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REVIEW ARTICLE

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The association between smartphone use, stress, and anxiety: A meta-analytic review

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Abstract

Research investigating the various mental, physical, and social effects of smartphone use has proliferated in the previous decade. Two variables of interest in this literature are the levels of anxiety and stress associated with smartphone use. The current meta-analysis aimed to provide the first quantitative review of this literature, as well as determine potential moderators that might influence this relationship. A total of 39 independent samples (N = 21, 736) were used to compute a summary effect size of r = .22, p < .001, CI [.17–.28] indicating a small-to-medium association between smartphone use and stress and anxiety. Significant moderators included the year in which the article was published, as well as whether problematic or nonproblematic phone use was assessed. In addition, studies using validated measures of smartphone use indicated a (nonsignificantly) larger association than studies using nonvalidated measures. Strengths and limitations of the meta-analysis, as well as future directions of research are discussed.

KEYWORDS

anxiety, meta-analysis, mobile phones, smartphones, stress

1 | INTRODUCTION

A *smartphone* is a piece of portable technology born from the technology of handheld computers (Campbell-Kelly & Garcia-Swartz, 2015) that allows users to access telephone and computer services within the same device (Soukup, 2015). The term was first introduced to the world in 1997, shortly after the creation of the *PalmPilot*. The industry was then revolutionized a decade later with Apple's introduction of the *iPhone*, and in 2008 with Google's *Android* devices (Campbell-Kelly & Garcia-Swartz, 2015). A smartphone allows users to stay connected with news and world events as one would using a computer with internet access but also with their social group as one would with a traditional telephone. The multitasking capability of these devices results in users spending more time using them than they would a traditional telephone or cellphone (Soukup, 2015). American smartphone users report that they use their smartphones not just for communicating with others but also to look up health information, do online banking, and to look up real estate and job information (Smith & Page, 2015). This multifunctionality is thought to be a factor contributing to people's feelings of dependence on their smartphones. One study found that 20% of college students surveyed believed they were addicted to their smartphone, and over 50% believed that they were overly dependent on it (Emmanuel et al., 2015).

With the increased popularity and reliance on smartphones in the last decade (Smith & Page, 2015), research on the effects of smartphone use has proliferated. A search for peer-reviewed articles with the keyword "smartphone" on PsychInfo produces nearly 1,500 results from 2007 to 2017 (as of November 2017); roughly half of these were published within the last year alone. These studies investigate a variety of topics, from the use of smartphones for managing chronic diseases (Wang et al., 2014) to information privacy (Nguyen, Rosoff, & John, 2016).

2 | MOBILE PHONE USE AND PSYCHOLOGICAL WELL-BEING

One topic of particular interest to researchers has been the relationship between smartphone usage and various indices of psychological well-being (Sansone & Sansone, 2013). Studies have investigated the relationship between smartphone use and the quality of interpersonal

relationships (Abeele, Schouten, & Antheunis, 2016), sleep disturbances (Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2015), and mental illness (Park et al., 2015). Additionally, two topics that have gained considerable attention are the relationships between smartphone use and *stress* (e.g., Chiu, 2014), and smartphone use and *anxiety*. Although the terms stress and anxiety are sometimes used interchangeably, they refer to different constructs; stress is an immediate response to an external demand, whereas anxiety is more general, future-oreinted, and is typically not attributed to one specific cause (American Psychiatric Association, 2013; Giannakakis et al., 2017; Nydegger, 2016). Stress is described as the inability to cope with external demands, referred to as *stressors* (Baum, 1990; Schneiderman, Ironson, & Segal, 2005). Stressors can be biological (e.g., a viral infection), environmental (e.g., extreme temperatures), or psychological (e.g., taking a difficult exam). We can also classify stress into different categories depending on the domain the stress occurs in. For example, *social stress* would result from a stressor within a person's interpersonal relationships or their social environment. Distinctions may also be made between the time period in which the stress occurs; *perceived stress* refers to stress that an individual experiences in a given moment (Phillips, 2013), whereas *chronic stress* refers to stress an individual experiences over an extended period of time (Miller, Chen, & Zhou, 2007). Stress can result in physiological consequences such as elevated levels of stress hormones (e.g., cortisol) or psychological consequences such as *anxiety* (Baum, 1990; Schneiderman et al., 2005). Anxiety is a stress emotion (Endler & Parker, 1990) characterized by feelings of "unsettling anticipation" and "uneasy suspense" (Rachman, 2004). Like stress, anxiety can be classified by time period. State anxiety refers to the short-term emotional condition of anxiety, whereas trait anxiety refers to the long-term personality characteristic that describes an individual's potential for experiencing state anxiety (Endler & Parker, 1990). Anxiety disorders may develop when anxiety becomes severe enough to impact an individual's daily functioning (Anderson, 1998; Nydegger, 2016).

No comprehensive theory or explanation has been tested for *why* smartphones might be associated with feelings of stress or anxiety. Some researchers have posited that having constant access to one's smartphone might be stressful, because of a felt obligation to always be available to one's virtual social network (Thomée, Dellve, Härenstam, & Hagberg, 2010). Referred to as "communication overload," Thomée and colleagues found that this pressure to be constantly available was associated with greater smartphone use—to meet the expectation—and that this pressure was associated with feelings of guilt, stress, and depression. Various mechanisms, including (a) habitual use and checking of one's smartphone, (b) excessive reassurance seeking, and (c) the fear of missing important information or events, have been proposed to lead to the development of problematic—or addictive—smartphone use (Elhai, Dvorak, Levine, & Hall, 2017). This model of problematic smartphone use has been influenced by theoretical models of internet addiction, and these mechanisms are thought to be the route through which smartphone use can cause psychopathological symptoms such as stress, anxiety, and depression (Elhai, Dvorak, et al., 2017).

2.1 | Overview of the smartphone, stress, and anxiety literature

Although there are plenty of studies on this topic, the literature on smartphone use and stress shows mixed results; some studies suggest that smartphones are associated with reduced stress (e.g., Kline & Liu, 2005; Toda, Ezoe, & Takeshita, 2014), whereas the results of others suggest that smartphone use is associated with increased stress (e.g., Thomée, Härenstam, & Hagberg, 2011; Yun, Kettinger, & Lee, 2012). Consequently, it is difficult to accurately summarize the relationship between smartphone use and stress. Furthermore, studies in this literature are cross-sectional, and the typical methodology involves collecting self-report measures of smartphone use and stress, and correlating them. Thus, even when studies suggest the same relationship between smartphone use and stress, the causal direction of the relationship is unclear. For example, of the studies that suggest a relationship between smartphone use and increased stress, some propose that stress leads to smartphone use (e.g., Jeong, Kim, Yum, & Hwang, 2016; Wang, Wang, Gaskin, & Wang, 2015), whereas others propose that smartphone use may cause stress (e.g., Murdock, 2013). Further research involving experimental designs is required for causal claims to be made.

Similarly, the literature examining the association between smartphone use and anxiety is composed of mostly cross-sectional research. Levels of state and/or trait anxiety are often assessed using validated scales—such as the State-Trait Anxiety Inventory (Spielberger, 1983)—to determine participants' general levels of anxiety. Furthermore, anxiety in the context of social relationships specifically—such as attachment or relational anxiety—and its association with various aspects of smartphone use has also been investigated (e.g., Han, Geng, Jou, Gao, & Yang, 2017; Weisskirch, 2012; Weisskirch, Drouin, & Delevi, 2017). Results from these studies seem to indicate a positive correlation between smartphone use and anxiety (e.g., Elhai, Levine, Dvorak, & Hall, 2017; Han et al., 2017; Nassehi, Arbabisarjou, Jafari, Ghasemi, & Najafi, 2016), although some studies have obtained no significant relationship between these two variables (e.g., Jin & Pena, 2010; Lepp, Li, & Barkley, 2016).

3 | CURRENT STUDY RATIONALE

Research examining smartphone use and negative psychological constructs—such as stress and anxiety—is growing quickly. In the present article, we conducted a meta-analysis of studies that investigated the relationship between smartphone use (both normative and maladaptive) and stress and anxiety, to attempt to put together what is already known and to inform future research. The analysis includes studies with measures of overall, general stress such as the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983), and also "technostress"; a specific type of stress that is associated with technology use (Lee, Chang, Lin, & Cheng, 2014). Additionally, the current analysis looked only at the cognitive and emotional aspects of stress and anxiety, as studies that have looked at the biological aspects of these two constructs have generally focused on the biological aspects of smartphone use (i.e., radiation exposure); we were interested exclusively in the

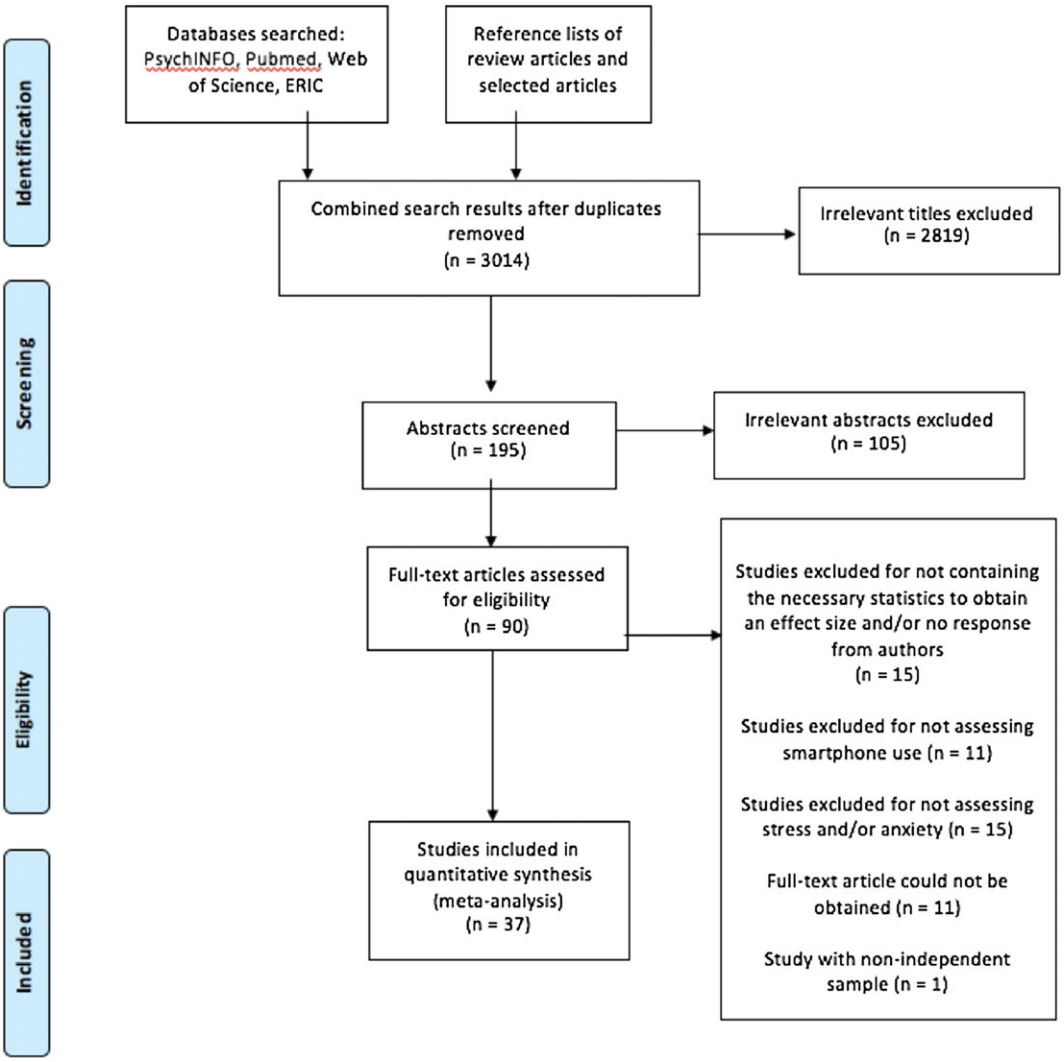

FIGURE 1 PRISMA diagram outlining steps involved in identifying studies included in the meta-analysis

nonbiological aspects of smartphone use. To date, there has been no quantitative culmination of this literature, to our knowledge. Considering the prevalence of these devices in our everyday lives, it is important for both researchers, and society at large, to have some sort of overall idea of the effect of smartphone use on stress and anxiety.

4 | METHOD

4.1 | Literature search

Following the method outlined in the PRISMA statement (see Figure 1 and Data S1), a step-by-step procedure was followed to obtain our final set of studies. First, we conducted article searches on several computerized databases, including *PsycINFO*, *PubMed*, *Web of Science*, and *ERIC*, for studies investigating the relationship between smartphone use and stress. The following keywords were used in combination with the appropriate Boolean terms: *smartphone*, *phone*, *cellphone*, *mobile phone*, and *stress*. Second, the reference lists of the selected articles and relevant review articles were examined to identify any other studies that were not identified in the original article search. We also contacted prominent authors in the field for any additional unpublished studies or data that they might have. A primary search based on the above search criteria was conducted in September 2016, where studies specifically examining the relationship between smartphone use and *stress* were obtained and coded. An additional search was conducted by both authors in November 2017, where the keyword *anxiety* was also included to obtain articles examining this psychological construct as well.[1]

4.2 | Selection criteria

For an article to be included in the meta-analysis, the following criteria must have been met:

1. Only studies that used a subjective measure of the psychological construct of stress were included. This is because studies that have used biological methods of assessing stress levels (i.e., cortisol) have also focused on the genetic or biological aspects of smartphone use (i.e., on potential detrimental effects from radiation exposure, such as genetic mutations). More specifically, these

[1]The authors would like to thank the anonymous reviewer for recommending the inclusion of this additional variable.

studies do not necessarily investigate the psychological component of smartphone use. Rather, emphasis is instead placed on the exposure to electromagnetic fields emitted from smartphones. Because this type of biological stress is conceptually different from the stress that is either increased or alleviated by smartphone *use*, this subset of studies was excluded. Similarly, only studies that used a subjective measure specifically focused on the psychological construct of anxiety were included. Studies that had assessed anxiety measures in combination with related psychological constructs (such as negative affect) were not included. Furthermore, studies assessing *any* operationalization of anxiety—including state and trait anxiety measures—were included.

2. Studies were only included if they used a measure of smartphone, mobile phone, or cellphone usage specifically. Studies that assessed phone use in conjunction with other related constructs in a single measure (i.e., phone use *and* computer use) were not included. A study was included regardless of the type of phone use being assessed (general phone use or specific function) and regardless of whether the measure was validated or not. Additionally, only studies assessing *mobile* phone use were included; studies investigating traditional telephone or landline phone use were not included.
3. Only studies that included a measure of smartphone *use* were included. Studies that only determined whether participants owned a smartphone, without assessing the level of use, were not included. In addition, studies that assessed aspects of smartphone separation and its effects on participants' stress and anxiety were also excluded. This small subset of studies was not included for two main reasons: (a) Only six studies (all experimental designs) were identified, and their inclusion would not have been enough to produce a separate meta-analysis specific to smartphone separation; and (b) there was much variability in experimental designs between these studies—such as whether it was a complete separation or a restriction of specific smartphone activities that was manipulated, or whether or not participants' awareness of their phone being separated from them was experimentally manipulated. This resulted in an inability to meaningfully combine these studies.
4. Finally, studies were only included if the statistical results provided could be transformed into a summary effect size. In studies where appropriate statistics were not reported (e.g., odds ratios and regression analyses), the authors were contacted.
5. Studies had to be written in the English language.

An initial search conducted in September 2016 generated 1,640 titles, after the removal of duplicate titles across research databases. After an initial screening based solely on titles, 92 were agreed upon by both authors for inclusion. At both the title and abstract screening stage, only studies that were considered to have potentially assessed some aspect of smartphone use, anxiety, and/or stress were accepted. The authors then independently screened the abstracts of these titles and excluded 64, resulting in 28 full-text articles. All 28 eligible articles were independently read by the authors, and 14 were excluded for not meeting criteria. The remaining 14 articles from this initial search were included in the meta-analysis. A secondary search was conducted in November 2017 to include articles that had assessed the relationship between smartphone use and anxiety. The aforementioned Boolean terms were again used, with the addition of the search term "anxiety." Because this secondary search encompassed results from the initial search as well—due to the same keywords and Boolean terms used—results pertaining to this secondary search are presented in the PRISMA flow diagram, with the above outlined steps for our initial search duplicated in the secondary search.

In total, 37 studies yielding 39 independent samples were included in our meta-analysis based on the outlined inclusion criteria (see Figure 1). A description of the studies included is shown in Table 1.

4.3 | Coding of studies

Both authors developed a coding scheme prior to independently coding the final articles for moderators. Because no previous meta-analysis exists on this topic, several moderators were coded based on the authors' judgements of potentially influential factors across studies. All moderators were coded by the two authors. Interrater reliability for both continuous and categorical moderators was above 90%. Any discrepancies in coding were resolved through further discussion.

4.3.1 | Age

Participant age was coded according to the mean age of participants in the sample. Mean age of participants was not provided in five studies and was estimated using sample age frequencies or age ranges in three studies (Al-Khamees, 2007; Lepp et al., 2016; Panova & Lleras, Study 1, 2016). Participants' median age was provided in one study (Reid & Reid, 2007) and was used instead of mean age in the moderator analyses.

4.3.2 | Gender

Participant gender was coded according to the percentage of males in the sample. Two studies (Thomée et al., 2011; Thomée, Eklöf, Gustafsson, Nilsson, & Hagberg, 2007) provided separate effect sizes for males and females, allowing for each gender to be treated as an independent sample in the analyses. Only one study (Hong, Chiu, & Huang, 2012) did not provide demographic information regarding the gender composition of participants.

4.3.3 | Geographical location

The countries in which the studies were conducted were recorded and then coded into three different geographical locations: (a) Europe (n = 8); (b) Asia (n = 15); and (c) North America (n = 15). One study (Saling & Haire, 2016) was coded as being conducted in Australia but was not included in the moderator analysis as a subgroup given that only one study exists.

4.3.4 | Stress and anxiety

Studies were coded depending on whether they assessed the relationship between smartphone use and (a) stress, or smartphone use and (b) anxiety.

TABLE 1 Characteristics of the studies reviewed and included in the meta-analysis on mobile phone use and stress

Study	*N*	Mean age	Phone use measure		Anxiety or stress	Location
			Validation	Type of use		
Adams and Kisler (2013)	236	22.13	NV	NP	Anxiety	North America
Al-Khamees (2007)	1,813	19.5	NV	NP	Stress	Asia
Chiu (2014)	387	—	V	P	Stress	Asia
Choi et al. (2015)	448	—	V	P	Anxiety	Asia
Coccia and Darling (2014)	534	20.8	NV	NP	Stress	North America
De-Sola, Talledo, Rubio, and Rodríguez de Fonseca (2017)	1,126	32.8	V	P	Anxiety	Asia
Demirci, Akgönül, and Akpinar (2015)	319	20.50	V	P	Anxiety	North America
Elhai, Levine, et al. (2017)	308	33.15	V	P	Anxiety	Asia
Han et al. (2017)	543	19.85	V	P	Anxiety	Asia
Harwood, Dooley, Scott, and Joiner (2014)	274	27.24	NV	NP	Stress	Europe
Haug et al. (2015)	1,519	18.2	V	P	Stress	Europe
Hong et al. (2012)	269	—	NV	NP	Anxiety	Asia
Hussain, Griffiths, and Sheffield (2017)	640	24.89	V	P	Anxiety	Europe
Jeong et al. (2016)	944	11.97	NV	NP	Stress	Asia
Jin and Pena (2010)	197	19.40	NV	NP	Anxiety	North America
Lee et al. (2014)	325	28.98	NV	P	Stress	Asia
Lepp, Barkley, and Karpinski (2014)	496	20.48	NV	NP	Anxiety	North America
Lepp et al. (2016)	493	23.5[a]	NV	NP	Anxiety	North America
Lu et al. (2011)	146	42.4	V	P	Anxiety	Asia
Murdock (2013)	83	18.41	NV	NP	Stress	North America
Murdock, Gorman, and Robbins (2015)	142	19.58	NV	NP	Stress	North America
Nassehi et al. (2016)	229	21.7	NV	P	Anxiety	Asia
Panova and Lleras (2016)						
Study 1	318	19	V	P	Anxiety	North America
Study 2	72	—	V	P	Anxiety	North America
Reid and Reid (2007)	158	20.0	NV	NP	Anxiety	Europe
Rosen et al. (2013)	942	29.96	NV	NP	Anxiety	North America
Rosen, Carrier, Miller, Rokkum, and Ruiz (2016)	734	25.87	V	NP	Anxiety	North America
Saling and Haire (2016)	397	34.35	NV	NP	Anxiety	Australia
Samaha and Hawi (2016)	249	20.96	V	P	Stress	Asia
Söderqvist, Carlberg, and Hardell (2008)	1,269	16.6	NV	NP	Stress	Europe
Thomée et al. (2011)						
Males	1,452	22.07	NV	NP	Stress	Europe
Females	2,690	22.04	NV	NP	Stress	Europe
van Deursen, Bolle, Hegner, and Kommers (2015)	386	35.2	V	P	Stress	Europe
Wang et al. (2015)						
Problematic users	264	18	V	P	Stress	Asia
Nonproblematic users	281	18.8	V	P	Stress	Asia
Weisskirch (2012)	31	19.9	NV	NP	Anxiety	North America
Weisskirch et al. (2017)	459	20.02	V	NP	Anxiety	North America
Weisskirch and Delevi (2011)	128	22.78	NV	NP	Anxiety	North America
Yang and Lay (2011)	435	—	NV	NP	Anxiety	Asia

Note. For phone use measure validation, V = validated; NV = nonvalidated. For phone use measure type of use, P = problematic; NP = nonproblematic.
[a]Median age.

4.3.5 | Type of stress

The type of stress assessed was coded into two different categories: (a) current (i.e., measures or questions that assessed participants' recent or present stress levels; *n* = 9), and (b) other (including social stress [*n* = 3], technostress [*n* = 1], and other non-specific forms of stress [*n* = 3]). Only two studies implemented stress questionnaires that were not validated, therefore validation of stress measures was not coded as a moderator.

4.3.6 | Type of anxiety

The type of anxiety assessed was coded into two different categories: (a) general (i.e., measures or questions that assessed participants'

recent or present anxiety levels; n = 14), and (b) social (i.e., measures or questions that assessed participants' anxiety surrounding social interactions or situations; n = 7). Two studies (Rosen, Whaling, Carrier, Cheever, & Rokkum, 2013; Rosen et al., 2016) assessed anxiety levels specifically pertaining to technology use but were not included in the moderator analyses.

4.3.7 | Validation of phone use measure

The type of measure used to assess mobile phone use in each of the studies was coded. Due to the variety of measures used, the authors coded these measures as either a previously validated measure (i.e., the Smartphone Addiction Scale; Kwon et al., 2013) or as a nonvalidated measure of participants' phone use (i.e., questions regarding the number of daily texts participants sent or received).

4.3.8 | Type of phone use

The type of phone use assessed in the articles was coded into two categories, problematic or nonproblematic. Measures that assessed some aspect of problematic phone use—such as compulsion or addiction—were coded as measures of problematic phone use. Alternatively, measures assessing nonproblematic aspects of phone use—such as number of texts sent or received—were coded as measures of nonproblematic phone use.

4.3.9 | Other

Additional descriptive moderators also coded included (a) sample size; (b) year of publication; and (c) journal impact factor.

4.4 | Computation of effect sizes

Effect sizes were computed using Comprehensive Meta Analysis 3.0 (CMA, Borenstein, Hedges, Higgins, & Rothstein, 2011). Because all included studies were cross-sectional, the principle effect size extracted was a zero-order correlation coefficient. To obtain more generalizable results, data were analysed using a random effects model. This method allowed for studies to be weighted in proportion to their sample size when calculating the overall effect size (Hedges & Olkin, 1985). Furthermore, to test for significant categorical moderators, the Q statistic—a test of homogeneity of variance—was calculated. Continuous moderators were analysed using the method of moments, random effects model regression.

4.5 | Publication bias

Publication bias is a pervasive issue in scholarly research. Because significant findings are more likely to be published, the scholarly research in psychology is skewed towards studies demonstrating significant effects. This poses an issue for meta-analyses, where the summary effect size will then also be skewed. What is important to assess in this case is the impact that publication bias—or missing studies containing nonsignificant results—has on the summary effect size. To address this issue, we conducted Duval and Tweedie's (2000) Trim-and-Fill Method. This algorithmic method determines the number of missing studies required to ensure symmetry of the funnel plot of the studies included. These effect sizes are then imputed, and an adjusted effect size is computed to reflect the impact of these "missing" studies due to publication bias. Additional tests assessing publication bias—such as the fail-safe N (Rosenthal, 1979), rank correlation test (Begg & Mazumdar, 1994), and Egger's regression intercept (Egger, Smith, Schneider, & Minder, 1997)—were also conducted to provide a comprehensive assessment of publication bias.

5 | RESULTS

5.1 | Smartphone use and stress and anxiety

Across 37 studies (N = 21, 736), yielding 39 independent samples, the summary association between mobile phone use and stress and anxiety was r = .22, p < .001, CI [.17–.28] (see Figure 2), with a heterogeneity Q-value = 607.84, p < .001. This indicates a small-to-medium association between mobile phone use with stress and anxiety, as well as significant variability in the effect size between studies. In addition, an I^2 value of 93.75 indicates that approximately 94% of the variation across these studies is due to heterogeneity, rather than chance or error.

5.2 | Significant moderators

5.2.1 | Problematic versus nonproblematic phone use

The use of measures that assessed problematic aspects of phone use versus measures that assessed nonproblematic phone use was a significant moderator (Q = 22.01, p < .001). Studies in which measures assessed problematic phone use obtained a stronger effect size (k = 17, r = .35, p < .001, CI [.27–.42]) than studies where measures did not assess problematic aspects of phone use (k = 22, r = .13, p < .001, CI [.07–.18]).

5.2.2 | Year of publication

The year in which the article was published was determined to be a significant continuous moderator (k = 39, b = .02, p = .01). The direction of this effect indicates that the relationship between smartphone use and stress and anxiety strengthened over the 10-year period in which the studies were published (2007–2017).

5.2.3 | Phone use measure validation

Finally, results from the moderator analysis investigating the validation of the phone use measure approached significance (Q = 3.78, p = .053). Studies that used validated measures of phone use (k = 17, r = .28, p < .001, CI [.22–.33]) found a stronger association between mobile phone use and stress than studies that used measures or questions that were not validated (k = 22, r = .18, p < .001, CI [.11–.26]).

5.3 | Nonsignificant moderators

The remainder of the moderators did not account for significant heterogeneity. These included the type of stress and anxiety measured and the geographical location in which the studies were conducted, as well as continuous moderators including the sample size, percent

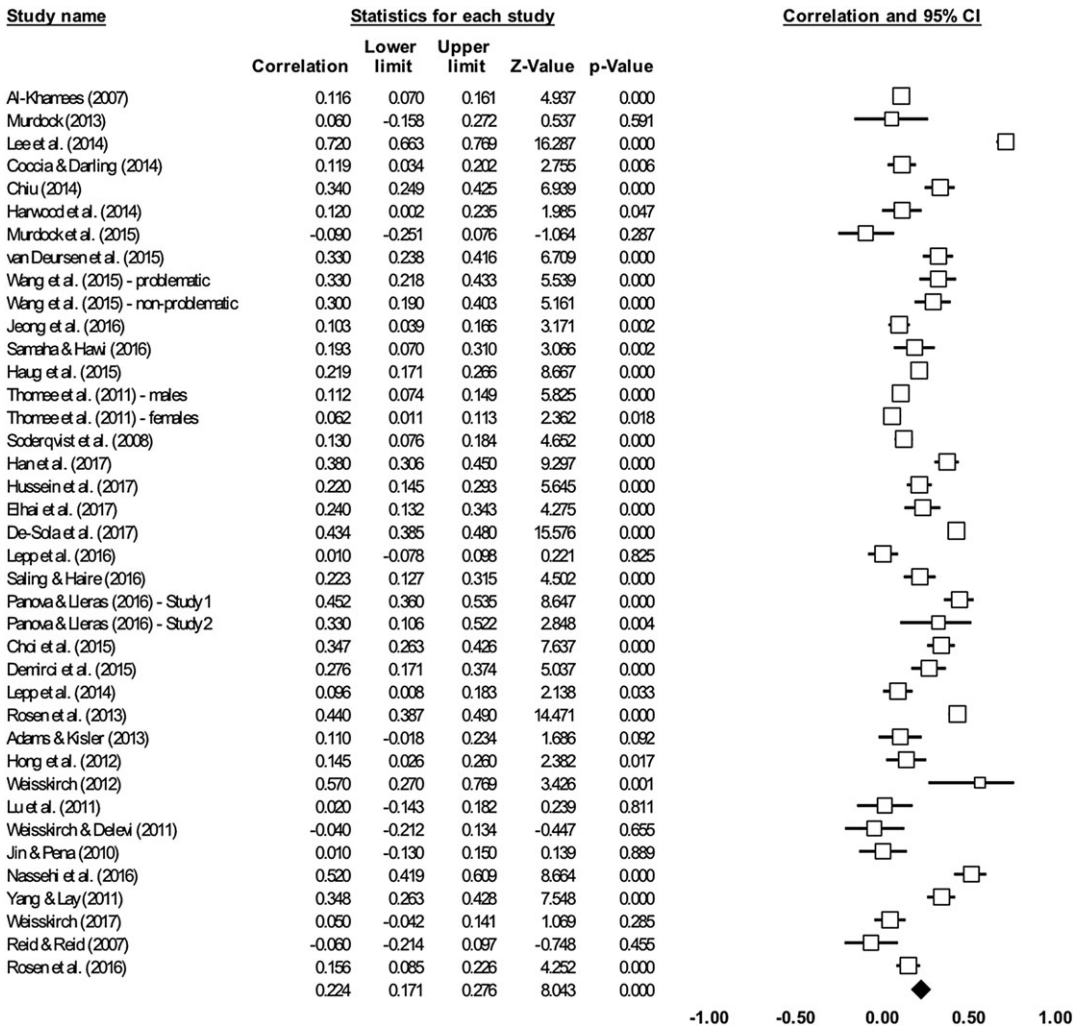

FIGURE 2 Studies included in the current meta-analysis investigating the association between mobile phone use and stress. Studies located to the right of the zero mark indicate a positive relationship between mobile phone use and stress, whereas studies included to the left of the zero mark indicate a negative association. The summary effect size (r = .21) is indicated by the filled diamond

of males in the sample, and the impact factor of the journal the study was published in (see Table 2).

5.4 | Publication bias

Using the Trim-and-Fill procedure (see Figure 3), no studies were imputed and the adjusted effect size was identical to the obtained effect size of r = .22. In addition, results from the fail-safe N test (Rosenthal, 1979) indicate that the inclusion of 8,971 missing studies with null results would be required in order to make the overall association statistically nonsignificant. Finally, results from Egger's regression intercept test obtained a nonsignificant finding of p = .30, further indicating no publication bias. The collective results of these analyses imply that publication bias does not have a significant influence on the results obtained in this meta-analysis.

5.5 | Sensitivity analyses

As indicated in Table 1, the study by Lee et al. (2014) had an obtained effect size (r = .72) that was much larger than the rest of the studies included in the meta-analysis. To determine whether this study had a disproportionate effect on the overall effect size, the summary effect size was calculated with this study removed. The resulting effect size, r = .21, p < .001, CI [.12–.21], indicates that this study does not have a disproportionate effect on the overall effect size.

6 | DISCUSSION

The current meta-analysis aimed to determine the association between smartphone use and stress and anxiety. Based on 39 independent samples, a small-to-medium summary effect size was obtained, indicating that a positive correlation exists between smartphone use and stress and anxiety. The following section will discuss both significant and nonsignificant moderators in the context of relevant literature. Limitations and strengths of the current meta-analysis will also be considered, as will future directions for research.

6.1 | Significant moderators

The type of phone use was a significant moderator, with problematic phone use having a larger association with stress and anxiety than

TABLE 2 Results of categorical and continuous moderator analyses for the association between mobile phone use and stress

Categorical moderators	*k*	*N*	*r*	95% CI	Heterogeneity *Q*	*p* Value
Geographical location						
Europe	8	9,514	.18	.09–.27	4.72	.10
Asia	15	6,383	.31	.21–.41		
North America	15	5,442	.17	.07–.26		
Stress versus Anxiety						
Anxiety	23	9,124	.23	.16–.30	.18	.67
Stress	16	12,612	.21	.14–.29		
Type of Stress						
Current	9	8,207	.16	.11–.22	.94	.33
Other	7	4,405	.26	.07–.43		
Phone use measure validation						
Validated	17	8,199	.28	.22–.33	3.74	.05
Nonvalidated	22	13,537	.18	.11–.26		
Type of anxiety						
General	14	7,173	.25	.16–.34	.69	.41
Social	7	1,951	.17	.01–.33		
Type of phone use						
Problematic	17	7,560	.35	.27–.42	22.01	.001
Nonproblematic	22	14,178	.13	.07–.18		
Continuous moderators	*k*	*N*	Slope	*SE*	*z* Value	*p* Value
Mean age	34	20,125	.007	.005	1.59	.11
Sample size	39	21,736	−.0000	.0001	−.77	.44
Year of publication	39	21,736	.02	.01	2.48	.01
Impact factor	36	20,370	−.02	.04	−.56	.58
Percent of males in sample	38	21,467	.002	.002	1.21	.23

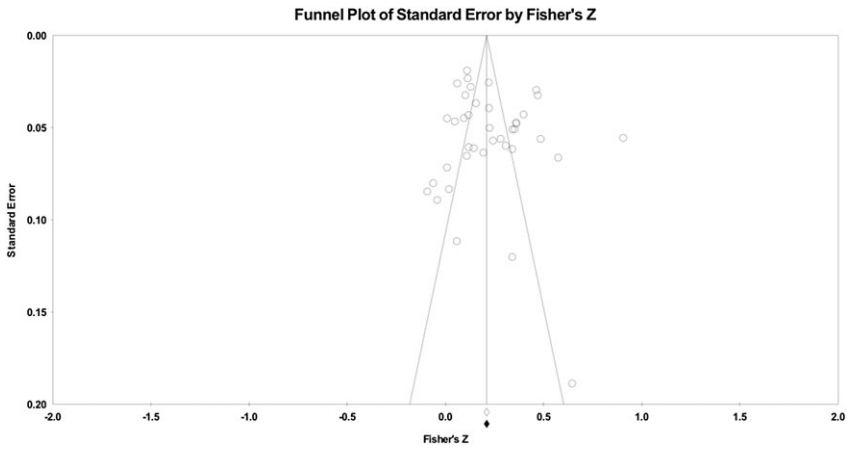

FIGURE 3 The *y*-axis represents the standard error, and the *x*-axis represents Fisher's Z. The filled circles represent imputed studies, and the filled diamond represents the adjusted effect size

nonproblematic phone use. This finding parallels results obtained in a recent systematic review by Elhai, Dvorak, et al. (2017), where effect sizes for the relationship between stress and problematic phone use were in the small-to-medium range. However, because all the studies included in our meta-analysis were cross-sectional, our findings cannot definitively determine whether problematic smartphone use causes increased stress and anxiety or if increased stress and anxiety levels lead to problematic smartphone use. Although previous literature suggests that problematic smartphone use might arise as a response to coping with extraneous stressors (Bianchi & Phillips, 2005; Cholíz, 2010) or loneliness (e.g., Kim, 2017), the exact direction of the causal relationship cannot be determined from cross-sectional data.

In addition, year of publication was a significant continuous moderator of the relationship between smartphone use and stress and anxiety. The included studies were published between 2007 and 2017. Studies published later in this range obtained a stronger association than those published earlier. Demographic information pertaining to smartphone ownership indicates a steady increase in ownership over the last decade, particularly in the last 5 years (Pew Research Center, 2018). Moreover, the increasing multifunctionality of smartphones

over this time period—such as access to social media and email—might have increased behaviors and pressures associated with problematic smartphone use, such as habitual checking and the pressure to be constantly connected, ultimately resulting in greater effects on stress and anxiety. Empirical research, however, is required to determine (a) how smartphone use has changed over this time period; and (b) whether these changes in use are associated with greater effects on stress and anxiety.

A stronger association was obtained for studies that used validated measures of smartphone use, although the results of this analysis did not reach the threshold for statistical significance (p = .053). A measure is considered validated if its psychometric properties have been previously empirically confirmed by researchers; in other words, its validity has been statistically confirmed. Results from nonvalidated measures might not be as reliable (Viswanathan, 2005), partly because they might capture associated constructs in addition to the construct of interest. Thus, one interpretation of this result is that studies that used validated measures were assessing smartphone use—or the varying aspects of smartphone use—specifically, whereas studies using nonvalidated measures might have also captured associated constructs, such as general social media use. The stronger association obtained for validated measures suggests that smartphone use specifically might be more strongly associated with psychological stress and anxiety, compared with related constructs (such as social media or internet use). This finding highlights the importance of using validated measures when measuring the effects of smartphone use; an effect is more likely to be detected if a validated scale is used, compared with an unvalidated one.

6.2 | Nonsignificant moderators

The rest of our moderators did not significantly account for any variance in the association between smartphone use and stress and anxiety. Most notably, the type of stress assessed was not identified as a significant moderator. This moderator was coded into two different categories: "current" stress, and a heterogeneous group coded as "other," which included social, technostress, and other non-specific forms of assessed stress. This resulted in a very heterogeneous "other" category, which might have included constructs that were quite dissimilar from one another. Similarly, a nonsignificant finding was also obtained for the type of anxiety moderator; although the subgroup of "social" anxiety was relatively homogenous, the moderator subgroup coded as "general" anxiety was heterogeneous in that it included assessments of both state, trait, and non-specified anxiety.

In addition, gender was also not a significant moderator. Previous research has suggested that males and females differ with respect to the types of activities for which they mainly use their smartphones (e.g., Baron & Campbell, 2012; Watten, Kleiven, Fostervold, Fauske, & Volden, 2008). More specifically, females are more likely to use their smartphones for engaging in social activities than males. Although these distinctions may well exist, our results indicate that they might not translate to differences in experienced stress and anxiety.

Finally, although the geographical location in which studies were conducted was not a significant moderator, considerable differences in effect sizes were identified between geographical locations. Notably, a stronger effect size was obtained for studies conducted in Asian countries (r = .31), compared with those conducted in European (r = .18) and North American (r = .17) countries. Previous research has indicated both differences in mobile phone use frequency and attitudes towards mobile phone use (Baron & af Segerstad, 2010) across different geographical locations, suggesting the presence of systematic differences in actual use and attitudes towards mobile phone use across geographical locations.

6.3 | Strengths and limitations

The current meta-analysis provides the first quantitative review of the literature pertaining to smartphone use and stress and anxiety. Due to the rapid growth of this field, it is timely to assess the state of the literature. Our results indicate that not only does a significant relationship exist between smartphone use and stress and anxiety but that this relationship is moderated by several factors. These significant moderators indicate areas of focus for future research. Finally, although our analyses did not include nonpublished literature, the assessment of publication bias indicated that our results were unlikely to be influenced by the lack of nonpublished literature.

It is important to also address the limitations of this meta-analysis; first, only cross-sectional studies were included in our analyses. As a result, claims regarding the directionality of the relationship cannot be made. In other words, we cannot determine whether increased smartphone use *causes* worse psychological outcomes or whether experiencing higher levels of stress and anxiety causes increased smartphone use. In addition, it is also difficult to determine if a third variable might be responsible for the relationship between smartphone use and these variables. For example, might a demanding occupation—where one is expected to always be available via smartphone—account for the association between experienced stressed and smartphone use? A second limitation of the current meta-analysis is the relatively small number of studies included to compute the summary effect size. As a result, several of the moderator groups included a heterogeneous grouping of studies (e.g. "type of stress") that might result in an inadequately classified group. Future research exploring the specific categories of the moderators we identified will allow for a more nuanced and accurate investigation of these variables. Finally, the current meta-analysis did not include any unpublished literature. Although this is a limitation, our quantitative assessments of publication bias allow us to conclude that it does not seem to have a significant impact on the summary effect size.

6.4 | Future directions and conclusions

Based on the obtained results, several lines of future research seem warranted. First, more experimental studies are required to determine the causal nature of this relationship. In addition, variables of interest identified through our moderator analyses should also be further explored to clearly define their role in the relationship between smartphone use and stress.

The current meta-analysis identified a positive relationship between smartphone use and stress and anxiety. In addition, several significant moderators were also identified, indicating possible directions for future research. Furthermore, to the authors' knowledge, this is the first quantitative review of this literature, providing a much-needed review of the existing studies and identifying potential important areas of future research. Although the results do indicate an association between smartphone use and stress and anxiety, it is important to note that the causal nature of this relationship cannot be determined until further experimental studies take place. As a result, our findings (a) serve as a reminder that this relationship exists, allowing us to be more aware of this association in our daily lives; and (b) provide an impetus for researchers to potentially untangle both the causal directionality of this association, as well as the impact of the various moderators we identified.

CONFLICT OF INTEREST

The authors have declared that they have no conflict of interest.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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