Computers in Human Behavior 37 (2014) 290–297

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Out of sight is not out of mind: The impact of restricting wireless mobile device use on anxiety levels among low, moderate and high users

Nancy A. Cheever [a,*], Larry D. Rosen [b], L. Mark Carrier [b], Amber Chavez [a]

[a] Department of Communications, California State University, Dominguez Hills, 1000 E. Victoria St., SAC 1166, Carson, CA 90747, United States
[b] Department of Psychology, California State University, Dominguez Hills, 1000 E. Victoria St., SBS B-241A, Carson, CA 90747, United States

ARTICLE INFO

Article history:

Keywords:
Anxiety
Smartphones
Mobile Phones
Wireless Mobile Devices
Dependence

ABSTRACT

Overuse of wireless mobile devices (WMDs) may be associated with a form of psychological dependency, of which a prominent feature may be anxiety arising from separation from these devices. College students, who are among the most avid consumers of WMDs, might be susceptible to the negative effects of WMD overuse. The present study examined anxiety in American college students when their WMDs were unexpectedly not available. Upon arrival, approximately one half of the 163 participants were randomly assigned to have their WMDs removed from their possession; the other half was allowed to keep their WMDs but were required to turn them off and place them out of sight. Participants were forced to sit quietly with no distractions during the study. The state portion of the State/Trait Anxiety Inventory (STAI) was administered three times, 20 min apart, beginning 10 min after the participants entered the room. The results showed that participants felt significantly more anxious over time. However, this pattern was evident only with heavy WMD users and with moderate WMD users whose devices were taken away. Dependency upon WMDs, mediated by an unhealthy connection to their constant use, may lead to increased anxiety when the device is absent.

1. Introduction

In the last two decades mobile phones have made the transition from being simple communication tools to sophisticated wireless mobile devices (WMDs) commonly referred to as "smartphones." Recent estimates by the Pew Internet and Life Project (Brenner, 2013) indicate nearly 60% of Americans own a smartphone, and the increased adoption of these devices permeates every demographic, though more young, college-aged people in urban areas own smartphones than older people in rural areas who are not in college (Smith, 2012). The adoption of these devices has reached a level of saturation, and their complex functionality and sophisticated design has played a role in their users' dependency (Leung, 2008). These devices enable users to locate information instantaneously, access entertainment and make and rearrange plans (Leung, 2008; Vincent, 2006), as well as communicate immediately through social media platforms and text messaging. While the preferred method of communicating among young adults is face to face, the most common method is text messaging using the WMD (Rosen, Cheever, & Carrier, 2012), suggesting that communication through these devices is now an essential part of everyday American life.

In addition to rampant text messaging, people check their smartphones for notifications, email messages, alerts, and social media comments multiple times per hour, and use the Internet on their smartphones multiple times daily (Rosen, Whaling, Carrier, Cheever, & Rokkum, 2013a,b). As people use their WMDs regularly, they find it more difficult to be without them (Hooper & Zhou, 2007). Because of the ubiquitous nature of the WMD, it is important to understand how its use affects people's well-being, and the psychological consequences of having the device taken from frequent users.

1.1. Frequency of WMD use

With the majority of American adults using smartphones on a daily basis (Brenner, 2013), people's dependence on these devices has created a culture of connectedness in which users access their WMDs everywhere and at any time. This has prompted educators, researchers and medical professionals to devise strategies to assuage the negative effects of this dependency (American

* Corresponding author. Tel.: +1 310 243 3817.
E-mail address: ncheever@csudh.edu (N.A. Cheever).

http://dx.doi.org/10.1016/j.chb.2014.05.002
0747-5632/

Academy of Pediatrics.org, 2014; Derks & Bakker, 2012; Kim, 2013; Rosen et al., 2012), and lawmakers to create legislation restricting WMD use while driving, referred to as "distracted driving" laws (Governors Highway Safety Association., 2014).

Recently, text messaging through the WMD has become the most common method of communicating among 18- to 24-year-olds, with an average of 109.5 text messages exchanged per day (Smith, 2012). Research on the psychological consequences of removing the ability to communicate via text has had mixed results. In a study restricting text messaging, researchers allowed participants to self-regulate their text abstention behavior for two days. After the hiatus from their devices, participants reported feeling "annoyed," "anxious," and "agitated" when unable to text those they felt close to (Skierkowski & Wood, 2012). Lepp, Barkley, and Karpinski (2013) found through survey research that cell phone use was positively related to anxiety among college students, while Reid and Reid (2007) discovered that anxious participants preferred text messaging over other methods of communication, which mediated the effects of anxiety.

The expectation of being connected 24/7 may lead to higher WMD use. Thomée, Dellve, Härenstam, and Hagberg (2010) discovered through interviews that a common perception regarding mobile phone use was the constant demand and expectation to be available everywhere at all times. This perceived demand of availability was shown to increase mobile phone use. A concept the authors label as "communication overload" is evident in excerpts from interviews that assert feelings of guilt, resentment, and stress attempting to answer and decipher important from less important messages. Thomée, Härenstam, and Hagberg (2011) examined the same concept along with other elements such as mental overload, disturbed sleep, and never feeling free as consequences of high mobile phone use. They found a positive association between availability demands and current stress and symptoms of depression among men and all of the mental health variables among the women. Being awakened at night was associated with all mental health variables for both men and women. They found the highest association to be with accessibility stress in relation to negative mental health outcomes.

Previous literature has explored other possible factors including age, gender and health status as potential determinants of those most affected or likely to be affected by the inclusion of WMDs into everyday modern life. In a study on technology use, Rosen et al. (2012) found that more than 60% of younger people—specifically those in the iGeneration (born in the 1990s) and Net Generation (born in the 1980s)—check their smartphones every 15 min or less, while just 40% of Gen Xers (born between 1965 and 1979) and less than 20% of Baby Boomers (born between 1946 and 1964) engage in this behavior. Further, the study found about 50% of young people reported they felt anxious when they could not check their technology, compared to about 25% of Gen Xers and 15% of Baby Boomers who felt the same. A study on the impact of "keitai" (Japanese cellphones) on Japanese junior high school students found when restricted from communicating with their friends and family, almost 48% of the respondents experienced a feeling of insecurity, which created the perception of being ignored (Kamibeppu & Sugiura, 2005). The authors concluded this perception could cause great anxiety among children that age. Further, a study of cell phone use among young people found more use related to lower feelings of loneliness, suggesting higher dependency on the devices (Jin, 2007).

Although gender remains an inconclusive factor in studies, researchers have found that women use the devices to remain in close contact with relationships, while men utilize them for more functional purposes (Bianchi & Phillips, 2005; Sánchez-Martínez & Otero, 2009). Walsh, White, and Young (2010) expressed the importance for future studies to possibly attempt a gender equal population to further investigate how the differences affect behavior.

1.2. WMD use and anxiety

Minimal research exists on the implications of WMD use on psychological factors or psychiatric disorders such as anxiety levels when the device is absent. Previous inquiries into WMD overuse have suggested that being without the device for a period of time may induce anxiety in heavy users, and that the WMD serves as a distraction that may reduce anxiety in certain circumstances. While psychological researchers and practitioners differ in their definitions of anxiety, most agree that people who suffer anxiety have intense feelings of fear and physical discomfort that can range from mild to total incapacitation (Fauman, 2002; Halgin & Whitbourne, 2000; Maddux & Winstead, 2005; Turner & Hersen, 1984). Anxiety is demonstrated by a worrisome feeling of future events in which the person experiencing the problem is unusually tense, agitated, apprehensive and uneasy about the prospect of something unpleasant happening to them or others. Prescription drugs for anxiety are among the most widely prescribed and used in the United States, and it is estimated that every year about 18% of U.S. adults experience some form of pathological anxiety (National Institutes of Mental Health, 2013). No research we uncovered links anxiety to the absence of the WMD; however anxiety as an independent variable had a positive relationship with mobile phone addiction among Taiwanese college students (Hong, Chiu, & Huang, 2012), and had a positive association with cell phone use among American college students (Lepp et al., 2013).

Anxiety has further been identified as a component of fear of missing out (FoMO), which is operationally defined as "the fears, worries, and anxieties people may have in relation to being in (or out of) touch with the events, experiences, and conversations happening across their extended social circles" (Przybylski, Murayama, DeHaan, & Gladwell, 2013, p. 1842), commonly associated with WMD use. In a study that examined relationships between technology use and psychiatric disorders, Rosen et al. (2013a),Rosen et al. (2013b) discovered a link between anxiety and not being able to check in with various technologies. Having anxiety about not being able to check Facebook predicted increased symptoms of antisocial personality disorder, narcissism, and compulsive personality disorder, while anxiety about checking one's personal e-mail predicted additional symptoms of antisocial disorder and anxiety about checking work e-mail predicted compulsive disorder. However, the authors discovered the most anxiety was propagated by not being able to check text messages, which was linked to symptoms of antisocial and paranoid personality disorders.

A group of psychiatric researchers in Brazil have defined a new disorder called *Nomophobia*, which describes people's dependencies on mobile devices (King et al., 2013). This disorder refers to anxiety or discomfort caused by being out of contact with a WMD or computer, or a fear of remaining out of touch with technology, especially among those who exhibit social phobias. King et al. developed their hypothesis using case studies that described people's reactions to the absence of their devices.

King et al.'s (2013) findings suggest that technological distractions may ease social anxiety in adults. These distractions have also been documented to ease anxiety among children during medical procedures. Studies have explored distractions ranging from music and video games to virtual reality. For example, Patel et al. (2006) found a significant decrease in anxiety in children about to undergo surgery who were given a video game to play over those who had a parent present but did not play the video game. The same findings were found among children undergoing cancer procedures (Gershon, Zimand, Pickering, Rothbaum, & Hodges, 2004). In Gershon et al.'s pilot study the children for which a virtual reality distraction was provided showed a lower pulse rate than those without it. Both of these studies indicate the significant role distractions play in situations of pain. These findings can shed light

on the importance of distractions in other uncomfortable circumstances, such as having their WMDs taken away. This study's primary goal is to further the inquiry into the WMD's psychological impact on students by understanding how its absence may contribute to heightened levels of anxiety utilizing an experiment during which there are no alternative distractions to keep people from thinking about their device.

1.3. Classification of WMD overuse

Many of the substance-abuse disorders in the DSM-IV list anxiety as one of the major withdrawal symptoms (Fauman, 2002). The secondary goal of this study is to advance the understanding of anxiety as a withdrawal from technology use, further informing the existing literature on WMD overuse classifications. As a fairly new and important concept among researchers, overuse of the wireless mobile device has been studied and classified in a variety of ways, none of which points to widespread accepted terminology. The existing research wavers on classifying the condition as an addiction, a compulsion or an impulse disorder (Jenaro, Flores, Gomez-Vela, Gonzalez-Gil, & Caballo, 2007; Park & Lee, 2011), or correlates addiction tendency measures with smartphone use (Wu, Cheung, Ku, & Hung, 2013). Addiction as a medical concept involves the use of chemical substances and associated behaviors. Some researchers have attempted to apply this term to mobile phone overuse using established scales that measure other concepts, while others have introduced new measures for Internet addiction that are extended to smartphone use. For example, Bianchi and Phillips (2005) examined technological addiction—which develops through behavior change, a symptom of substance addiction. The authors found high construct validity in measuring problematic mobile phone use with the Mobile Phone Problem Usage Scale, which they found was "related to an established measure of addiction—the MMPI-2 Addiction Potential Scale" (p. 47). The consensus reiterated throughout previous research, however, is the need to develop an appropriate measure to assess behaviors that exist outside the traditional concept of addiction (Boca & Brown, 1996; Jenaro et al., 2007). Jenaro et al. (2007) found a lack of significant association between cell phone overuse and additional substance abuse, and suggested that "cell phone overuse or pathological use constitute additional symptoms of broader disorders such as depression, anxiety, and so on" (p. 317). Blaszczynski (2006) asserted the need for researchers to discontinue comparing and adapting criteria of one disorder to assess another on the basis that it is most similar and instead provide empirically supported data that the disorder exhibits the salient features of an addictive disorder before further labeling it an addiction.

To further confound the understanding of WMDs' impact on people's psychological well-being, the existing literature seems to concede that the common self-report method brings limitations to establishing accurate levels of mobile device use (Jenaro et al., 2007; Jin & Pena, 2010). In addition, Walsh et al. (2010) found that the previous research about mobile phones has focused primarily on frequency of use and does not adequately measure the interactions people have with their device as a mobile computer, and how cognitively preoccupied they were when not using it. Walsh and colleagues conceptualized the concept of mobile phone "involvement" after discovering that young people reported thinking about their phone when they did not have it and when they did have it, the device was prominently displayed, keeping it in constant awareness and causing a distraction from other tasks (Walsh & White, 2007; Walsh, White, & Young, 2008; Walsh et al., 2010).

Lortie and Guitton (2013) examined 14 questionnaires published between 1993 and 2011 that purported to measure Internet addiction. Across the 14 measures, factor analysis revealed six distinct components that related to DSM-IV criteria for substance dependence including salience, compulsive use, negative outcomes, escapism, and mood regulation. The authors pointed out the limits of current assessment tools, and suggested that "additional elements could be evaluated in questionnaires to ensure that immoderate behaviors are occurring, such as minimum time spent online" (p. 1213), duration of presented symptomology, and the severity of associated consequences such as a decline in professional or academic performance.

Without a clear label for WMD overuse or dependency, the secondary goal of the present study is to help further define the concept of WMD dependency by measuring anxiety—a symptom of substance withdrawal associated with addiction—when the wireless mobile device is taken away for a short time and there are no distractions keeping people from thinking about it.

1.4. Hypotheses

The purposes of this study are to: (1) examine students' anxiety levels when their device is absent—either taken by the experimenters or stowed out of sight at their seat—and there are no distractions; (2) to compare anxiety levels of those with and without their device in local proximity, and (3) to examine how WMD use habits relate to anxiety levels with or without the device nearby. It is posited that removing the mobile device from young people's possession will cause anxiety over a very short time period, especially if no distractions exist, and that high WMD users will experience the most anxiety from having their devices removed from their possession.

With that, the following hypotheses were developed:

Hypothesis 1. Participants without the use of their device will report significantly more anxiety over time, regardless of whether they had their device taken away or it was turned off and out of sight.

Hypothesis 2. Participants without the use of their device will report significantly more anxiety than those with their device close by, even though the latter are not able to access their device.

Hypothesis 3. Participants who use their WMD more during a typical day will report significantly more anxiety than those who use their WMD less in a typical day.

2. Method

2.1. Participants

Participants ($N = 175$) were recruited from a large upper division general education social science course at a mid-sized Southern California university. Twelve participants were excluded from the analyses: four participants were dismissed during the experiment because they were being disruptive or they did not follow directions; six participants who were randomly assigned to the have their WMD taken away were removed because they either did not have their phone with them or they would not relinquish it; the final two participants were removed because data screening results indicated that they did not answer honestly or were intentionally being deceitful. All subsequent analyses were conducted with the cleaned sample ($N = 163$).

Participants ranged in age from 19 to 57 with an average age of 24.40 ($SD = 6.1$). Seventy-five percent ($n = 122$) were 24 years old or younger. The age distribution generally represented the university's student population. Gender was evenly distributed with

males ($n = 83$) comprising 51% and females 49% ($n = 80$) of the sample. The ethnicity of the sample was varied and approximately reflected the general Los Angeles population with the majority being Hispanic/Latino/Spanish Descent (49%), followed by Black/African–American (17%), Asian/Asian–American/Pacific Islander (10%), and Caucasian, Non-Hispanic (9%). Half of the participants were employed part-time, a third were unemployed, and 12% were employed full-time.

2.2. Measures

2.2.1. State-trait anxiety inventory

The state portion of the State-Trait Anxiety Inventory (STAI; Spielberger, 1983) was used to assess anxiety levels of the participants. The state portion of the STAI consists of 20 statements that assess feeling states (e.g., *I feel calm*) with Likert-type response options (1 = not at all to 4 = very much so). The state portion of the STAI was administered three times at 20-min intervals over the course of the 75-min. experiment beginning 10 min after the participants were seated in the classroom (allowing five minutes for participants to locate the materials and complete the questionnaire). The nine STAI items that were phrased as positive states (e.g., calm, secure) were reverse scored and then the total of all 20 items was computed to create the dependent variable. Anxiety scales consisting of 20 aggregated scores were created for each administration ($Anxiety_1$, $Anxiety_2$, and $Anxiety_3$). Reliability analysis was conducted and each scale was found to have strong internal consistency with Cronbach's Alpha levels at .907 ($Anxiety_1$), .928 ($Anxiety_2$), and .940 ($Anxiety_3$).

2.2.2. Daily wireless mobile device usage

A survey measuring participants' technology use was given in the last 15 minutes of the experiment. A series of nine questions assessed hours of daily WMD use (adapted from Rosen et al., 2013a; Rosen et al., 2013b) including using the WMD to: *go online and visit websites, send and receive e-mail, participate in instant message conversation or participate in online chats, talk on a telephone, send and receive text messages, play video games, listen to music on the radio, watch television, read books or magazines.* Answer choices included the following options which were converted to the indicated numerical hours *not at all* (0), *less than 1 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). The hours for each WMD use were summed to create a single scale (Cronbach's alpha = .705).

2.3. Procedure

Students from a large social science course at a Southern California university were given extra credit to participate in a study about anxiety. The students were randomly assigned to one of two test days. The true nature of the study was not disclosed until a debriefing statement was issued at the conclusion of the study. The study took place in a large lecture hall with no windows or clocks—the only visual stimuli were the researchers, who spoke briefly when administering directions and stood silent for the duration of the experiment.

Upon arrival, participants were randomly assigned to one of two groups—one in which researchers removed the wireless device from participants' possession (in return for a claim check) and handed them a study packet (No WMD group; $n = 79$), and the other in which only the study packet material was given (WMD group; $n = 84$). Participants in this latter group were allowed to keep their device but were told to silence it and keep it out of sight for the duration of the experiment. Participants were escorted to stadium-style seats and placed alternately with every other student still having possession of their device. Participants were asked not to speak to one another and to only hold a pen/pencil and the study packet. Beginning 10 min after participants were seated, The paper version of the State/Trait Anxiety Inventory (STAI) was administered at three 20-min intervals (allowing five minutes to complete the questionnaire, the inventory was administered at 10 min, 35 min, and 60 min after seating the participants).

2.4. Statistical analyses

A three-way mixed-model analysis of variance was used to test all three hypotheses with three independent variables—WMD possession (taken away or close by but turned off), daily WMD use (high, moderate or low), and testing time (administration 1, administration 2, and administration 3)—and the dependent variable representing anxiety. The daily WMD use independent variable was developed by first converting the daily usage scale into hours per day as described in the methods section and then dividing the sample into three groups—low, moderate and high daily use—based on those hours. Significant main effects were examined, where appropriate, with post-hoc multiple comparisons using Tukey's B test and trend analyses to assess linear and quadratic trends in the anxiety scores over time. Significant interactions were further examined through post-hoc simple effects tests, post-hoc group comparisons using Tukey's B Test and trend analyses.

3. Results

3.1. Daily WMD use

On average, participants reported spending an average of 13.58 h daily ($SD = 10.73$) using their WMD ranging from one hour per day to 64.50 h per day. Note that these items were phrased as independent estimates of nine WMD activities and previous research has indicated that many of these activities are done simultaneously by college students (Carrier, Cheever, Rosen, Benitez, & Chang, 2009). Across all participants, WMD usage included the following mean hours in rank order from most used to least used: texting ($M = 4.80$; $SD = 4.17$), listening to music ($M = 2.47$; $SD = 2.76$), going online and visiting websites ($M = 2.19$; $SD = 2.50$), talking on the telephone ($M = 1.19$; $SD = 1.57$), using e-mail ($M = 1.29$; $SD = 2.30$), watching television ($M = 0.69$; $SD = 1.35$), playing games ($M = 0.50$; $SD = 1.22$), reading books or magazines ($M = 0.45$; $SD = 0.79$), and instant messaging ($M = 0.44$; $SD = 1.29$). Due to the wide range of responses, the daily hours using WMDs was partitioned into three groups: low daily usage ($n = 54$, $M = 4.09$; $SD = 1.65$; range from 1 to 7), moderate daily usage ($n = 55$, $M = 11.51$; $SD = 2.53$; range from 7.50 to 16.50), and high daily usage ($n = 54$, $M = 25.19$; $SD = 10.45$; range from 17 to 64.50).

3.2. Hypothesis testing

The study tested three specific hypotheses. First, Hypothesis 1 predicted that participants who had their device taken away would report feeling significantly more anxious as time passed—regardless of whether the device was removed from their possession or simply stored out of sight. Secondly, Hypothesis 2 predicted that participants without their device would feel significantly more anxious than those with their device close by. Finally, Hypothesis 3 predicted that participants who were heavier users of their WMD would feel significantly more anxious than those who were lighter users. These three hypotheses were tested using a three-way mixed model analysis of variance with testing time (three

Table 1
Three-way analysis of variance with testing time × WMD possession × daily WMD usage as the independent variables and anxiety as the dependent variable.

Source	SS	df	MS	F-Score	Significance level	Eta Squared
Testing Time (T)	515.83	2	257.91	6.91	<.001	.042
WMD Possession (W)	133.10	1	133.10	0.36	.548	–
Daily WMD Use (U)	1905.35	2	952.68	2.59	.078	–
T × W	76.30	2	38.15	1.02	.361	–
T × U	455.66	4	113.92	3.05	.017	.037
W × U	390.56	2	195.28	0.53	.589	–
T × W × U	472.34	4	118.09	3.17	.014	.039

repeated measurements), WMD possession (taken away vs. close by), and daily WMD use (high, moderate, low) as the independent variables and anxiety as the dependent variable. The results of the three-way ANOVA are depicted in Table 1.

Hypothesis 1, which predicted that anxiety in participants without their devices—regardless of its location—would increase over time was supported by the significant impact of testing time [$F(2, 314) = 6.91$, $p < .001$]. A post-hoc Tukey's B test and trend analysis indicated that there was a statistically significant increase in the means from the first testing time ($M = 34.23$) to the second testing time ($M = 36.10$) to the third testing time ($M = 36.65$); while the linear trend was statistically significant [$F(1,157) = 8.79$, $p = .004$)] the quadratic trend was not [$F(1,157) = 2.17$, $p = .143$)] indicating that their anxiety continued to increase over the three testing times and did not level off or abate.

Hypothesis 2, which predicted that participants without their device would feel significantly more anxious than those with their device close by but out of sight was not supported both by the nonsignificant main effect of WMD possession [$F(1,157) = 0.36$, $p = .548$)] and the nonsignificant interaction between WMD possession and testing time [$F(2,314) = 1.02$, $p = .078$)].

Hypothesis 3, which predicted that heavier daily users of WMDs would be more negatively impacted by their absence was supported as seen in the significant interaction between testing time and daily WMD use [$F(4,157) = 3.05$, $p = .017$)] as well as the significant three-way interaction between testing time, daily WMD use and WMD possession [$F(4,314) = 317$, $p = .014$)]. Fig. 1 displays the two-way interaction while Fig. 2 displays the three-way interaction for those who had their WMD taken away (top panel) and those who had it turned off but were allowed to keep it close by (bottom panel).

Several conclusions can be drawn from simple effects tests performed on the two-way interaction displayed in Fig. 1. First, it is clear that regardless of where the participant's WMD was placed, those who used their WMD for the most daily hours (black line) showed a strong increase in anxiety over time with only the linear trend being statistically significant [$F(1,52) = 18.44$, $p < .001$)]. Second, for the moderate daily WMD users (dark gray line) there was a significant change in anxiety over time [$F(2,106) = 3.38$, $p = .04$] where the pattern indicates a slight increase between the first two testing times and essentially no change between Time 2 and Time 3. Third, for the low WMD users (light gray line) there was no significant differences in anxiety over time [$F(2, 104) = 0.09$ $p = .91$] and the graph shows that anxiety remained constant over time for this group of low WMD users. Fourth, when examining differences separately for the three testing times, there was no significant difference in anxiety between the three daily WMD users groups at Time 1 [$F(2, 160) = 0.86$, $p > .05$] although the highest daily WMD users did show one and a half points more anxiety than the moderate and low WMD users combined. This will be explored further in the discussion section. In contrast, there was a significant difference in anxiety between the three daily WMD user groups at Time 2 [$F(2, 160) = 8.48$, $p < .001$] and Time 3 [$F(2, 160) = 13.83$, $p < .001$] with Tukey's B Test showing that high daily

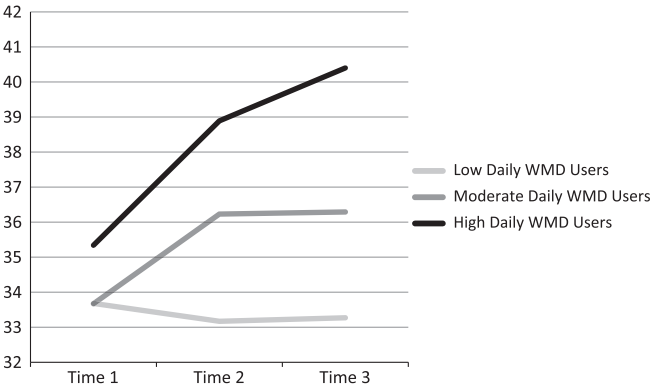

Fig. 1. Interaction of testing time and daily WMD use on anxiety.

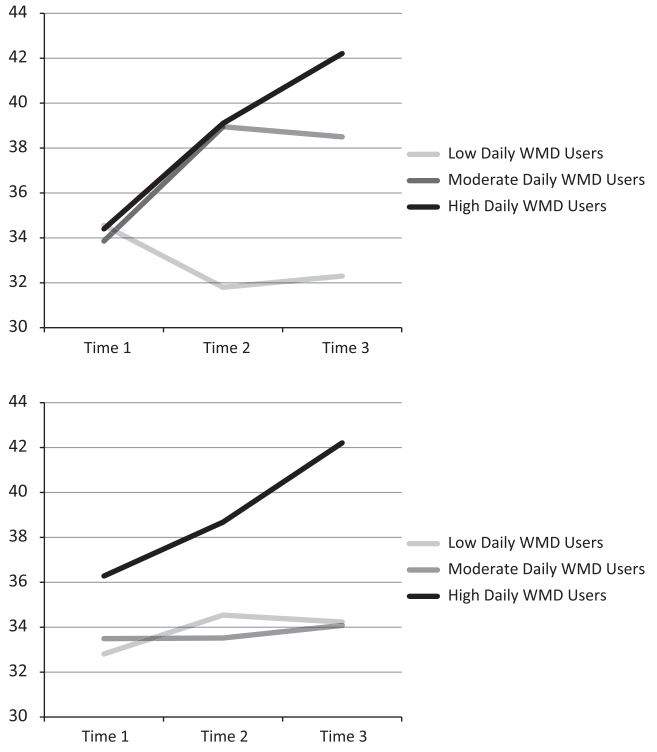

Fig. 2. Three-way interaction between testing time and daily WMD use on anxiety separately for those without their WMD (top panel) and those with their WMD close by (bottom panel).

WMD users had significantly more anxiety than moderate daily WMD users who, in turn, had significantly more anxiety than low daily WMD users at both Time 2 and Time 3.

The three-way interaction depicted in Fig. 2 further clarifies these conclusions. From this figure it is clear that for the group who had their WMD taken away, those with high daily WMD use

showed increases in anxiety across the three testing times while those with moderate daily WMD use showed an increase in anxiety from Time 1 to Time 2 and then no change from Time 2 to Time 3. The low daily WMD users showed no change in anxiety over time and had less anxiety at each testing time than moderate or high users who did not differ. A slightly different picture emerges when examining the bottom panel of Fig. 2 (those with their WMD turned off but put away) where the high daily WMD users again show strong increases in anxiety over the three testing times but there is no difference between the moderate and low daily users. This suggests that Hypothesis 3 is supported only for high and moderate daily WMD users who had their WMD removed and high daily WMD users who had their device turned off but close by. It is also important to note that an examination of the two panels of Fig. 2 indicates that while those who had their devices taken away showed equal anxiety at Time 1 regardless of the level of daily WMD use, while those high daily WMD users who had their WMD close by (although turned off and out of sight) showed three points higher anxiety than either the moderate or low daily WMD user groups.

4. Discussion

This study intended to strengthen the understanding of wireless mobile device use and its classification. We sought to understand whether taking the wireless mobile device (WMD) from university students for a short time in an environment void of distractions would induce anxiety; whether those without their device would feel more anxious than students who were able to hold onto it; and whether the amount of daily WMD use would alter these outcomes. The results of the experiment yielded support for two hypotheses: that over time students who did not possess their device felt significantly more anxious, and those who had heavy daily WMD use showed steadily increasing anxiety over time while low daily WMD users showed no change in anxiety over time. Interestingly, the moderate daily WMD users showed a steady increase in anxiety over time only when their device was removed from their possession but not when it was turned off but close by. Our hypothesis that students without their device would feel significantly more anxious than those with their device was not supported. These results suggest that students are so dependent on their WMDs that anxiety increases when the device is absent—even when they are aware the device will be back in their possession shortly—and those who use the device more frequently become significantly more anxious as time passes than those who use it less frequently.

Although the second hypothesis was not supported, it is important to note the differences observed between those who held onto their devices but could not use them and those who had their device removed from their possession. Both groups began the experimental period—10 min after either giving up their phone or turning it off and storing it out of sight—with virtually identical anxiety levels. As time passed, the anxiety levels of the group that had their devices taken away increased significantly, whereas no significant change in anxiety occurred in the group that held onto their devices. This change over time supports the first contention (Hypothesis 1) that anxiety will increase when possession of the WMD is restricted. It is not until daily WMD behaviors are taken into account that we observed a marked difference between the groups. Among the different daily WMD use groups, those who had their devices taken away started the experiment with virtually identical anxiety levels, while for those who were allowed to hold onto their device but not use it, heavy daily WMD users started the experiment with anxiety about three points higher than the low and moderate daily WMD users. Although this difference was not statistically significant, it suggests that merely being restricted from using the device, but still having it close by, triggered anxiety in heavy users such that over a 10-min period they already started to show an increase in anxiety. Further, between the groups, anxiety in those with high WMD use increased significantly while anxiety in those with moderate use leveled off from the second to third administrations and among the low WMD users, anxiety levels were virtually constant throughout the three administrations. This finding implies that heavy WMD use may contribute to a psychological dependence, and that being without the device may cause an anxiety state.

The secondary goal of this study was to better understand the classification of potential WMD overuse. Researchers have stressed the need to develop an appropriate measure to assess WMD behaviors that exist outside the traditional concept of addiction (Boca & Brown, 1996; Jenaro et al., 2007). While the present study does not test such a measure, our findings support this notion by showing that heavy smartphone users who were not allowed to use their device—whether it is removed from their possession or simply placed out of sight even for a short time—felt significantly more anxious as time passed. While anxiety is a symptom of substance withdrawal, researchers have been unable to clearly classify WMD overuse or dependency as an addiction. A more appropriate classification might be separation anxiety (Kins, Soenens, & Beyers, 2013) whereby moderate to heavy WMD users experience a feeling of loss when their device is absent. Separation anxiety is a salient feature of most close relationships. Because many people rely on their WMD for communication, entertainment, information, and to stay connected to loved ones and acquaintances, the WMD may have become a surrogate friend or family member that satisfies people's needs and desires. When the device is taken away or even placed out of sight, people who rely on this technology more will undoubtedly feel separation anxiety or "lost" without it. Light users, on the other hand, would not feel this loss because of less reliance on the device for support and nurture.

Another possible explanation for the anxiety felt by heavy WMD users is the concept of "fear of missing out" (FoMO), in which people become worrisome, fearful and anxious when they feel out of touch with the events, conversations and experiences of those in their social circles (Przybylski et al., 2013). In a study examining FoMO and social media engagement, university students who scored high in FoMO were more likely to check their Facebook page during lectures than those lower in FoMO. Participants in this study may have experienced FoMO when access to their devices was restricted, creating heightened anxiety levels.

5. Conclusions and limitations

The goal of this study was to understand how wireless mobile device (WMD) use might cause anxiety in those who were unable to use the device for a short time. The 75-min experiment yielded important results in understanding and classifying daily WMD use. This study found that university students who were unable to use their WMDs and were forced to sit quietly with no distractions became significantly more anxious over time, even when they were aware their devices would be returned to them shortly. The effect was stronger for heavy daily WMD users and for some moderate daily WMD users, regardless of whether or not the device was in their possession.

There were a few limitations to this study. First, the STAI is not a physiological test of anxiety. Anxiety is frequently exhibited by responses such as rapid heart rate, sweating, numbness, and lightheadedness. Measuring anxiety based on these physiological responses is common; however, social psychologists argue that autonomic arousal does not match subjective feeling states and that people who are frightened or panicky may show few, or no, physiological responses (Maddux & Winstead, 2005). Regardless,

the results of this study suggest furthering this investigation by examining the absence of WMDs and anxiety levels using GSR and heart rate monitoring equipment.

Another possible limitation was that the environment might have influenced participants' anxiety levels. The participants sat silently in a large hall with many other students, were given instructions not to talk, and were monitored by the lead experimenter and several research assistants. The situation itself may have increased participants' anxiety over time. If this were the case, an initial rise in anxiety would have been observed for all groups followed by similar patterns of increasing anxiety over time. However, this was not what was observed. Only the moderate and heavy WMD users had a rise in anxiety levels over time; those who used their device less frequently showed no difference in anxiety throughout the experiment.

Future replicated studies may seek to minimize this possible confounding environment by having smaller group sizes and possibly having the participants perform a mundane, unskilled, and non-goal oriented task that serves to buffer against anxiety increase. Further, completing an experiment in which participants were not aware of when they would be asked to complete certain tasks may have induced more anxiety. Also, the participants' mean age was 24, with approximately 25% of the sample over 25. This skewed distribution of ages indicates a possible threat to external validity, as this study cannot be generalized to all college students; although the distribution is typical of this particular university's population. Finally, participants may have had increased anxiety thinking about who had possession of their WMDs rather than worrying about the devices not being with them.

Given the results of this study, it is important that an appropriate assessment tool is created to more fully understand this phenomenon, such as a separation anxiety measure adapted from current scales. While the literature on adult separation anxiety is scant, recent research suggests that among people with anxiety and mood disorders, those who were diagnosed with these disorders as children, and those with no history of anxiety mood disorders experience separation anxiety as an adult (Pini et al., 2010). Testing daily WMD use as a moderating factor in people with existing anxiety and mood disorders would enhance the understanding of how the device may exacerbate such disorders.

References

American Academy of Pediatrics (2014). Media and children. <http://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Pages/Media-and-Children.aspx> (Retrieved 15.03.14).

Bianchi, A., & Phillips, J. G. (2005). Psychological predictors of problem mobile phone use. *CyberPsychology & Behavior, 8*(1), 39–51.

Blaszczynski, A. (2006). Internet use. In search of an addiction. *International Journal of Mental Health and Addicion, 4*, 7–9.

Brenner, J. (2013). *Pew Internet: Mobile*. Pew Internet and American Life Project. <http://pewinternet.org/Commentary/2012/February/Pew-Internet-Mobile.aspx> (Retrieved 11.07.13).

Carrier, L. M., Cheever, N. A., Rosen, L. D., Benitez, S., & Chang, J. (2009). Multitasking across generations: Multitasking choices and difficulty ratings in three generations of Americans. *Computers in Human Behavior, 25*, 483–489.

Del Boca, F. K., & Brown, J. M. (1996). Issues in the development of reliable measures in addictions research: Introduction to Project MATCH assessment strategies. *Psychology of Addictive Behaviors, 10*(2), 67–74.

Derks, D., & Bakker, A. B. (2012). Smartphone use, work-home interference, and burnout: A diary study on the role of recovery. *Applied Psychology: An International Review* (pp. 1–30).

Fauman, M. A. (2002). *Study Guide to DSM-IV-TR*. Washington D.C.: American Psychiatric Publishing.

Gershon, J., Zimand, E., Pickering, M., Rothbaum, B., & Hodges, L. (2004). A pilot and feasibility study of virtual reality as a distraction for children with cancer. *Journal of the American Academy of Child & Adolescent Psychiatry, 43*(10), 1243–1249.

Governors Highway Safety Association. (2014). *Distracted driving laws*. <http://www.ghsa.org/html/stateinfo/laws/cellphone_laws.html> (Retrieved 5.03.14).

Halgin, R. P., & Whitbourne, S. K. (2000). *Abnormal psychology: Clinical perspective on psychological disorders* (third ed.). Boston: McGraw Hill.

Hong, F., Chiu, S., & Huang, D. (2012). A model of the relationship between psychological characteristics, mobile phone addiction and use of mobile phones by Taiwanese university female students. *Computers in Human Behavior, 28*, 2152–2159.

Hooper, V., & Zhou, Y. (2007). Addictive, dependent, compulsive? A study of mobile phone usage. *20th Bled eConference eMergence: Merging and Emerging Technologies, Processes, and Institutions* (pp. 272–285).

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 and Theory, 15*(3), 309–320.

Jin, B. (2007). *Mobile communication as a mode of interpersonal communication*. *Paper presented at the National Communication Association Convention*. Chicago, Illinois.

Jin, B., & Pena, J. (2010). Mobile communication in romantic relationships: Mobile phone use, relational uncertainty, love, commitment, and attachment styles. *Communication Reports, 23*(1), 39–51.

Kamibeppu, K., & Sugiura, H. (2005). Impact of the mobile phone on junior high school students' friendships in the Tokyo Metropolitan Area. *CyberPsychology & Behavior, 8*(2), 121–130.

Kim, H. (2013). Exercise rehabilitation for smartphone addiction. *Journal of Exercise Rehabilitation, 9*(6), 500–505.

King, A. L. S., Valença, A. M., Silva, A. C. O., Baczynski, T., Carvalho, M. R., & Nardi, A. E. (2013). Nomophobia: Dependency on virtual environments or social phobia? *Computers in Human Behavior, 29*, 140–144.

Kins, E., Soenens, B., & Beyers, W. (2013). Separation anxiety in families with emerging adults. *Journal of Family Psychology, 27*(3), 495–505.

Lepp, A., Barkley, J. E., & Karpinski, A. C. (2013). The relationship between cell phone use, academic performance, anxiety and satisfaction with life in college students. *Computers in Human Behavior, 31*, 343–350.

Leung, L. (2008). Linking psychological attributes to addiction and improper use of the mobile phone among adolescents in Hong Kong. *Journal of Children and Media, 2*(2), 93–113.

Lortie, C. L., & Guitton, M. J. (2013). Internet addiction assessment tools: Dimensional structure and methodological status. *Addiction, 108*, 1207–1216.

Maddux, J. E., & Winstead, B. A. (2005). *Psychopathology: Foundations for a contemporary understanding*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

National Institutes of Mental Health (2013). *The numbers count: Mental disorders in America*. <http://www.nimh.nih.gov/health/publications/the-numbers-count-mental-disorders-in-america/index.shtml#Anxiety> (Retrieved 11.07.13).

Park, B. W., & Lee, K. C. (2011). The effect of users' characteristics and experiential factors on the compulsive usage of the smartphone. *Communications in Computer and Information Science, 151*, 438–446.

Patel, A., Schieble, T., Davidson, M., Tran, M. C. J., Schoenberg, C., Delphin, E., et al. (2006). Distraction with a hand-held video game reduces pediatric preoperative anxiety. *Pediatric Anesthesia, 16*(10), 1019–1027.

Pini, S., Abelli, M., Shear, K. M., Cardini, A., Lari, L., Gesi, C., et al. (2010). Frequency and clinical correlates of adult separation anxiety in a sample of 508 outpatients with mood and anxiety disorders. *Acta Psychiatrica Scandinavica, 122*(1), 40–46.

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*, 1841–1848.

Reid, D. J., & Reid, F. J. M. (2007). Text or talk? Social anxiety, loneliness, and divergent preferences for cell phone use. *Cyberpsychology & Behavior, 10*(3), 424–435.

Rosen, L. D., Cheever, N. A., & Carrier, L. M. (2012). *IDisorder: Understanding our obsession with technology and overcoming its hold on us*. New York: Palgrave-MacMillian.

Rosen, L. D., Whaling, K., Carrier, L. M., Cheever, N. A., & Rokkum, J. (2013a). The media/technology usage, attitudes and anxiety scale: An empirical investigation. *Computers in Human Behavior, 29*(6), 2501–2511.

Rosen, L. D., Whaling, K., Rab, S. A., Carrier, L. M., & Cheever, N. A. (2013b). Is Facebook creating "iDisorders"? The link between clinical symptoms of psychiatric disorders and technology use, attitudes and anxiety. *Computers in Human Behavior, 29*(3), 1243–1254.

Sánchez-Martínez, M., & Otero, A. (2009). Factors associated with cell phone use in adolescents in the community of Madrid (Spain). *CyberPsychology & Behavior, 12*(2), 131–137.

Skierkowski, D., & Wood, R. M. (2012). To text or not to text? The importance of text messaging among college-aged youth. *Computers in Human Behavior, 28*, 744–756.

Smith, A. (2012). *Nearly half of American adults are smartphone owners*. Pew Internet & American Life Project. <http://www.pewinternet.org/Reports/2012/Smartphone-Update-2012.aspx> (Retrieved 22.08.12).

Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory (STAI)*. PaloAlto, CA: Consulting Psychologists Press.

Thomée, S., Dellve, L., Härenstam, A., & Hagberg, M. (2010). Perceived connections between information and communication technology use and mental symptoms among young adults—a qualitative study. *BMC Public Health, 10*, 1–14.

Thomée, S., Härenstam, A., & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults—a prospective cohort study. *BMC Public Health, 11*, 1–11.

Turner, S. M., & Hersen, M. (1984). *Adult psychopathology and diagnosis*. New York: John Wiley and Sons.

Vincent, J. (2006). Emotional attachment and mobile phones. *Knowledge, Technology, & Policy, 19*(1), 39–44.

Walsh, S. P., & White, K. M. (2007). Me, my mobile, and I: The role of self- and prototypical identity influences in the prediction of mobile phone behavior. *Journal of Applied Social Psychology, 37*(10), 2405–2434.

Walsh, S. P., White, K. M., & Young, R. M. (2008). Over-connected? A qualitative exploration of the relationship between Australian youth and their mobile phones. *Journal of Adolescence, 31*(1), 77–92.

Walsh, S. P., White, K. M., & Young, R. M. (2010). Needing to connect: The effect of self and others on young people's involvement with their mobile phones. *Australian Journal of Psychology, 62*(4), 194–203.

Wu, A. M. S., Cheung, V. I., Ku, L., & Hung, E. P. W. (2013). Psychological risk factors of addiction to social networking sites among Chinese smartphone users. *Journal of Behavioral Addictions, 2*(3), 160–166.