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Review

The relationship between anxiety symptom severity and problematic smartphone use: A review of the literature and conceptual frameworks

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ABSTRACT

In the present paper, we examine the literature studying relations between problematic smartphone use (PSU) and anxiety symptom severity. We first present background on the health advantages and disadvantages of using a smartphone. Next, we provide caveats in distinguishing healthy smartphone use from unhealthy PSU, and we discuss how PSU is measured. Additionally, we discuss theoretical frameworks explaining how some people develop PSU, including Uses and Gratifications Theory, and Compensatory Internet Use Theory. We present our own theoretical model of how PSU is specifically related to anxiety. We discuss and review mental health constructs associated with PSU severity, based on prior literature. Next, we systematically review the research on PSU severity in relation to anxiety symptoms, given the recent growth of studies on this research question. Finally, we offer implications and recommendations for future research in this area.

1. Background on smartphone use and problematic smartphone use

1.1. Smartphone use

Smartphones are ubiquitous in society. Recent data from the Pew Research Center demonstrates that the prevalence of smartphone ownership among adults is 77% in the U.S. and 59% globally (Poushter, Bishop, & Chwe, 2018). Smartphones offer many advantages to people in their daily lives. For example, smartphones can facilitate productivity through mobile access to calendars, reminders, email, and informational web searching. In fact, smartphones are found to boost productivity among employees (Bertschek & Niebel, 2016; Lee, Lee, & Kim, 2017), and enhance learning among students (George & DeCristofaro, 2016; Remón, Sebastián, Romero, & Arauzo, 2017). Smartphones are also used for entertainment (e.g., viewing videos), diversion and relaxation. Finally, smartphones are used for social purposes, such as text messaging and social media, and consequently smartphone use is found to build social capital (Kim, Wang, & Oh, 2016; Li & Lin, 2018). However in the present paper, we focus on excessive smartphone use, and how such excessive use relates to anxiety symptoms.

1.2. Problematic smartphone use

Despite their advantages, there are adverse consequences from smartphone overuse. Problematic smartphone use (PSU) is a construct defined as excessive use of a smartphone with accompanying functional impairments in daily living, and symptoms resembling those found in substance use disorders (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). De-Sola Gutierrez, Rodriguez de Fonseca, and Rubio (2016) explained in detail, and with examples, how all eight DSM-5 substance use disorder symptoms have relevance to similar PSU symptoms. For example, PSU can involve dangerous use, such as texting while driving. PSU can involve deficits in social relationships, work or school performance from excessive smartphone use. For example, individuals engaging in PSU may have arguments with their family and friends because of their excessive phone use during social activities and interactions (Billieux, Philippot et al., 2015). Other symptoms of PSU found in substance use disorders include withdrawal when not able to use one's smartphone (e.g., when overuse drains the battery), and tolerance (i.e., gradual overuse across time) (Billieux, Maurage et al.,

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2015).

PSU is associated with adverse health and functional consequences. PSU is related to sleep impairments from late-night overuse (Demirci, Akgonul, & Akpinar, 2015; Liu et al., 2017), as well as musculoskeletal pain primarily involving the hand, shoulder and neck (İNal, Demİrcİ, ÇetİntürK, Akgönül, & Savaş, 2015; Shan et al., 2013; Xie, Szeto, Dai, & Madeleine, 2016). PSU is related to traffic and pedestrian accidents (Cazzulino, Burke, Muller, Arbogast, & Upperman, 2014; Schwebel et al., 2012; Thompson, Rivara, Ayyagari, & Ebel, 2013), because of distracting drivers from their surroundings (Klauer et al., 2014). Additionally, PSU is associated with worse physical fitness (Lepp, Barkley, Sanders, Rebold, & Gates, 2013; Rebold, Sheehan, Dirlam, Maldonado, & O'Donnell, 2016), and academic problems (Jacobsen & Forste, 2011; Lepp, Barkley, & Karpinski, 2014; Prabu, Kim, Brickman, Ran, & Curtis, 2015).

PSU is conceptually similar to other forms of problematic internet communications technology use, including problematic internet use (PIU) (reviewed in Kuss, Griffiths, Karila, & Billieux, 2014), problematic social network site use (reviewed in Kuss & Griffiths, 2011), and problematic internet gaming (reviewed in Petry et al., 2014). However, these constructs are statistically distinct from one another, associated with different adverse outcomes (Baggio et al., 2018; Kiraly et al., 2014). Additionally, PSU is a unique and distinct phenomenon, as a smartphone is small, highly portable and constantly accessible to individuals in their pockets or handbags. Portability and accessibility make it easy to use or overuse one's smartphone, and very likely to form the habit of constant phone checking behavior (Oulasvirta, Rattenbury, Ma, & Raita, 2012).

At this juncture, we present some caveats. First, PSU is not a recognized mental disorder, but instead is a construct relevant to psychopathology research. More importantly, we caution the reader to not overpathologize "normal" or healthy levels of internet communications use (Kardefelt-Winther, 2014; Panova & Carbonell, 2018). After all, many individuals may use their smartphones for numerous hours per day, but do so productively (i.e., for work or school) (Bertschek & Niebel, 2016). For example, a married business professional and mother may use her smartphone for six hours per day while traveling to and from her office and client appointments. Her smartphone use while "on the go" for arranging appointments, engaging in client phone calls, and note-taking for later invoicing and reporting is clearly a productive use of her time, as long as she can adequately relax and enjoy her evening, and spend some quality time with her family. In this scenario, the professional's smartphone use, although extensive (six hours daily) does not appear to involve functional impairment or significant distress.

1.3. Measurement of PSU

In the late 1990s, when PIU first began to be studied, researchers adapted psychological scales measuring substance use disorder symptom criteria (i.e., functional impairment associated with excessive substance use), modifying items to inquire about symptoms from excessive internet use rather than excessive substance use (Kuss et al., 2014). In the late 2000s and early 2010s, researchers adapted PIU scales to inquire about PSU (Billieux, Maurage et al., 2015). Thus measures inquiring about PSU not only query the frequency of smartphone use, but primarily inquire about functional areas of impairment from excessive use – just as substance use scales do. Very frequent or extensive use would therefore not necessarily be considered problematic unless such use is functionally impairing and/or causes significant distress.

2. Prior theoretical models

Several theoretical frameworks have been developed that can explain how such individual differences as psychological and psychopathological constructs (including anxiety symptoms) may relate to the use of internet communications (such as smartphone use, and excessive use). Uses and Gratifications Theory (UGT) (Blumler, 1979) is a long-standing mass communications theory (Ruggiero, 2000) proposing that people have diverse needs that they wish to satisfy through the use of different types of media. UGT proposes that motivations to use media include sociodemographic and psychological characteristics. As a concrete example, someone who is lonely may turn to social media in an attempt to satisfy their need for social connection. Furthermore, if the lonely person is also angry and irritable, s/he may turn to Twitter to troll other users. Of relevance to this paper, UGT would propose that anxiety can drive people to use, or overuse, internet technology such as smartphones in order to satisfy or calm their anxiety. In fact, several papers have used UGT to conceptualize anxiety symptoms as driving PSU (Contractor, Weiss, & Elhai, in press; Elhai, Levine, Dvorak, & Hall, 2017; Lee, Chang, Cheng, & Lin, 2018; van Deursen, Bolle, Hegner, & Kommers, 2015).

A theory of excessive internet communications use that is more specific to, and explicitly addresses, psychopathological constructs is Compensatory Internet Use Theory (CIUT) (Kardefelt-Winther, 2014). CIUT assumes that after experiencing stressful life events, many people attempt to reduce their resulting negative emotion by engaging in excessive internet use (such as PSU). Thus in contrast to UGT, CIUT's primary focus is on psychopathology in explaining excessive internet communications use. People may turn to other means for alleviating their negative emotion, whether adaptive such as exercise and social support, or maladaptive such as promiscuous sex or substance abuse. But as discussed above, the smartphone is constantly accessible and available on our person, and as such may be the first and most obvious object (or process) that many people may use to regulate or alleviate their negative emotion. CIUT fits well with negative reinforcement models of addiction, also referred to as "self-medication" or "affect regulation" models, emphasizing substance use as a means of alleviating negative emotion (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Robinson & Berridge, 2003). Numerous papers have used CIUT to conceptualize anxiety severity as driving PSU (Elhai et al., 2018e; Gao et al., 2018; Long et al., 2016; Wolniewicz, Tiamiyu, Weeks, & Elhai, 2018). Because CIUT more prominently incorporates psychopathology into its framework than UGT does, we believe that CIUT is more relevant in understanding anxiety's relationship with PSU.

We should emphasize that the theoretical models discussed above would conceptualize anxiety-related psychopathology as driving PSU, rather than the other way around. Furthermore, this sequence of psychopathology driving PSU is the typical type of analytic model tested and supported in the literature (e.g., Elhai, Levine, O'Brien, & Armour, 2018b; Kim, Seo, & David, 2015; van Deursen et al., 2015). However, it is alternatively possible that excessive engagement in a smartphone can drive anxiety symptoms. For instance, people who engage in PSU may consequently isolate themselves, and neglect to engage in behavioral activity that is important to psychological health (Dimidjian, Barrera, Martell, Munoz, & Lewinsohn, 2011). As a result of such social isolation and decreased behavioral activity, people engaging in PSU may suffer from anxiety symptoms as a consequence. However, the vast majority of studies examining relations between psychopathology and PSU are cross-sectional. Only a limited number of longitudinal papers have examined the sequence of these constructs, with some support found for bidirectional effects between mental health problems and PSU severity (Lu, Katoh, Chen, Nagata, & Kitamura, 2014; Thomée, Härenstam, & Hagberg, 2011). Nonetheless, within the context of these theoretical models, we conceptualize PSU as a means of, and consequence of, attempting to regulate negative emotion. In behavioral terms, PSU would be considered a negative reinforcer aimed at reducing or preventing anxiety symptoms.

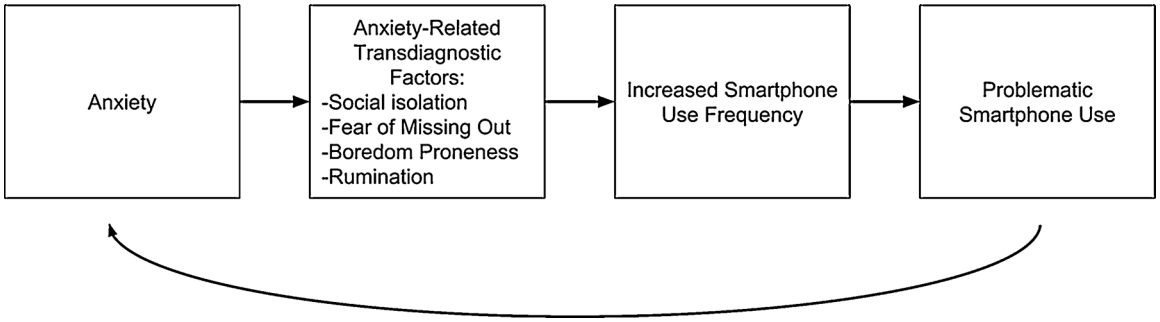

Fig. 1. Theoretical Model of PSU and Anxiety Symptoms.

3. Theoretical model of PSU and anxiety symptoms

We present our theoretical model of PSU and anxiety in Fig. 1. Our model fits with CIUT in explaining how anxiety ultimately drives many individuals to engage in PSU to alleviate their anxiety and negative emotion. As such, as with CIUT, this model can be viewed as a negative reinforcement model.

Fig. 1 begins with anxiety at the left. The model adds additional intermediary variables between anxiety and PSU. First, anxiety symptomatology is not the only driving force behind increased and PSU, but rather other "transdiagnostic" psychopathology factors are likely important. Transdiagnostic psychopathology constructs are constructs that appear across numerous mental disorders, found to be important in understanding the etiology, mechanisms and maintenance of mental disorders (Mansell, Harvey, Watkins, & Shafran, 2008). Transdiagnostic factors are also targets of clinical intervention (Hofmann, Sawyer, Fang, & Asnaani, 2012). Fig. 1 displays examples of anxiety-related transdiagnostic constructs (discussed later in this paper). These constructs fit into the larger, underlying negative affectivity and emotional distress dimension of psychopathology (Watson, 2009).

Fig. 1 also depicts increased smartphone use frequency (not necessarily excessive use) as an intermediary variable between anxiety-related constructs and PSU. Anxiety and associated transdiagnostic factors alone do not cause PSU. Rather, increased frequency of, and habitual use of a smartphone, are believed to progress over time into PSU for some individuals (Oulasvirta et al., 2012; Soror, Hammer, Steelman, Davis, & Limayem, 2015; van Deursen et al., 2015). A prominent reason for the progression of increased use into PSU is the behavior of checking for smartphone notifications. Initially, receiving smartphone notifications is positively reinforcing, leading to more frequent, habitual checking behavior over time in order receive additional reinforcement (Oulasvirta et al., 2012). Numerous studies build smartphone use frequency into their models of psychopathology accounting for PSU severity (e.g., Elhai et al., 2018b; Kim, Seo et al., 2015; van Deursen et al., 2015).

Additionally, Fig. 1 demonstrates a feedback loop. As discussed earlier, in addition to anxiety driving PSU, PSU can also drive anxiety because of the negative toll PSU can have on mental health. Thus the model demonstrates a vicious cycle between anxiety and PSU. Finally, we should note that our model does not present other sociodemographic or non-anxiety-related mental health variables that have been conceptualized as influencing PSU, discussed elsewhere (Billieux, Maurage et al., 2015).

4. Using a smartphone to avoid socialization

It is worth noting that several anxiety disorders and related conditions involve a social avoidance component, such as social phobia, panic disorder, and posttraumatic stress disorder (PTSD). Such social avoidance, and associated disorders, can play a role in PSU. We next discuss the role of social avoidance in PSU.

Of relevance, internet use is often categorized in the literature as either involving social (e.g., social networking, messaging) or process (non-social) use (e.g., viewing videos, browsing the news) (Elhai, Hall, Levine, & Dvorak, 2017; van Deursen et al., 2015). Research demonstrates that in contrast to social smartphone use, non-social use is more related to anxiety severity (Elhai, Levine et al., 2017; van Deursen et al., 2015). Compared to social use, non-social smartphone use is also more related to PSU severity (Elhai, Levine et al., 2017; van Deursen et al., 2015), possibly because of the social capital advantages of smartphone use (Kim, Nam et al., 2016; Li & Lin, 2018). Furthermore, findings show that increased non-social use of a smartphone mediates relations between anxiety and PSU (Elhai, Levine et al., 2017).

5. PSU's mental health associations

5.1. PSU and mental health constructs

Numerous studies have examined the relationship between PSU severity and mental health variables, and several review papers recently summarized these findings (De-Sola Gutierrez et al., 2016; Elhai, Dvorak et al., 2017; Vahedi & Saiphoo, 2018). The most commonly studied mental health variables examined in relation to PSU severity are depression, anxiety, stress, and low self-esteem (Elhai, Dvorak et al., 2017). Based on this literature, PSU severity has demonstrated moderate, positive associations with depression severity (Elhai, Dvorak et al., 2017), and small to moderate associations with stress (Elhai, Dvorak et al., 2017; Vahedi & Saiphoo, 2018).

5.2. PSU and anxiety constructs: systematic review

Next, we focus more specifically on the literature regarding relations between PSU and anxiety symptom severity. Recently published reviews found that PSU and anxiety severity evidenced small to moderate positive associations (Elhai, Dvorak et al., 2017; Vahedi & Saiphoo, 2018). However, the literature has grown rapidly in the last two years, with many newer papers studying this research question that were not included in those reviews (see below for details). Furthermore, these recent reviews focused on several different psychopathological constructs associated with PSU in addition to anxiety, including stress (Elhai, Dvorak et al., 2017; Vahedi & Saiphoo, 2018), as well as depression and self-esteem (Elhai, Dvorak et al., 2017). Therefore, we present a newly conducted systematic review here, specific to relations between severity of PSU and anxiety.

We searched for publications from 2008 (after debut of the original iPhone abruptly advanced smartphone technology) until June 10, 2018, using PRISMA review guidelines (Moher et al., 2015). We searched the PsycINFO, PubMed and Google Scholar bibliographic databases. Using Boolean operators, we searched for such terms as: ("cellular phone" OR "cell phone" OR "mobile devices" OR "mobile phone") AND ("problem use" OR "compensatory use" OR "addiction" OR "internet addiction" OR "smartphone addiction") AND ("anxiety" OR "anxiety disorder");

we also repeated this search by substituting "anxiety" with broader terms involving mental health and disorder, to ensure that we did not miss relevant papers. We imported full-text results into an Endnote X8 database, removing duplicates. We also manually searched "in press"/"early view"/"online first" contents of relevant journals that have published the vast majority of prior papers on relations between PSU and mental health variables, including: *Computers in Human Behavior*; *Internet Research*; *Social Science Computer Review*; and *Cyberpsychology, Behavior and Social Networking*.

In our final review, we only included papers with the following characteristics: a) published or in press in peer-reviewed journals, b) written in English, c) included standardized instruments of both anxiety and PSU severity, c) conducted inferential statistics to examine relations between anxiety and PSU severity. Data extraction was conducted by the first author (JDE), inserting the studies as rows in an Excel spreadsheet, and relevant study variables/characteristics (discussed below) as columns.

The final search resulted in 28 studies meeting our inclusion criteria. The rapid growth of this literature in recent years can be observed by comparing this number to the number of similar studies included in other prior (but recent) reviews. Specifically, in Elhai, Dvorak et al. (2017), and Vahedi and Saiphoo (2018), the number of papers included that examined relations between anxiety and PSU severity using validated, standardized instruments were seven and 11 (non-orthogonal studies), respectively.

Table 1 displays characteristics of these studies examining anxiety and PSU severity (n = 28). Anxiety constructs most commonly examined in regard to PSU severity involve trait anxiety, and social anxiety. The most widely used anxiety scales in this literature were the Beck Anxiety Inventory (BAI), State Trait Anxiety Inventory (STAI), and Depression Anxiety Stress Scale-21's (DASS-21) Anxiety subscale. A majority of studies examining social anxiety used the Social Interaction Anxiety Scale (SIAS). Most bivariate, unadjusted correlations between severity of anxiety and PSU ranged between .20–.40 in magnitude, representing small to moderate positive effects.

A majority of these studies used the Smartphone Addiction Scale (SAS) or its short version (SAS-SV) to measure PSU severity. The SAS (Kwon, Lee et al., 2013) is a 36-item measure of PSU based on earlier PIU scales. The SAS was developed and initially validated against measures of PIU and smartphone use frequency in South Korean university students and adult employees (Kwon, Lee et al., 2013), later validated with U.S. community residents (Elhai, Levine, Dvorak, & Hall, 2016), and university students from the U.S. (Elhai, Tiamiyu, & Weeks, 2018c), Malaysia (Ching et al., 2015), and Turkey (Demirci, Orhan, Demirdas, Akpinar, & Sert, 2014). The SAS-SV (Kwon, Kim et al., 2013, is a shorter, 10-item version of the SAS. The SAS-SV was developed and initially validated with Korean junior high school students (Kwon, Kim et al., 2013), later validated with university students from the U.S. (Elhai et al., 2018b), Spain and Belgium (Lopez-Fernandez, 2017). Other measures were used in few studies.

Most of these studies sampled college students or community samples. The community samples were primarily convenience samples recruited through Amazon's Mechanical Turk online labor market. Most studies from this literature used samples of more than 300 participants. 12 of these 28 studies used between 300–400 participants each. The majority of studies were conducted in North America or China.

We note positive trends in this literature. First, well-established and validated measures of anxiety symptom severity have been used. Second, well-established and validated measures of PSU severity have been widely used. However, we note several trends that can be improved upon. First, the majority of studies used convenience samples of college students or online research panels; more representative samples of the general population, as well as clinical samples, are needed. Second, the majority of these studies were conducted in North America or China (17 studies, or 61%); the next most prevalent country studied was South Korea (only 3 studies, or 11%), and thus more representation from other parts of the world is needed.

5.3. PSU and other anxiety-related constructs

In addition to the anxiety constructs studied in conjunction with PSU severity, above, newer studies have examined other constructs that are not central to the construct of "anxiety" but are quite relevant. One study assessed anxiety sensitivity, or fear of arousal-based anxiety sensations (Reiss & McNally, 1985), finding it positively related to PSU severity (Elhai et al., 2018b). Additionally, two studies supported rumination as positively associated with PSU severity (Elhai et al., 2018c; Liu et al., 2017); found that increased rumination mediated relations between depression and anxiety with PSU severity Elhai, Tiamiyu, and Weeks (2018c). Rumination involves repetitive negative thinking, representing the cognitive aspect of anxiety, and is itself related to anxiety and depression severity (Aldao, Nolen-Hoeksema, & Schweizer, 2010).

Several papers have studied fear of missing out (FOMO) in relation to PSU severity. FOMO involves the apprehension that some people have about missing out on pleasurable experiences that their social network is having, and feeling the need to stay in ever close contact (Przybylski, Murayama, DeHaan, & Gladwell, 2013). FOMO is positively related to PSU severity (Chotpitayasunondh & Douglas, 2016; Elhai et al., 2016, 2018a; Fuster, Chamarro, & Oberst, 2017; Wolniewicz et al., 2018). In fact, FOMO is also positively related to anxiety severity (Blackwell, Leaman, Tramposch, Osborne, & Liss, 2017; Dhir, Yossatorn, Kaur, & Chen, 2018; Elhai et al., 2018a; Elhai et al., 2016, 2018a; Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017; Scalzo & Martinez, 2017), including social anxiety (Wolniewicz et al., 2018). Furthermore, increased FOMO mediated relations between anxiety and PSU severity (Elhai et al., 2018a; Oberst et al., 2017).

Finally, one recent paper supported the proneness to boredom as positively related to PSU severity, and mediated relations between anxiety and PSU severity (Elhai, Vasquez, Lustgarten, Levine, & Hall, 2018e). Boredom proneness is conceptualized to arise from inattention and negative affect (Eastwood, Frischen, Fenske, & Smilek, 2012), and is associated with anxiety and depression (Elhai et al., 2018e). Thus boredom proneness may be an important, previously neglected psychological factor that can explain why people excessively engage in their smartphones.

5.4. PSU and Anxiety Relations in Experimental and Prospective Studies

In addition to the literature presented above, we also note that a small number of studies have examined relations between PSU severity and anxiety using experimental designs. Two studies separated college students from their smartphones, and measured physiological anxiety ratings from separation, comparing these ratings to those from participants unseparated from their phones. Cheever, Rosen, Carrier, and Chavez (2014) found that anxiety increased gradually upon separation among excessive smartphone users. And Clayton, Leshner, and Almond (2015) discovered that anxiety, heart rate and blood pressure increased when separated participants could hear their phones ring from nearby.

Furthermore, two studies have used prospective research designs to explore relations between anxiety and increased or PSU. The study by 2018b, supported anxiety sensitivity as a significant positive correlate of PSU severity, using a repeated measures design with PSU assessed one month after anxiety sensitivity. Additionally, Rozgonjuk, Levine, Hall, and Elhai (2018) objectively measured daily minutes of smartphone use over one week, finding anxiety (albeit inversely) related to the number of smartphone screen unlocks.

6. Implications and future research

We now return to our theoretical model in Fig. 1, evaluated based on the research literature reviewed above. Based on this literature,

Table 1
Studies examining anxiety symptom severity in relation to problematic smartphone use.

Study	Sample Size	Sample Type	Sample's Country	Anxiety Type Studied	Anxiety Measure	PSU Measure	Bivariate r for PSU Measure with Anxiety Measure
(Chen et al., 2017)	1441	Medical students	China	Anxiety	ZSRAS	SAS-SV	NR
(Chen et al., 2016)	1087	College students	China	Social anxiety	Social Anxiety Subscale of the Self-Conscientiousness Scale	MPAS	.49
(Contractor, Frankfurt, Weiss, & Elhai, 2017)	347	Mturk	USA	PTSD	PCL-5	SAS-SV	Range of .23 to .41 across PCL-5 latent factors
(Contractor et al., in press)	347	Mturk	USA	PTSD	PCL-5	SAS-SV	Range of .22 to .38 across PCL-5 latent factors
(Contractor, Weiss, Tull & Elhai, 2017)	346	Mturk	USA	PTSD	PCL-5	SAS-SV	.40
(Demirci et al., 2015)	319	College students	Turkey	Anxiety	BAI	SAS	.28
(Elhai Vasquez et al., 2018e	298	College students	USA	Anxiety	Anxiety Subscale of the DASS-21	SAS	.35
(Elhai et al., 2016)	308	Mturk	USA	Anxiety	Anxiety Subscale of the DASS-21	SAS	.24
(Elhai, Levine et al., 2017)	308	Mturk	USA	Anxiety	Anxiety Subscale of the DASS-21	SAS	.24
(Elhai et al., 2018c)	296	College students	USA	Social anxiety	SIAS	SAS-SV	.22
(Enez Darcin et al., 2016)	375	College students	Turkey	Social phobia	Brief Social Phobia Scale	SAS	Range of .26 to .28 across social phobia subscale scores
(Gao et al., 2018)	1105	College students	China	Anxiety	Anxiety Subscale of the DASS-21	MPAI	Range of .32 to .41 across MPAI subscale scores
(Harwood, Dooley, Scott, & Joiner, 2014)	274	College students and community participants	Not specified	Anxiety	Anxiety Subscale of the DASS-21	MPIQ	.24
(Hawi & Samaha, 2017)	381	College students	Lebanon	Anxiety	BAI	SAS-SV	NR
(Hussain, Griffiths, & Sheffield, 2017)	640	College students and community participants	UK	Anxiety	STAI	PSUS	.22
(E. Kim & Koh, 2018)	313	College students	South Korea	Anxiety	BAI	SAPS	.23
(R. Kim, Lee, & Choi, 2015)	351	Middle school students	South Korea	Anxiety	BAI	MPOQ	.30
(Y. J. Kim, Jang, Lee, Lee, & Kim, 2018)	4854	Adult community participants	South Korea	Anxiety	Anxiety subscale of the SCL-90-R	SAPS	NR
(Kuss et al., 2018)	373	Adult community participants	Multiple countries	Anxiety	Anxiety Subscale of the DASS-42	PMPUS	NR
(E. B. Lee, 2015)	304	College students	USA	Social anxiety	SIAS	SAS-SV	NR
(Y.-K. Lee et al., 2018)	431 (Sample 1), and 347 (Sample 2	College students	USA and China	Social anxiety	SIAS	SAS-SV	.34 for Study 1; .32 for Study 2
(Y.-K. Lee, Chang, Lin, & Cheng, 2014)	325	Adult community participants	China	Social anxiety	SIAS	A scale measuring compulsive smartphone use	.44
(Long et al., 2016)	1072	College students	China	Anxiety	ZSRAS	PCPUS	NR
(Matar Boumosleh & Jaalouk, 2017)	688	College students	Lebanon	Generalized anxiety	GAD-2	SAI	NR
(Richardson, Hussain, & Griffiths, 2018)	310	Adult community participants	Multiple countries	Anxiety	STAI	PSUS	.31
(Rozgonjuk et al., 2018)	101	College students	USA	Anxiety	Anxiety Subscale of the DASS-21	SAS	.35
(Sapacz, Rockman, & Clark, 2016)	152	College students	Canada	Anxiety; Social anxiety	STAI; SBRSAS	MPPUS	NR
(Wolniewicz et al., 2018)	296	College students	USA	Social anxiety	Brief Fear of Negative Evaluation Scale; Fear of Positive Evaluation Scale	SAS-SV	.12 (Fear of positive evaluation);.29 (Fear of negative evaluation)

Notes. BAI = Beck Anxiety Inventory; DASS-21 = Depression Anxiety Stress Scale-21; DASS-42 = Depression Anxiety Stress Scale-42; GAD-2 = Generalized Anxiety Disorder-2 Scale; PSU = Problematic smartphone use; MPAI = Mobile Phone Addiction Index; MPAS = Mobile Phone Addiction Scale; MPIQ = Mobile Phone Involvement Questionnaire; MPOQ = Mobile Phone Overuse Questionnaire; MPPUS = Mobile Phone Problem Use Scale; Mturk = Amazon's Mechanical Turk Labor Market; NR = Not reported; PCL-5 = Posttraumatic Stress Disorder Checklist-5; PCPUS = Problematic Cellular Phone Use Scale; PMPUS = Problematic Mobile Phone Use Scale; PSUS = Problematic Smartphone Use Scale; PTSD = Posttraumatic stress disorder; SAI = Smartphone Addiction Inventory; SAPS = Smartphone Addiction Proneness Scale; SAS = Smartphone Addiction Scale; SAS-SV = Smartphone Addiction Scale-Short Version; SBRSAS = Self-Beliefs Related to Social Anxiety Scale; SCL-90-R = Symptom Checklist-90-Revised; SIAS = Social Interaction Anxiety Scale; STAI = State Trait Anxiety Inventory; ZSRAS = Zung's Self-Rating Anxiety Scale.

there is support for anxiety's positive relationship with PSU severity, and this relationship is likely bidirectional (Lu et al., 2014; Thomée et al., 2011), as depicted in the Figure. The importance of anxiety-related transdiagnostic constructs in the anxiety-PSU severity relationship also has supporting evidence (Elhai et al., 2018a, 2018c, 2018e; Oberst et al., 2017). Furthermore, the influence of increased or habitual smartphone use in accounting for relations between anxiety and PSU severity has support (Elhai, Levine et al., 2017; van Deursen et al., 2015).

Finally, we offer recommendations for future research examining relations between PSU and anxiety severity. First, in addition to self-report, more research on PSU should include behavioral methods for collecting data on smartphone use, such as objectively examining participants' smartphone use logs (Elhai et al., 2018d; Montag et al., 2015; Rozgonjuk et al., 2018). Second, in addition to cross-sectional data, more studies should be executed longitudinally, inquiring about mental health constructs and PSU severity across multiple time-points (Elhai et al., 2018b; Lu et al., 2014; Thomée et al., 2011). Third, we recommend broader application of person-centered analyses, in order to uncover latent subgroups of smartphone (and/or problematic) users, including examination of relations with psychopathology constructs (Elhai & Contractor, 2018; Kim, Nam et al., 2016; Mok et al., 2014). Fourth, another promising approach to understanding the associations between PSU and psychopathology involves using network based analytic methods (Baggio et al., 2018). Fifth, moderators of the relationship between psychopathology and PSU severity should be further investigated, such as age, perceived social support, and cultural background. Finally, in addition to college student samples, studies examining PSU and mental health variables (such as anxiety symptoms) should include clinical samples, and larger community samples. In fact, a rich literature has developed on the use of smartphone apps and internet technology in treating anxiety-related disorders (Firth et al., 2017; Olthuis et al., 2016; Van Ameringen, Turna, Khalesi, Pullia, & Patterson, 2017). Balance may be needed in promoting healthy (non-excessive) smartphone use among anxiety-disordered individuals, while also promoting the use of smartphone apps for facilitating management of anxiety symptoms for some individuals.

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