smartphone as an alarm clock and even sleep with their phone under their pillow or on their bedside table. This type of cell phone attachment and dependency gives users the impression that they are constantly connected to the world and therefore feel less alone (Srivastava, 2005).

Attachment to one’s cell phone may result from the phone’s capacity to provide information access, social interaction, and personal safety (Aoki & Downes, 2003). One alternative explanation as to why people may become attached to their iPhone is the component of fear of missing out (FoMO), which is operationally defined as “the fears, worries, and anxieties people may have in relation to being out of touch with the events, experiences, and conversations happening across their extended social circles” (Przybylski, Murayama, DeHaan, & Gladwell, 2013, p. 1482). For instance, research by Rosen, Carrier, & Cheever (2013) and Rosen, Whaling, Rab, Carrier, & Cheever (2013) found anxiety to be associated with not being able to check in using various technologies, such as checking online social networking sites such as Facebook. In addition to FoMO, psychiatric researchers have defined a new disorder related to people’s dependence on mobile devices termed *Nomophobia* (a portmanteau for “no mobile phone” and phobia). This disorder refers to the pathological fear, anxiety, or discomfort related to being out of touch with technology (King et al., 2013). Based on the literature above, it seems quite likely that users may experience feelings of anxiety that can result from technology separation (i.e., Nomophobia) or concerns of missing out within one’s social circles (i.e., FoMO) when separated from their ringing iPhone.
Extended Self

In addition to Nomophobia and FoMO, one additional theoretical explanation as to why cell phone users may experience anxiety when separated from their device is the Extended Self Theory (Belk, 1988/2013). Similar to Harkin’s (2003) notion that mobile technologies can become extension of our physical selves as described above, the Extended Self Theory proposes that an individual’s possessions, whether knowingly or unknowingly, intentionally or unintentionally, can become an extension of one’s self. For example, Belk (1988) illustrates his theory by referring to McClelland (1951), who suggests that external objects become viewed as part of self when we are able to exercise power or control over them, just as we might control an arm or leg. The point is that when we are able to exercise power or control over our possessions, the more closely allied with the self the object becomes. In addition, Clark (2008) discusses extension of self, termed “embodiment.” Clark introduces the idea of a “negotiable body” in which, under certain conditions, the brain incorporates external elements into the body schema, treating these as part of the subject’s body. Similar to McClelland (1951), Clark (2008) provides a scenario about a skilled carpenter and his hammer to explain the idea of negotiable body. In this example, Clark explains that once the carpenter has mastered using the hammer, the carpenter sees through the hammer to the task at hand. Thus, the body has incorporated the hammer into the body schema treating it as an extension of the body to complete the task. Clark’s negotiable body thesis adds further support to Belk’s Extended Self Theory, suggesting that the more an object becomes a possession, the more a part of the self it becomes. Thus, it seems likely that if possessions are viewed as part of self (Belk, 1988/2012), unintentional loss of a possession should be regarded as a loss or lessening of self. The researchers hypothesize that iPhone separation should lead to variation in perceived levels of extended self.

H1: Self-reported levels of extended self will be lower when participants are separated from their ringing iPhone than when they possess it.

Embodied Motivated Cognition

In addition to the theoretical propositions predicted by the Extended Self Theory, this study also operates under the Embodied Motivated Cognition (EMC) theoretical framework (see Bolls, Wise, & Bradley, 2012 for a review). The EMC framework posits that cognitive and emotional processing is determined by patterns of motivational activation elicited as our embodied cognitive/emotional system perceives and adaptively responds to information in our environment, which clearly includes the range of media content we are exposed to on a daily basis (A. Lang, 2009; P.J. Lang, Bradley, & Cuthbert, 1997). Motivational activation may be either appetitive or aversive (Cacioppo, Gardner, & Berntson, 1997). Generally, the appetitive motivational system is activated when we encounter stimuli that attract us or that which we like, and the aversive motivational system is activated when we encounter negative or unpleasant stimuli or that which we don’t like (Cacioppo et al., 1997). Appetitive motivation drives a person to engage with the stimuli and aversive motivation activation drives people to distance themselves, or withdraw, from the stimuli (Cacioppo, Gardner, & Berntson, 1999).

Viewing processing of iPhone separation through the lens of the EMC framework enables researchers to validly index cognitive and emotional processes evoked during iPhone possession and separation. The EMC framework affords this capability because mental processes are thought to be reflected in the moment-by-moment or second-by-second physical functioning of the human brain, which is connected to the rest of the body through the nervous system (Bolls et al., 2012). These processes are capable of being indexed through reliable psychophysiological measures including blood pressure and heart rate measures (Potter & Bolls, 2012). Moreover, incorporating meaningful self-report measures of psychological states emerging from embodied motivated processing in
experimental research provides a holistic approach to understanding how media may impact different processes (Potter & Bolls, 2012). Thus, we will briefly highlight the literature on self-reported anxiety as it relates to iPhone separation before discussing our psychophysiological predictions.

**State Anxiety**

Several scholars have investigated the impact of cell phone separation on self-reported feelings of panic and anxiety finding evidence of a relationship between cell phone attachment and greater feelings of panic during separation (Vincent, 2006) and anxiety during separation (Beranuy, Oberst, Carbonell, & Chamarro, 2009; Bianchi & Phillips, 2005; Cheever et al., 2014; Rosen et al., 2013a; Rosen et al., 2013b). This research suggests that the relationship between cell phone separation and self-reported anxiety should be positively related. Moreover, since being separated from one’s mobile device while not being able to answer is most likely a common daily occurrence for most users, we take the above line of literature a step further by measuring the extent to which iPhone users experience state anxiety when separated from their iPhone while it is ringing. Based on the above literature, we hypothesize the following:

\[ \text{H2: Self-reported levels of state anxiety will be greatest when participants are separated from their ringing iPhone than when they possess it.} \]

**Physiological Anxiety**

In addition to self-reported anxiety, we also examine the psychophysiological manifestations of cell phone-related separation anxiety. Spielberger (1979) refers to the overall state of anxiety as “stress.” Stress, from a physiological perspective, manifests as a biological process within the sympathetic nervous system in preparation for the “flight or fight response.” In a flight response (i.e., aversive situation), adrenaline and cortisol are released. These hormones increase heart rate, breathing rate, and perspiration and constrict blood vessels in order for the heart to pump more blood to the core of the body rather than the extremities (heart.org, 2012). The constriction of blood vessels, in conjunction with an increase in heart rate acceleration, increases blood pressure (Lazarus & Folkman, 1984; Severtsen & Pranulis, 1995). However, in response to an acute stressor the constriction of blood vessels and acceleration in heart rate is situational and temporary and is contingent on the duration of the stressor. Thus, both blood pressure and heart rate return to their prestress level once the situational stressor is removed (heart.org, 2012).

**Conceptualization of a Situational Stressor**

For the current study, the researchers conceptualized “temporary stressor” as a temporary separation between the participant and his or her ringing iPhone. In our study, although the iPhone may stop ringing, the stressor remains in effect until the iPhone is returned to the participant’s immediate possession. Based on the EMC framework (Bolls et al., 2012), the researchers hypothesize that a temporary acute stressor/aversive situation (i.e., cell phone ringing during separation) will cause temporary increases in blood pressure levels but that participants’ blood pressure levels will return to baseline when in possession of their iPhone.

\[ \text{H3: Systolic blood pressure will be greatest when participants are separated from their ringing iPhone than when they possess it.} \]

\[ \text{H4: Diastolic blood pressure will be greatest when participants are separated from their ringing iPhone than when they possess it.} \]
Further, the researchers suspect that an acute stressor may impact cognition. According to the EMC framework (Bolls et al., 2012) and Cacioppo et al.’s (1999) dual systems model, two independent motivational systems are capable of influencing cognition: the appetitive (or approach system) and the aversive (avoid/defensive systems). In the case of iPhone separation, the researchers suspect that anxiety from not having one’s iPhone will elicit aversive motivation activation. Activation of this system is typically indexed by self-reported increases in feelings of unpleasantness with a simultaneous increase in cardiac activity (Bradley, Codispoti, Cuthbert, & Lang, 2001; Lazarus & Folkman, 1984; Spielberger, 1979). Thus, under acute stress/aversive situation (e.g., a cell phone ringing during separation), the researchers suspect that the aversive motivational system will be activated, resulting in greater feelings of unpleasantness and poorer attention to, and performance on, the puzzle task as indicated by an increase in cardiac activity and poor performance on word search puzzles.

H5: Self-reported unpleasantness will be greatest when participants are separated from their ringing iPhone than when they possess it.

H6: Self-reported levels of pleasantness will be lowest when participants are separated from their ringing iPhone than when they possess it.

H7: Heart rate in beats per minute (BPM) will be greatest when participants are separated from their ringing iPhone than when they possess it.

H8: Performance on a word search puzzle will be worse when participants are separated from their ringing iPhone than when they possess it.

**Method**

**Design**

This study employed a 2 (cell phone: possession/separated and ringing) x 2 (time: possession/separation) repeated-measures experiment. Possession or separation of participants’ iPhone devices during the completion of word search puzzles was manipulated within subjects. Time in which participants did or did not have their iPhone during the word search puzzles was a between-subjects factor.

**Induction Checks**

Prior to the experiment, the researchers generated two word search puzzles using an online generator at (http://puzzlemaker.discoveryeducation.com). The word search format for each word search puzzle consisted of 23 columns by 23 rows containing 50 names of U.S. states. The second word search contained the same structure and words as the first puzzle. However, the words of the U.S. states were rescrambled in a different arrangement, eliminating practice effects. Both word search puzzles were pretested (N = 16) for level of difficulty before the experiment. Results of the pretest are later discussed.

The researchers asked three questions after participants completed the experiment to ensure the manipulation worked. Participants indicated (Y/N) whether they saw and heard their iPhone ringing from the nearby cubicle. In addition, participants also indicated whether they had any prior knowledge about the experiment being cell-phone-related or whether they had any suspicion that it was the researchers calling their iPhone during the experiment by answering Y/N to both questions.
Dependent Variables

Cell phone extension
Cell phone extension is conceptualized as the degree to which participants consider their iPhone an extension of self. Cell phone extension was measured by having participants complete the Objects Incorporated Into the “Extended Self” Scale (Sivadas & Machleit, 1994) in an online questionnaire prior to the main experiment (i.e., with possession of their iPhone), as well as after the word search task in the lab in which their iPhone was removed from their possession (i.e., during cell phone separation). This scale is comprised of six items anchored by 1 = strongly disagree to 7 = strongly agree. The six items on this scale include: “My iPhone helps achieve the identity I want to have,” “My iPhone helps me narrow the gap between what I am and what I try to be,” “My iPhone is central to my identity,” “My iPhone is part of who I am,” “My iPhone is stolen from me I will feel as if my identity has been snatched from me,” and “I derive some of my identity from my iPhone.” Cronbach’s alpha for this scale was .89.

State Anxiety
State anxiety is conceptualized as perceived feelings of fear, nervousness, and discomfort and the arousal of the autonomic nervous system induced by different situations that are perceived as dangerous (Spielberger, 1979). This type of anxiety refers to how a person is feeling at the time of a perceived threat and is considered temporary. State anxiety was measured after each word-search task (i.e., prior to cell phone separation and after cell phone separation). State anxiety was indexed by having participants rate six statements included in the State-Trait Anxiety Inventory (STAI Y-6) (Marteau & Bekker, 1992). Items included “I feel calm,” “I am tense,” “I feel upset,” “I am relaxed,” “I feel content,” and “I am worried.” Statements were rated on a Likert-type scale anchored by 1 = not at all to 4 = very much. The “calm,” “relaxed,” and “content” items were reverse coded. Cronbach’s alpha for this scale = .84.

Physiological Anxiety
Blood pressure is operationalized as variation in systolic (SBP) and diastolic (DBP) blood pressure levels. Systolic measures the amount of pressure in the arteries when the heart beats. Thus, greater systolic blood pressure indicates that there is more pressure needing to be pumped when the muscle contracts (heart.org, 2012). Diastolic measures the pressure in the arteries between the heartbeats (i.e., when the heart is resting between beats) (heart.org, 2012). Typical blood pressure levels of a healthy individual is 120 mmHg (SBP) / 80 mmHg (DBP) (heart.org, 2012). Blood pressure was measured in this experiment as a physiological indicator of anxiety in response to cell phone separation (e.g., acute stressor). The iHealth Lab wireless blood pressure monitor cuff, model BP5, was used to collect DBP and SBP blood pressure responses. Responses were sent via Bluetooth to the researchers’ iPad for data collection. The blood pressure cuff was located on the participants’ nondominant arm just above the elbow region. Three recordings were averaged as a measure of baseline. Two additional recordings were collected during each word search task (i.e., during cell phone possession and during cell phone separation).

Aversive activation
Aversive activation within the aversive motivational system was conceptualized as a significant underlying dimension of emotional responses. Unpleasant emotional responses are reflective of activation in the aversive motivational system. Aversive activation was indexed by having participants rate how “unpleasant” they felt while completing each word search puzzle. These ratings were obtained on 9-point response
scales anchored by the terms “1 = not at all” and “9 = extremely” (Bradley & P. Lang, 1994). Unpleasantness was measured after each word-search task (i.e., during cell phone possession and during cell phone separation).

Appetitive activation
Activation within the appetitive motivational system was conceptualized as a significant underlying dimension of emotional response. Pleasant emotional responses are reflective of activation in the appetitive motivational system. Appetitive activation was indexed by having participants rate how “pleasant” they felt while completing each word search puzzle. These ratings were obtained on 9-point response scales anchored by the terms “1 = not at all” and “9 = extremely” (Bradley & P. Lang, 1994). Pleasantness was measured after each word-search task (i.e., during cell phone possession and during cell phone separation).

Defensive responding
Heart rate was recorded in beats per minute (BPM) and was conceptualized as an indicator of defensive responding to the iPhone ringing during cell phone separation (Bradley et al., 2001; Lazarus & Folkman, 1984; Spielberger, 1979). Heart rate is operationalized as variation in the sympathetic nervous system. The iHealth Lab wireless blood pressure monitor cuff, model BP5, was used to collect BPM responses. Heart rate data responses were sent via Bluetooth to the researchers’ iPad for data collection. The blood pressure cuff was located on the participants’ nondominant arm just above the elbow region. Three recordings were averaged as a measure of baseline. Two additional recordings were collected during each word search task (i.e., during cell phone possession and during cell phone separation).

Performance
Performance was operationalized as the amount of words participants found within a 5-minute time frame of working on a word search puzzle task. The word search puzzle tasks comprised 60 possible words (U.S. states). The first word search puzzle contained the same words as the second word search puzzle; however, both word searches were scrambled so that both had the same words but in different arrangements. This was done in order to eliminate practice effects. In order to measure performance, the researcher totaled the amount of words found during each word search task.

Procedures
Survey Procedure
This study was a multistaged experiment. The survey phase of this study was designed to screen for iPhone users for the experimental portion of the study. Had the researchers explicitly recruited iPhone users, participants would have attended their experiment session expecting that they were participating in a cell-phone-related study, threatening the manipulation of the experiment. Therefore, the researchers recruited students (N = 208) from three journalism courses at a large university in the Midwestern United States to complete an online questionnaire designed on qualtrics.com. Out of the 208 who were recruited, 136 completed the online questionnaire.

Participants were informed that the purpose of the survey was to understand “media usage among a sample of college students.” However, to mask the true purpose of the survey, which was to screen for iPhone users and to collect a premeasure of iPhone extension, the researchers included several distractor questions in the survey. Distractor questions consisted of items measuring Facebook usage, Twitter
usage, Instagram usage, television viewing, and frequency of newspaper reading. Responses from these questionnaires were not included in data analyses.

Once the survey data had been collected, the researchers screened the data for iPhone users (N = 117). The researchers e-mailed those participants who indicated that they were iPhone users with information indicating that they qualified to participate in a second study for additional extra credit and a chance to win a Best Buy $50 gift card. iPhone users were specifically recruited due to the ease with which the researchers could disable the silence mode on the participants’ iPhones. The purposes for disabling the silence mode are explained in the next section of this paper. Of those recruited (N = 117), 41 agreed to participate in the experiment. Participants were then scheduled to participate in a 20-minute experiment conducted in a media psychology lab. Participants were scheduled to participate one at a time in 30-minute time slots.

Experiment procedure
The purpose of the experiment was to examine the degree to which perceived level of self, cognition, emotion, and physiology are affected when a participant is separated from their iPhone while it is ringing. However, participants were told that the experiment was to understand “how well students could complete word search puzzles and for the researchers to test a new blood pressure cuff.” Thus, the participants had no prior knowledge that they were participating in a cell-phone related study or that the researchers would be calling their iPhones during the experiment.

Upon arrival to the lab, participants provided their consent to participate in the study. Participants (N = 41) were randomly assigned to one of two experimental orders. Order one (O1) consisted of participants completing a word-search puzzle with their iPhone followed by a second word-search puzzle without their iPhone. Order two (O2) consisted of participants completing a word-search puzzle without their iPhone followed by a second word-search puzzle with their iPhone in their possession. After randomly being assigned to one of the two orders, each participant was seated in a cubicle in front of an individual PC computer in a computer lab room. Participants were instructed not to get up from their computer for any reason unless notified by the researchers.

Once participants were comfortable, the researchers measured their blood pressure and heart rate levels using the iHealth Lab wireless blood pressure monitor cuff, model BP5. The BP5 sends blood pressure and heart rate in beats per minutes (BPM) readings via Bluetooth to the researchers’ iPad for data collection. The researchers collected three blood pressure and heart rate readings as baseline measurements. Participants then completed demographic questions programmed in MediaLab (Jarvis, 2006) on the desktop computer. Participants were not asked to do anything with their iPhone at this point in the experiment. Next, the researchers provided the participants a pencil-and-paper copy of the word-search puzzle and instructed the participants to find as many words as possible in 5 minutes to increase their chances of winning a $50 BestBuy gift card. At minute 4 of the word search, the researchers wirelessly collected blood pressure and heart rate levels. After 5 minutes elapsed, the researchers collected the word search puzzles and asked participants to complete the unpleasantness and pleasantness items from the Self-Assessment Mannequin (SAM) (Bradley & Lang, P., 1994) and the State Trait Anxiety Inventory (Y-6) (Marteau & Bekker, 1992) programmed in MediaLab (Jarvis, 2006). After completing both questionnaires, the researchers then provided participants a second word search puzzle.

At this point in the experiment, the researchers informed the participants that their iPhone was creating “signal interference” with the blood pressure cuff’s Bluetooth signal and that their iPhone needed to be placed farther away from them in the room. Upon collecting participants’ iPhones, the researchers discretely disabled silence mode by flipping the on/off switch located on the perimeter of the iPhone and then placed the iPhone in a nearby cubicle (4 feet away) located in the same room, which allowed
participants the ability to see and hear their iPhone. Participants were then given a second word-search puzzle and again were instructed to try to find as many words as possible in 5 minutes to increase their chances of winning the gift card.

At minute 3 during the second word search puzzle, the researchers called the participants’ iPhones. The silent mode had been disabled in order to ensure the iPhone rang out loud. Participants had provided their cell phone number on the consent form. This scenario was structured in hopes of simulating the inability to answer one’s ringing iPhone during a cognitive task. The researchers allowed six rings before ending the call, which lasted roughly 20 seconds. At minute 4 of the word search (in order to avoid recording an orienting response (OR) to the onset of ringing), the researchers wirelessly collected blood pressure and heart rate levels. Each measurement lasted roughly 45 s. After 5 minutes elapsed, the researchers collected the word search puzzles and asked participants to complete the Objects Incorporated Into the “Extended Self” Scale (Sivadas & Machleit, 1994), the unpleasantness and pleasantness items from the Self-Assessment Mannequin (SAM) (Bradley & Lang, P., 1994), and the State Trait Anxiety Inventory (Y-6) (Marteau & Bekker, 1992) in MediaLab (Jarvis, 2006).

The procedure for order two was the same as order one except order two consisted of participants completing the first word-search puzzle without their iPhone while it was ringing followed by a second word-search puzzle with their iPhone in their possession. In addition, the researchers informed participants that their iPhones were causing “Bluetooth” interference with the baseline measures and therefore needed to be placed further away in the room. After completing the first word search puzzle without their iPhones in their possession, the researchers informed participants that their iPhones were no longer creating Bluetooth interference and could therefore have it closer to them as long as they enabled silence mode to avoid any further distractions during the experiment (i.e., phone rings). Participants then enabled silence mode and their iPhones on the computer desk in front of them before beginning the next word search puzzle. During the second word search (i.e., possession) all participants focused on the word search puzzle without stopping to view or interact with their iPhone. Participants’ iPhones were on silent mode for the majority of the experiment. Thus, the iPhones did not ring for either phone calls or text messages except when the researcher called during cell phone separation.

During the debriefing, the researchers informed participants of the true purpose of the experiment. Participants were told that the online questionnaire they had completed earlier in the week was to screen for iPhone users for the experiment. In addition, the researchers informed participants that this study used deception by omission by withholding any information about the study measuring cell phone separation anxiety. Before being dismissed, the researchers informed the participants that they had called their iPhone during one of the two word search puzzles using an auto-generated number from GoogleVoice.com. Participants were then informed that they had the option of having their data withheld from data analysis. None of the participants chose this option. Participants were then thanked and dismissed. This study was approved by the university Institutional Review Board (IRB).

Results

Participants
Survey participants (N = 136) were undergraduate students at a large Midwestern U.S. university enrolled in journalism courses. Of those who completed the survey, 117 were iPhone users. The remaining participants were either Android or Galaxy S5 phone users. The average amount of time participants reported being on their iPhone each day was (M$_{\text{minutes}}$ = 207.35, SD$_{\text{minutes}}$ = 254.32) or 3.5 hours per day. Of the 117 iPhone users who completed the survey, 41 participated in the experiment portion of the study. A majority of the participants (73%) were female. The mean age was (M$_{\text{age}}$ = 21.21, SD$_{\text{age}}$ = 3.78),
and most participants (88%) were White; 5% were Black, 5% were Asian, and 2% were Hispanic. Despite being instructed to stay seated throughout the experiment, one participant got up from her chair to answer her iPhone. Her data were not included in the analyses. However, our sample of 40 participants provided > 80% power to detect a moderate effect size with α = .05, one tailed.

Data Analysis
Heart rate, systolic, and diastolic data were analyzed as change from baseline and submitted to a 2 (possession/separated and ringing) x 2 (order) repeated-measures ANCOVA while controlling for self-reported iPhone usage. Change scores from baseline were computed for each time point of data collection by subtracting each time point of heart rate, systolic, and diastolic activity collected during the word search puzzles from the average of the baseline recordings. Each analysis was conducted with a specific focus on examining interaction effects between each dependent variable and time. Data analysis revealed that for all physiological interaction terms with time, the sphericity assumption was violated; thus, Huynh-Feldt degrees of freedom adjustments were made. However, the original degrees of freedom are cited in the results to aid interpretation. Cognitive performance (number of words found on each word search) and self-reported state anxiety, pleasantness, and unpleasantness were submitted a 2 (possession/separated and ringing) x 2 (order) repeated-measures ANCOVA while controlling for self-reported iPhone usage. iPhone use, as a covariate, had no main effect on any of the dependent variables, nor did it interact with the cell phone and time manipulations.

Induction check of materials
The researchers pretested the word-search puzzles to ensure both were of equal difficulty prior to the experiment. Participants (N = 16) were given either word search one (N = 8) or word search two (N = 8). The amount of correct words found was computed for group comparison. An independent samples t-test showed that the means of word search one (M_{WS1} = 7.25, SD_{WS1} = 1.78) and word search two (M_{WS2} = 7.12, SD_{WS1} = 1.69) were not statistically different (t(14) = 1.34, p = .769) in level of difficulty.

The researchers analyzed the postexperiment questions to ensure the manipulation was not compromised. All participants (N = 41) answered “Yes” to having heard and seen their iPhone ringing during the experiment. All participants indicated that they had no prior knowledge about the study being cell-phone related or suspicion that it was the researchers calling their iPhone during the experiment, signifying that the online survey questionnaire was sufficiently masked. After completing the experiment, participants also indicated the degree to which they felt the urge to answer their iPhone while it was ringing during the experiment (M = 4.58, SD = 1.57) and degree to which they felt anxious/nervous from not being able to answer their iPhone during the experiment (M = 5.17, SD = 1.21). Both items were anchored by “1 = not at all” to “7 = extremely.”

Analysis of dependent variables
H1 predicted that self-reported levels of extended self would be lowest when participants were separated from their ringing iPhone than when they possessed it. A paired-samples t-test revealed that the two means were statistically different (t(39) = 3.14, p = .003). iPhone extended self was higher during possession (M = 4.30, SD =1.11) and lower (M = 3.63, SD = 1.40) during separation. H1 was supported.

H2 predicted that self-reported state anxiety would be greatest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on self-reported state anxiety and time, F(1,38) = 14.72; p < .001, η^2_{p} = .27, such that for order 1 self-reported state anxiety was lowest (M = 2.40, SD = .27) at time 1 when participants were in possession of their iPhone and greatest (M = 2.68, SD = .52, p = 0.039 ) at time 2 when participants were
separated from their ringing iPhone. For order 2, self-reported state anxiety was greatest \((M = 2.65, SD = .43)\) at time 1 when participants were separated from the ringing iPhone and lowest \((M = 2.30, SD = .26, p = 0.004)\) at time 2 when participants were in possession of their iPhone. \(H_2\) was supported; see Table 1 and Figure 1a.

\(H_3\) predicted that systolic blood pressure would be greatest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on systolic blood pressure and time, \(F(1,38) = 41.54; p < .001, \eta^2_p = .52\), such that for order 1 systolic blood pressure was lower \((M = 114.61 \text{ mmHg}, SD = 8.81 \text{ mmHg})\) at time 1 when participants were in possession of their iPhone and greater \((M = 120.45 \text{ mmHg}, SD = 8.89 \text{ mmHg}, p = 0.042)\) at time 2 when participants were separated from their ringing iPhone. For order 2, systolic blood pressure was greatest \((M = 124.31 \text{ mmHg}, SD = 13.69 \text{ mmHg})\) at time 1 during iPhone separation and lowest \((M = 109.81 \text{ mmHg}, SD = 8.15 \text{ mmHg}, p = 0.001)\) at time 2 when participants were in possession of their iPhone. \(H_3\) was supported; see Table 1 and Figure 1b.

\(H_4\) predicted that diastolic blood pressure would be greatest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on diastolic blood pressure and order, \(F(1,38) = 63.78; p < .001, \eta^2_p = .62\), such that for order 1 diastolic blood pressure was lowest \((M = 75.96 \text{ mmHg}, SD = 6.60 \text{ mmHg})\) at time 1 when participants were in possession of their iPhone and greatest \((M = 80.69 \text{ mmHg}, SD = 9.73 \text{ mmHg}, p = 0.040)\) at time 2 when participants were separated from their ringing iPhone. For order 2, systolic blood pressure was greatest during iPhone separation \((M = 82.74 \text{ mmHg}, SD = 9.69 \text{ mmHg})\) at time 1 and lowest \((M = 72.34 \text{ mmHg}, SD = 9.74 \text{ mmHg}, p = 0.002)\) at time 2 when participants were in possession of their iPhone. \(H_4\) was supported; see Table 1 and Figure 1c.

\(H_5\) predicted that self-reported unpleasantness would be greatest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on unpleasantness and time, \(F(1,38) = 13.03; p < .001, \eta^2_p = .25\), such that for order 1 unpleasantness was lowest \((M = 2.55, SD = 1.37)\) at time 1 when participants were in possession of their iPhone and greatest \((M = 3.45, SD = 1.39, p = 0.043)\) at time 2 when participants were separated from their ringing iPhone. For order 2, unpleasantness was greatest during iPhone separation \((M = 3.40, SD = 1.35)\) at time 1 and lowest \((M = 2.40, SD = 1.14, p = 0.016)\) at time 2 when participants were in possession of their iPhone. \(H_5\) was supported; see Table 1 and Figure 1d.

\(H_6\) predicted that self-reported pleasantness would be lowest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on pleasantness and time, \(F(1,38) = 3.68; p = .05, \eta^2_p = .08\), such that for order 1 pleasantness was greatest \((M = 4.70, SD = 1.21)\) at time 1 when participants were in possession of their iPhone and lowest \((M = 4.20, SD = 1.43, p = 0.020)\) at time 2 when participants were separated from their ringing iPhone. For order 2, pleasantness was lowest during iPhone separation \((M = 4.44, SD = 1.09)\) at time 1 and greatest \((M = 4.80, SD = 1.15, p = 0.047)\) at time 2 when participants were in possession of their iPhone. \(H_6\) was supported; see Table 1 and Figure 1e.

\(H_7\) predicted that heart rate would be greatest when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on heart rate and time, \(F(1,38) = 181.41; p < .001, \eta^2_p = .82\), such that for order 1 heart rate was lowest \((M = 80.01, SD = 4.72)\) at time 1 when participants were in possession of their iPhone and greatest \((M = 83.83, SD = 6.75, p = 0.043)\) at time 2 when participants were separated from their ringing iPhone. For order 2, heart rate was greatest during iPhone separation \((M = 87.31, SD = 4.67)\) at time 1 and lowest \((M = 74.38, SD = 7.38, p = 0.001)\) at time 2 when participants were in possession of their iPhone. \(H_7\) was supported; see Table 1 and Figure 1f.
Table 1  F-scores (F), degrees of freedom (df), means (M), and standard deviations (SD) for all interaction terms.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>F-score</th>
<th>df</th>
<th>Order 1 (N = 20)</th>
<th>Order 2 (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Anxiety *Time</td>
<td>14.72***</td>
<td>(1, 38)</td>
<td>2.40 (.27)</td>
<td>2.68 (.52)</td>
</tr>
<tr>
<td>Systolic *Time</td>
<td>41.54***</td>
<td>(1, 38)</td>
<td>114.61 (8.81)</td>
<td>120.45 (8.89)</td>
</tr>
<tr>
<td>Diastolic *Time</td>
<td>63.78***</td>
<td>(1, 38)</td>
<td>75.96 (6.60)</td>
<td>80.69 (9.73)</td>
</tr>
<tr>
<td>Unpleasantness *Time</td>
<td>13.03***</td>
<td>(1, 38)</td>
<td>2.55 (1.37)</td>
<td>3.45 (1.39)</td>
</tr>
<tr>
<td>Pleasantness *Time</td>
<td>3.68*</td>
<td>(1, 38)</td>
<td>4.70 (1.21)</td>
<td>4.20 (1.43)</td>
</tr>
<tr>
<td>Heart Rate *Time</td>
<td>181.41***</td>
<td>(1, 38)</td>
<td>80.01 (4.72)</td>
<td>83.83 (6.75)</td>
</tr>
<tr>
<td>Performance *Time</td>
<td>56.37***</td>
<td>(1, 38)</td>
<td>8.50 (2.21)</td>
<td>5.50 (2.32)</td>
</tr>
</tbody>
</table>

Means which do not share a superscript differ significantly from one another (p < .05). Planned comparisons were computed using protected paired samples t-tests.

*p < .05
**p < .01
***p < .001
H8 predicted that performance on the word search puzzle would be worst when participants were separated from their ringing iPhone than when they possessed it. A significant interaction was found on performance and time, $F(1,38) = 56.37; p < .001, \eta^2_p = .59$, such that for order 1 performance was better ($M = 8.50, SD = 2.21$) at time 1 when participants were in possession of their iPhone and worse ($M = 5.50, SD = 2.32, p = 0.001$) at time 2 when participants were separated from their ringing iPhone. For order 2, performance was worse when participants were separated from their ringing iPhone ($M = 6.50, SD = 2.81$) at time 1 and better ($M = 8.35, SD = 2.47, p = 0.034$) at time 2 when participants were in possession of their iPhone. H8 was supported; see Table 1 and Figure 1g.

In order to examine the relationship between self-reported urge to answer one's iPhone and self-reported feelings of anxiety, while statistically controlling for age, ethnicity, gender, and iPhone use, a post hoc multiple regression was used. When urges to answer was regressed on the predictors, the resulting $F$-score was $4.21 \ (p < .001)$. The variance explained in the criterion was .43. Given the significant omnibus $F$-score, the regression coefficients were examined for statistical significance. The standardized beta weight for anxiety was $.551 \ (p < .001)$. Age ($\beta = .043, SE = .09$), ethnicity ($\beta = -.118, SE = .198$), gender ($\beta = -.014, SE = .476$), and iPhone usage ($\beta = .158, SE = .002$), were all nonsignificant predictors. Thus, urges to answer one's iPhone while it was ringing during the
experiment, while statistically controlling for demographics and iPhone usage, significantly predicted self-reported feelings of anxiety from iPhone separation.

In addition, to examine whether separation anxiety or urges to answer one’s iPhone during separation predicted poor performance on the word search puzzles, while statistically controlling for age, ethnicity, gender, and iPhone use, a post hoc multiple regression was used. When anxiety and urges were regressed on the predictors, the resulting $F$-score was 4.73 ($p < .001$). The variance explained in the criterion was .50. Given the significant omnibus $F$-score, the regression coefficients were examined for statistical significance. The standardized beta weight for anxiety was $-0.547$ ($p < .001$). Urges to answer one’s iPhone, however, did not predict poor performance on the puzzle task during iPhone separation ($\beta = -0.050, SE = .263, p = .731$). Age ($\beta = 0.145, SE = .214$), ethnicity ($\beta = -0.248, SE = .360$), gender ($\beta = -0.197, SE = .822$), and iPhone usage ($\beta = 0.144, SE = .003$), were all nonsignificant predictors. Thus, self-reported anxiety from not being able to answer one’s ringing iPhone during a word-search puzzle, while controlling for demographics and iPhone usage, significantly predicted poorer performance on the word search puzzles whereas urges to answer one’s iPhone did not.

Discussion

This study investigated the relationship among a group of 40 cellphone users (who are all iPhone users) and the psychological and physiological effects of their separation from these cellphones during cognitive tasks. The researchers hypothesized that the aversive motivational system would activate (i.e., increases in heart rate and self-report unpleasantness) during iPhone separation, resulting in poor performance on word search puzzles (i.e., finding fewer words). We also hypothesized that iPhone separation would lead to greater physiological anxiety (i.e., increases in blood pressure levels) and self-reported anxiety. As a test of the Extended Self Theory (Belk, 1988), we hypothesized that iPhone users in this study would report a lessening of self during iPhone separation. These propositions were completely supported.

The data tell an interesting and unique story about how iPhone separation and the inability to answer one’s iPhone during cognitive tasks affects a variety of psychological outcomes. The data showed that the inability to answer one’s iPhone while it was ringing activated the aversive motivational system (increases in heart rate and unpleasantness), and also led to a decline in cognitive performance. In addition, physiological levels of anxiety (blood pressure) increased in response to iPhone separation (i.e., acute stressor, Spielberger, 1979). It is interesting to note that self-reported feelings of unpleasantness and anxiety reflected participants’ physiological responses such that perceived levels of unpleasantness and anxiety were greatest during iPhone separation. In contrast, when participants completed word-search puzzles with their iPhone in their possession, heart rate and blood pressure levels returned to baseline and cognitive performance increased. Again, self-reported feelings of unpleasantness and anxiety reflected participants’ physiological responses such that perceived levels of unpleasantness and anxiety were lowest when participants were in possession of their iPhone. The Extended-Self Theory (Belk, 1988/2013) was also supported in our study, which showed that iPhone users indeed felt greater extension of self when in possession of their iPhone as opposed to during separation. This finding shows that cellphone users are capable of perceiving their iPhone as an object of their extended self, which can be negatively impacted (i.e., lessening of self) during separation (Belk, 1988). This finding alone calls for future research on whether other technological devices are capable of becoming incorporated into the extended self.

Our results also provide insight into the role of attention and the impact of external and internal distractions. According to González and Mark (2004), workers switch tasks every 3 minutes, and, once distracted by external stimuli (e.g., alerts, ringing iPhones, etc.), take nearly a half-hour to resume the original task. In addition, people distract themselves by internal stimuli (i.e., anxiety) about half as much...
as they are interrupted by external influences (González & Mark, 2004). In our study, we believe we captured both aspects of this phenomenon, which further validates the real-world experience of working on cognitive demanding tasks when being simultaneously distracted by both external and internal stimuli. Moreover, readers of this study may initially believe that the ringing of an iPhone caused an external distraction, which led to users performing poorly on the word search puzzles. However, results from our study show quite the opposite. Anxiety from not being able to answer one’s iPhone significantly predicted poor performance on word search puzzles whereas urges to answer one’s iPhone did not. However, we acknowledge that the more separation anxiety one experiences the more distracting their ringing iPhone may be while completing a task. In contrast, we believe that if one does not experience cell phone separation anxiety from his or her iPhone, the ringing of their iPhone would be less of a distraction, if at all.

The findings from our study also provide several useful advancements in this area of research. Our findings suggest that iPhone separation can severely impact attention during cognitive tasks. Perhaps not just in the case of completing cognitive tasks, but also in all areas of our lives including communicating with strangers, friends and family, colleagues, and care-providers. Simply not being able to answer one’s iPhone may reduce attention toward those daily interactions. In addition, separation from one’s iPhone may also impact allocation of mental resources to processing media, which raises several potential questions for message processing scholars.

Limitations

Limitations of this study may also lead to several possibilities for future research. Further research into this area should consider some methodological alternatives to the current study. For instance, measuring facial electromyography as an indicator of positive/negative emotion and skin conductance as a measure of arousal/motivation activation might provide greater insight into the cognitive and emotional processes associated with iPhone separation. Due to our limited sample size, the generalizability of our findings should be approached with caution. In addition, future research should investigate psychophysiological responses to iPhone separation on other subgroups of the general population, as well as with a larger sample of cellphone users. For example, future studies should examine how different smart phone users, beyond iPhone users, are affected by cell phone separation and whether separation from other technological devices results in similar negative outcomes. Future research should also take steps to measure how simple cell phone separation (i.e., without calling participants’ iPhones) affects users’ cognitive and emotional responses.

Conclusion

This study examined how extended self, cognition, emotion, and physiology are affected when iPhone users are unable to answer their iPhone during cognitive tasks. Overall, it appears that iPhone separation negatively affects the aforementioned outcomes. The preceding results serve to propel this line of inquiry toward a better understanding of how technology separation affects users.

References


About the Authors

**Russell B. Clayton** is at the School of Communication, Florida State University, 4100 University Center, Building C, Tallahassee, FL 32306.

**Glenn Leshner** is at the Gaylord College of Journalism and Mass Communication, University of Oklahoma, 395 W. Lindsey Room, Norman, OK 73019.

**Anthony Almond** is at The Media School, Indiana University, 1229 E. 7th St., Bloomington, IN 47405.