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Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use

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ABSTRACT

Problematic smartphone use is an important public health challenge and is linked with poor mental health outcomes. However, little is known about the mechanisms that maintain this behavior. We recruited a sample of 308 participants from Amazon's Mechanical Turk labor market. Participants responded to standardized measures of problematic smartphone use, and frequency of smartphone use, depression and anxiety and possible mechanisms including behavioral activation, need for touch, fear of missing out (FoMO), and emotion regulation. Problematic smartphone use was most correlated with anxiety, need for touch and FoMO. The frequency of use was most correlated (inversely) with depression. In regression models, problematic smartphone use was associated with FoMO, depression (inversely), anxiety, and need for touch. Frequency of use was associated with need for touch, and (inversely) with depressive symptoms. Behavioral activation mediated associations between smartphone use (both problematic and usage frequency) and depression and anxiety symptoms. Emotional suppression also mediated the association between problematic smartphone use and anxiety. Results demonstrate the importance of social and tactile need fulfillment variables such as FoMO and need for touch as critical mechanisms that can explain problematic smartphone use and its association with depression and anxiety.

1. Introduction

Smartphones are ubiquitous in modern day society globally. Pew Research polling indicates that 72% of Americans own a smartphone, with a global average ownership of 43% (Poushter, 2016, February 22). However, for many people, problematic smartphone use has harmful effects. For example, research indicates hazardous outcomes for problematic smartphone use, including distracting drivers and pedestrians (reviewed in Cazzulino, Burke, Muller, Arbogast, & Upperman, 2014; Thompson, Rivara, Ayyagari, & Ebel, 2013). Additionally effects include musculoskeletal health effects (Xie, Szeto, Dai, & Madeleine, 2016; İNal, Demİrcİ, ÇetİntÜrk, Akgönül, & Savaş, 2015), poor physical fitness (Lepp, Barkley, Sanders, Rebold, & Gates, 2013; Rebold, Sheehan, Dirlam, Maldonado, & O'Donnell, 2016) and academic deficits (Lepp, Barkley, & Karpinski, 2014; Prabu, Kim, Brickman, Ran, & Curtis, 2015). Studying problematic smartphone use is therefore of significant public health significance. Our focus in the present paper is on correlates and mechanisms of problematic smartphone use involving psychopathology, dysfunctional self- and emotional control, and social and tactile need fulfillment.

Evidence for the construct of problematic smartphone use, or smartphone addiction, comes from a growing literature base. In Pew Research polling, nearly half of Americans reported that they "couldn't live without" their smartphones (Smith & Page, 2015, April 1). When separated from one's smartphone in experimental studies, many participants evidence mounting anxiety (Cheever, Rosen, Carrier, & Chavez, 2014) and physiological increases in heart rate and blood pressure (Clayton, Leshner, & Almond, 2015). Furthermore, phantom cell phone vibrations are commonly reported, despite an absence of incoming phone notifications (Kruger

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& Djerf, 2016). These dependency-like behaviors and withdrawal-like symptoms are not surprising given how much people rely on their phones in daily life for productivity, information seeking, and social interaction, among other things (van Deursen, Bolle, Hegner, & Kommers, 2015).

Recent studies identified the psychopathological correlates of problematic smartphone use. Methodologically, this literature base has generous sample sizes ($n > 200$), primarily using student participants collected in the U.S., China and Korea, with standardized measures of problematic mobile phone use. The majority of these studies are cross-sectional, using regression or structural equation modeling analyses. Most widely reported are relationships between problematic smartphone use and severity of depression and anxiety symptoms. Other research has shown associations between problematic smartphone use and more general stress and self-esteem, but with less consistent findings (e.g., Smetaniuk, 2014; van Deursen et al., 2015). The association between smartphone use and depression typically ranges from 0.3 to 0.5 for bivariate correlations and standardized regression coefficients when adjusting for other relevant variables such as age and gender (most recently in Demirci, Akgonul, & Akpinar, 2015; Harwood, Dooley, Scott, & Joiner, 2014; J. Kim, Seo, & David, 2015; Smetaniuk, 2014). Anxiety symptoms are associated with problematic smartphone use on a bivariate and multivariate basis with coefficients averaging 0.2 (recently in Demirci et al., 2015; Harwood et al., 2014; R. Kim, Lee, & Choi, 2015; Lee, Chang, Lin, & Cheng, 2014).

Thus the literature demonstrates solid evidence for small to medium effect size associations between problematic smartphone use and depression and anxiety. There is evidence from prospective studies for bidirectional relations, whereby excessive smartphone use can result in psychopathology, which in turn drives smartphone use (van den Eijnden, Meerkerk, Vermulst, Spijkerman, & Engels, 2008; Thomee, Härenstam, & Hagberg, 2011; Yen et al., 2012).

Theoretical explanations specific to problematic smartphone use are limited. Very recently, Billieux and colleagues developed a theoretical model to explain problematic mobile phone use (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). Their model is based on primary pathways to problematic use including excessive reassurance seeking, impulsivity, and extraversion. We examine variables falling within this model in the prediction of problematic smartphone use, but we also extend this model by focusing on additional, newer variables with theoretical support that have only recently been tested empirically.

First, within Billieux et al.'s (2015) extraversion pathway, fear of missing out (FoMO) is a newer personality construct involving reluctance to miss important information, including social information. FoMO results in the need to frequently stay connected to social networks. FoMO was first discussed in the news media (Fake, 2011, March 15; Morford, 2010, August 4). People high in FoMO likely overuse their smartphones to satisfy the need to stay connected. FoMO appears to drive overuse of social media based on web surveys with college students and community participants (Alt, 2015; Przybylski, Murayama, DeHaan, & Gladwell, 2013). Among college students, FoMO was associated with increases in problematic smartphone use in a laboratory study (Clayton et al., 2015).

Another relevant construct, within the impulsive pathway to problematic smartphone use, is decreased emotional self-control, or emotional dysregulation. Dysregulated emotion is often defined by two processes – decreased cognitive reappraisal, and increased emotional suppression (Gross & John, 2003; Gross, 1998). Problematic smartphone users likely overuse their phones in part because of an inability to regulate their emotions. Additionally, problematic smartphone use may be a technique (albeit ineffective) to deal with or regulate negative emotion. In fact, Hoffner and Lee (2015) found in a survey study with undergraduates that habitual use of emotional suppression was associated with more intense missing of particular aspects of smartphone use, including entertainment and information content. A host of research has shown that the relationship between problematic behaviors and associated mental disorders is mediated by emotional dysregulation (reviewed in Weiss, Sullivan, & Tull, 2015). We were particularly interested in whether emotional dysregulation mediates relations between problematic smartphone use in accounting for depression and anxiety.

We propose an additional variable to Billieux et al.'s (2015) model. One addictive aspect of smartphone use is the pleasure derived from tactile sensations in holding the phone, and the autotelic touch (Peck & Childers, 2003a) required in completing tasks with one's fingers (Lee et al., 2014). "Need for touch" (Peck & Childers, 2003b) is a construct from the marketing field describing a personality variable of desiring haptic information through the hands. People high in this trait are more likely to analytically and experientially sample a product's features (Yazdanparast & Spears, 2012). Research demonstrates that if experiential product sampling is satisfying and fun, people high in the need for touch are likely to engage in impulse purchasing (Peck & Childers, 2006; Vieria, 2012). People high in the need for touch may demonstrate an overuse of a smartphone's touch screen to satisfy this need. Lee et al. (2014) found in a Taiwanese community survey that problematic smartphone use was significantly related to need for touch.

We also assess potential mechanisms that can account for relations between problem smartphone use and both depression and anxiety. One candidate mechanism is behavioral activation. According to the Behavioral Model of Depression, low levels of positive reinforcement are responsible for depressive symptoms, and increasing positive reinforcement can be obtained by increasing the number and types of gratifying/pleasurable events in one's environment (Lewinsohn, 1974). An elaboration of this model, the Integrated Model of Depression, adds a more comprehensive interplay of environmental and dispositional factors to developing depression, such as environmental stressors and maladaptive cognitions (Lewinsohn, Hoberman, Teri, & Hautzinger, 1985). Behavioral activation involves engagement in adaptive gratifying/pleasurable activities as a functional response alternative to avoidance. Behavioral activation has shown great promise as a target for alleviation of clinical depression (reviewed in Dimidjian, Barrera, Martell, Munoz, & Lewinsohn, 2011). It has also been found effective for other disorders with depression content, such as posttraumatic stress disorder (Acierno et al., 2016), as well as using different delivery formats, such as via the internet (Carlbring et al., 2013). Yet unexplored is whether increased behavioral activation offsets the impact of problematic smartphone use on depression and anxiety outcomes.

1.1. Hypotheses

In the present study, we had several hypotheses about variables predicting problematic smartphone use and usage frequency outcomes:

Hypothesis 1) We hypothesized that depression severity would be significantly, positively related to the smartphone use outcome variables, with moderate effect sizes. This hypothesis is based on prior research finding such effects for depression severity in relation these smartphone use variables (Demirci et al., 2015; Harwood et al., 2014; J. Kim, Seo et al., 2015; Smetaniuk, 2014).

Hypothesis 2) We expected that anxiety severity would be

significantly, positively related to our smartphone use outcomes, with small to medium effects. This hypothesis is based on findings from prior studies examining these relationships (Demirci et al., 2015; Harwood et al., 2014; R. Kim, Lee et al., 2015; Lee et al., 2014).

Hypothesis 3) We anticipated that behavioral activation would be inversely related to the smartphone use outcome variables. Decreased behavioral activation is related to greater depression severity (Dimidjian et al., 2011), and depression is related to problematic smartphone use (Demirci et al., 2015; Harwood et al., 2014; J. Kim, Seo et al., 2015; Smetaniuk, 2014). Thus as with depression, we expected moderate (but inverse) effects for behavioral activation, whereby people with less behavioral activation should use their smartphones more.

Therefore, we were interested in testing these psychopathology variables in relation to our smartphone use variables. Additionally, we were interested in testing the newer variables that have theoretical but only limited empirical inquiry for relations with smartphone use: emotion regulation, FoMO and need for touch.

Hypothesis 4) We hypothesized that emotion regulation would be significantly, inversely related to our smartphone use outcomes. Maladaptive emotion regulation processes (or dysregulation) fall within Billieux et al.'s (2015) impulsive pathway to problematic smartphone use. Specific types of emotion dysregulation - decreased cognitive reappraisal and increased emotional suppression (Gross & John, 2003; Gross, 1998) - are increasingly important variables in explaining clinical psychopathology (Weiss et al., 2015). And thus the use of decreased cognitive reappraisal (Hypothesis 4a) and increased emotional suppression (4b) should be related to increases in our smartphone use outcomes based on recent research (Hoffner & Lee, 2015).

Hypothesis 5) We expected that FoMO would be significantly, positively related to the smartphone use outcomes. FoMO falls within Billieaux et al.'s (2015) extraversion pathway toward problematic smartphone use. FoMO should be at least moderately related to the smartphone use outcome variables (Clayton et al., 2015) because it involves social need fulfillment which an important predictor of problematic smartphone use (Lopez-Fernandez, Honrubia-Serrano, Freixa-Blanxart, & Gibson, 2014).

Hypothesis 6) We hypothesized that need for touch would be significantly, positively related to the smartphone use outcome variables. Need for touch involves the fulfillment of tactile needs. And tactile need fulfillment is related to increased smartphone use (Lee et al., 2014).

We were also interested in examining the incremental contribution of these newer variables that have only recently been examined for associations with smartphone use.

Hypothesis 7) We expected that a block of variables including emotion dysregulation, FoMO and need for touch would contribute unique variance, above psychopathology, in association with the smartphone use variables. These variables as a whole involve deficits in emotional coping, and social and tactile need fulfillment. Because smartphone use is important in need fulfillment for emotional (Clayton et al., 2015; Hoffner & Lee, 2015), social (Clayton et al., 2015; Lopez-Fernandez et al., 2014) and tactile needs (Lee et al., 2014), we expected to find support for this hypothesis.

Finally, we were interested in testing mediation effects for behavioral activation and emotion regulation scores.

Hypothesis 8) We hypothesized that behavioral activation would mediate relations between smartphone usage and both depression and anxiety severity. That is, the relationship between greater smartphone use and greater depression/anxiety would be accounted for through decreased behavioral activation. This mediation hypothesis is exploratory, without prior research investigating this exact question.

Hypothesis 9) We expected that maladaptive emotion regulation would mediate relations between our smartphone use variables and both depression and anxiety. That is, relations between increased smartphone usage and increased depression/anxiety would be accounted for by the less adaptive use of emotion regulation skills (i.e., lower cognitive reappraisal and higher emotional suppression). This mediation hypothesis is exploratory, having not been investigated before.

2. Method

2.1. Procedure

In early 2016, we recruited participants from Amazon's Mechanical Turk (Mturk), an online labor market often used in social science research (Shapiro, Chandler, & Mueller, 2013). Though a convenience sample, Mturk offers several advantages in data collection, discussed by Landers and Behrend (2015). We chose Mturk to obtain avid technology users most likely to own a smartphone. We described the study on Mturk as a 15–20-min investigation of mobile phone and web service use, offering 75 cents compensation to participants' Amazon Payment accounts. We recruited from English-speaking North Americans (verified by online screening, querying country of residence) who were age 18 and over (required for Mturk accounts, verifying identities with credit checks). Participants were routed to a web-based consent statement, and those agreeing to participate were routed to a web survey hosted on Psychdata.com, using the measures below. Afterward, they were shown text that thanked them for their participation.

2.2. Participants

Three hundred and twenty-two participants signed up for the study on Mturk. We removed 14 people, for indicating non-North American residence (n = 4), providing a duplicate or no Mturk worker identification number (n = 5), or skipping multiple psychological test instruments in the survey (n = 5). The remaining 308 participants all reported owning a smartphone.

We first queried demographic variables in the survey, such as age and gender. Among the 308 participants, 165 (53.6%) were men, with 143 (46.4%) women. Age averaged 33.15 years (SD = 10.21). Most participants were White (n = 253, 82.1%), with 28 individuals (9.1%) identifying as Asian, 23 (7.5%) as African American, and 16 (5.3%) as Hispanic (rates are non-mutually exclusive). Most participants completed at least a Bachelor's degree (n = 170, 55.2%), or had some college education (n = 104, 33.8%). Most reported being employed full-time (n = 196, 44.1%) or part-time (n = 56, 18.3%). Annual household income was estimated at less than $25 K for 54 participants (24.1%), between $25 K to less than $35 K for 29 participants (9.4%), between $35 K to less than $50 K for 60 participants (19.5%), and $50 K to less than $80 K for 84 participants (27.3%), and $80K + for 61 participants (19.8%). About one-third of participants reported being currently married (n = 114, 37.3%).

2.3. Measures

Smartphone Usage. We inquired about the frequency of using 11 types of smartphone features, including "video and voice calls (making and receiving)," "text/instant messaging (sending and receiving)," "email (sending and receiving)," "social networking sites," "internet/websites," "games," "music/podcasts/radio," "taking pictures or videos," "watching videos/TV/movies," "reading books/magazines," and "maps/navigation." We used a six-point

Likert-type scale, ranging from "1 = Never" to "6 = Very often," adapted from similar measures used elsewhere (Cheever et al., 2014; Hoffner & Lee, 2015; Smith & Page, 2015, April 1). Coefficient alpha in this sample was 0.86.

Problematic Smartphone Use. We measured problematic smartphone use with the Smartphone Addiction Scale (SAS; Kwon et al., 2013). The SAS consists of 33 items using a Likert scale ranging from "1 = Strongly disagree" to "6 = Strongly agree." The SAS taps smartphone-related functional and health disturbances, positive anticipation from use, withdrawal from non-use, tolerance, and overuse in digital relationships. Coefficient alpha is reported at 0.97, with convergent validity against scales measures internet and smartphone addiction (Kwon et al., 2013). Coefficient alpha in the present sample was 0.95.

Need for Touch. We measured need for touch using six Likert scale items ranging from "1 = Strongly disagree" to "7 = Strongly agree." These items were used by Lee et al. (2014), selected from a larger set of need for touch items in Peck and Childers (2003b). The items tap desires and needs to touch consumer products while shopping. Coefficient alpha was 0.93, and the scale correlates with other related measures (Lee et al., 2014). Coefficient in our sample was 0.96.

FoMO. We used the FoMO scale developed by Przybylski et al. (2013), a 10-item measure with a Likert scale ranging from "1 = Not at all true of me" to "5 = Extremely true of me." Items reflect apprehension from missing out on experiencing or learning about friends' rewarding experiences. Przybylski et al. (2013) found coefficient alphas ranging from 0.87 to 0.90, and total scores correlating negatively with psychological need satisfaction, positive mood and life satisfaction; and positively with social media engagement. Our sample's coefficient alpha was 0.84.

Depression and Anxiety. We measured depression and anxiety with the 21-item Depression Anxiety Stress Scale (DASS), a short version of the 42-item DASS (Lovibond & Lovibond, 1995). The DASS-21 includes Likert-type ratings from "0 = Did not apply to me at all" to "3 = Applied to me very much or most of the time." The DASS-21 has three subscales of seven items each, including depression, anxiety, and stress. We analyzed the depression and anxiety subscales in this paper. Coefficient alpha has been reported as 0.97 (depression) and 0.87 (anxiety), with convergent validity against other depression and anxiety measures (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Chorpita, Korotitsch, & Barlow, 1997). The present sample's coefficient alphas were 0.94 for depression, and 0.85 for anxiety.

Behavioral Activation. The *Behavioral Activation Scale for Depression-Short Form* (BADS) (Manos, Kanter, & Luo, 2011) measures behavioral activity and engagement, with response options from "0 = Not at all" to "6 = Completely," reverse-coding four items. Coefficient alpha is reported of 0.82, with positive correlations with reinforcement and coping, and negative correlations with depression, avoidance and disengagement (Manos et al., 2011). Coefficient in the present sample was 0.82.

Emotion Regulation. The Emotion Regulation Questionnaire (ERQ) is a 10-item measure of cognitive reappraisal and expressive suppression attempts to regulate emotion (Gross & John, 2003). The ERQ uses a Likert scale from "1 = Strongly disagree" to "7 = Strongly agree." Gross and John (2003), in their undergraduate samples, found coefficient alphas from 0.75 to 0.82 for the reappraisal subscale, and from 0.68 to 0.76 for the suppression subscale, with convergent validity against coping, mood and rumination scales. Coefficient alphas in our Mturk sample were 0.92 for reappraisal and 0.81 for suppression.

2.4. Analyses

Descriptive statistics are provided for the primary scales, using summed scores for the smartphone use survey, SAS, Need for Touch Scale, FoMO scale, DASS-21 Depression and Anxiety subscales, BADS, ERQ Reappraisal and Suppression subscales in Table 1. To test Hypotheses 1 through 6, zero-order Pearson correlations with SAS scores are presented. Summed scores were formed after estimating missing item-level values using maximum likelihood procedures. Based on skewness and kurtosis values, no summed scores departed from normality; specifically, no values were greater than 2.0 in absolute terms. Collinearity was not a serious problem for predictor variables; however, the correlation between depression and anxiety was 0.75.

Next, for testing Hypotheses 1 through 6 on a multivariate basis, we conducted sequential regression analyses, whereby the summed SAS score was the dependent variable. Step 1 included age and gender as covariates. Step 2 added depression and anxiety-related psychopathology variables – DASS-21 and BADS variables. To test Hypothesis 7, Step 3 added Need for Touch, FOMO, and ERQ Reappraisal and Suppression. We repeated the regression analysis using smartphone use frequency as the dependent variable.

We next tested Hypotheses 8 and 9 using mediation analyses. Mediators, tested separately, included BADS scores (testing Hypothesis 8), and ERQ Reappraisal and Suppression scores (testing Hypothesis 9). We first examined indirect effects by testing individual mediators accounting for relations between smartphone use (SAS scores and usage frequency) and depression severity. We repeated these analyses for testing the smartphone use-anxiety relationship. Predictor-mediator and mediator-outcome paths were multiplied to derive indirect effects. Indirect effect standard errors were estimated using the Delta method, bootstrapping 1000 samples (MacKinnon, 2008) with maximum likelihood estimation.

We estimated sample size and statistical power based on our linear regression analyses. Based on a model of nine predictors, alpha of 0.05, and power of 0.80, we would need only 114 participants in detecting a medium effect of $R^2 = 0.13$ as significantly greater than zero. Furthermore, based on those parameters, we would need only 85 participants in detecting an R^2 increase of 0.13 as significantly greater than zero for the four variables in the third regression step. Even with a more conservative effect size of $R^2 = 0.05$, we have an adequate number of participants.

3. Results

Descriptive statistics are presented for the primary measures in Table 1, including means and standard deviations for the primary variables. Measuring smartphone use frequency, the most prevalent features were text/instant messaging (M = 5.15, SD = 1.20), internet/websites (M = 5.03, SD = 1.17), email (M = 4.64, SD = 1.36), and social network sites (M = 4.41, SD = 1.62). Table 1 also presents zero-order Pearson correlations between the study variables. Smartphone use frequency and SAS scores were significantly correlated ($r = 0.34$, $p < 0.001$). All variables were significantly associated with SAS scores, with the exception of depression and cognitive reappraisal, supporting Hypotheses 2, 3, 4b, 5, and 6. Not surprisingly, depression and anxiety were highly correlated; and depression was highly inversely correlated with behavioral activation. FoMO had moderate to large relationships with depression and anxiety.

Table 2 presents linear regression results, with SAS scores as the dependent variable. Step 1, including age and gender, was significant, $F(2, 306) = 3.77$, $p = 0.02$, $R^2 = 0.02$. Step 2's psychopathology

Table 1
Descriptive statistics, zero-order intercorrelations, and coefficient alphas for the primary measures.

Variable	M	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Depression	4.89	4.79	(0.94)								
2. Anxiety	3.08	4.01	0.75***	(0.85)							
3. BADS	29.27	8.56	−0.65***	−0.52***	(0.82)						
4. ERQ Reappraisal	28.75	7.70	−0.31***	−0.20***	0.33***	(0.92)					
5. ERQ Suppression	15.35	5.65	0.22***	0.17**	−0.22***	0.04	(0.81)				
6. FoMO	21.27	7.24	0.40***	0.49***	−0.38***	−0.10	0.10	(0.84)			
7. Need for Touch	18.22	8.83	0.01	0.09	−0.15**	0.05	−0.04	0.19**	(0.96)		
8. SAS	167.80	88.50	0.10	0.24***	−0.19**	−0.01	0.13*	0.40***	0.27***	(0.95)	
9. SUF	45.51	10.01	−0.19***	−0.10	0.14*	0.15**	0.05	0.04	0.14*	0.34***	(0.86)

Note. SAS = Smartphone Addiction Scale; SUF = Smartphone Use Frequency; FoMO = Fear of Missing Out; BADS = Behavioral Activation for Depression Scale-Short Form; ERQ = Emotion Regulation Questionnaire. Alpha coefficients appear in parentheses on the diagonal.
*p < 0.05, **p < 0.01, ***p < 0.001.

Table 2
Multiple regression results for SAS scores: Final model.

Predictor of SAS scores (added)	β	B	SE B	t	ΔR^2
(Step 1)					0.02
Age	−0.06	−0.18	0.15	−1.25	
Gender	−0.09	−5.12	3.16	−1.62	
(Step 2)					0.09
Depression	−0.27	−1.47	0.49	−3.02**	
Anxiety	0.18	1.34	0.59	2.28*	
BADS	−0.10	−0.35	0.24	−1.45	
(Step 3)					0.13
ERQ Reappraisal	0.01	0.03	0.21	0.12	
ERQ Suppression	0.09	0.44	0.28	1.56	
FoMO	0.32	1.28	0.24	5.29***	
Need for Touch	0.20	0.66	0.18	3.70***	

SAS = Smartphone Addiction Scale; FoMO = Fear of Missing Out; BADS = Behavioral Activation for Depression Scale-Short Form; ERQ = Emotion Regulation Questionnaire.
*p < 0.05, **p < 0.01, ***p < 0.001.

variables contributed unique variance, $F(5, 303) = 7.87$, $p < 0.001$, $\Delta R^2 = 0.09$. Step 3's remaining variables were significant, $F(9, 299) = 10.82$, $p < 0.001$, accounting for the largest amount of unique variance, $\Delta R^2 = 0.13$[1], supporting Hypothesis 7. The strongest predictors of SAS scores in the final model were FoMO, depression (inversely), need for touch, and anxiety. The remaining predictors were non-significant and small in magnitude.

Table 3 presents linear regression results predicting smartphone use frequency scores. Step 1, including age and gender, was not significant, $F(2, 306) = 2.25$, $p = 0.11$, $R^2 = 0.01$. Step 2's psychopathology variables were significant, $F(5, 303) = 3.67$, $p = 0.003$, $\Delta R^2 = 0.04$. Step 3's remaining variables were significant, $F(9, 299) = 3.72$, $p < 0.001$, account for additional unique variance above step 2, $\Delta R^2 = 0.04$, supporting Hypothesis 7. The strongest predictors of smartphone use frequency were depression (inversely), need for touch, and age (inversely). The remaining predictors were non-significant and small in magnitude.

Next, we present mediation results to explain the problematic smartphone use-depression relationship. Table 4 indicates that behavioral activation was a significant mediator of this relationship, and a similar pattern was found when testing smartphone usage frequency as the predictor. Emotional suppression was a significant mediator for the problematic smartphone use test, while cognitive reappraisal was a significant mediator for the smartphone usage test. Thus behavioral activation and emotion regulation accounted for relations between problematic smartphone use/frequency with depression, supporting Hypothesis 8.

Finally, we present mediation results explaining the problematic smartphone use-anxiety relationship. Behavioral activation was a significant mediator, with a similar finding when using smartphone use frequency as the predictor. However, neither emotional suppression nor cognitive reappraisal were significant mediators. Thus only behavioral activation (but not emotion regulation) accounted for relations between problematic smartphone use/frequency and anxiety, partially supporting Hypothesis 9.

4. Discussion

The present study examined variables conceptually related to problematic smartphone use and use frequency. The results were largely consistent with hypotheses, offering an additional dimension for consideration in problematic smartphone use (need for touch), indicators which can separate use frequency from problematic use, as well as a potential target for intervention via a mediated relationship through emotion regulation and behavioral activation. The results are discussed in greater detail below.

FoMO was the variable most related to problematic smartphone use – on a bivariate and multivariate basis, supporting Hypothesis 5. These findings support previous research on the importance of FoMO to the overuse of technology such as smartphones and social media (Alt, 2015; Clayton et al., 2015; Przybylski et al., 2013). However, FoMO was not related to the continuum of smartphone use. Thus FoMO, a construct mapping onto the extraversion pathway of Billieux et al. (2015), does not necessarily discriminate high versus low use of the smartphone. Instead, FoMO discriminates problematic from non-problematic use – a finding corroborated by Przybylski et al. (2013), demonstrating that higher FoMO is related to low levels of satisfaction with competence, autonomy and relatedness.

The need for touch had the second highest bivariate relationship with problematic smartphone use, and the third highest multivariate effect, providing support for Hypothesis 6. Oulasvirta, Rattenbury, Ma, and Raita (2012) found in their field study that 35% of smartphone use sessions involves screen touching. Perhaps the haptic feedback from vibrations or on-screen motions that lend toward habitual checking for notifications is a driving force of problematic smartphone use (Oulasvirta et al., 2012).

Anxiety was the third most potent bivariate correlate of problematic smartphone use, but not for the continuum of use, partially supporting Hypothesis 2. Depression was not related to

[1] Depression severity had a negative regression coefficient (Table 2), which could suggest statistical suppression, in light of the research finding strong relationships between depression with low behavioral activation (Dimidjian et al., 2011) and anxiety (Cummings et al., 2014; Lamers et al., 2011). Therefore, we re-conducted analyses in three ways: a) removing depression as a predictor; b) removing anxiety as a predictor; and c) removing behavioral activation as a predictor. These revised analyses replicated the results in Table 2, and continued to demonstrate a negative regression coefficient for depression, even in the absence of anxiety and behavioral activation.

Table 3
Multiple regression results for smartphone use frequency: Final model.

Predictor of smartphone use frequency scores (added)	β	B	SE B	t	ΔR^2
(Step 1)					0.01
Age	−0.12	−0.12	0.06	−2.08*	
Gender	0.02	0.47	1.19	0.40	
(Step 2)					0.04
Depression	−0.21	−0.39	0.18	−2.15*	
Anxiety	0.02	0.04	0.22	0.17	
BADS	0.07	0.08	0.09	0.86	
(Step 3)					0.04
Reappraisal	0.07	0.10	0.08	1.21	
Suppression	0.09	0.11	0.10	1.52	
FoMO	0.11	0.15	0.09	1.65	
Need for Touch	0.13	0.15	0.07	2.29*	

FoMO = Fear of Missing Out; BADS = Behavioral Activation for Depression Scale-Short Form; ERQ = Emotion Regulation Questionnaire.
*p < 0.05, **p < 0.01, ***p < 0.001.

Table 4
Mediation effects in accounting for relations between problematic smartphone use and depression/anxiety; and between smartphone use frequency and depression/anxiety.

Mediating relationship	β	B	95% CI of B	SE	p
PSU- > BA- > Depression	0.13	0.02	0.01: 0.03	0.01	<0.001
PSU->ES- > Depression	0.03	0.01	0.00: 0.01	0.00	0.05
PSU- > CR- > Depression	0.00	0.00	−0.01: 0.01	0.00	0.84
PSU- > BA- > Anxiety	0.10	0.01	0.01: 0.02	0.00	<0.001
PSU->ES- > Anxiety	0.02	0.00	0.00: 0.01	0.00	0.08
PSU- > CR- > Anxiety	0.00	0.00	0.00: 0.00	0.00	0.84
SUF- > BA- > Depression	−0.09	−0.05	−0.08: −0.01	0.02	0.03
SUF- > ES- > Depression	0.01	0.01	−0.01: 0.02	0.01	0.47
SUF- > CR- > Depression	−0.04	−0.02	−0.04: 0.00	0.01	0.05
SUF- > BA- > Anxiety	−0.07	−0.03	−0.05: −0.01	0.01	0.03
SUF- > ES- > Anxiety	0.01	0.00	0.00: 0.01	0.01	0.48
SUF- > CR- > Anxiety	−0.03	−0.01	−0.03: 0.00	0.01	0.08

Note. PSU = Problematic Smartphone Use; BA = Behavioral Activation; ES = Emotional Suppression; CR = Cognitive Reappraisal; SUF = Smartphone Use Frequency.

problematic smartphone use on a bivariate basis, but was the strongest correlate (though inversely) of continuum of use, partially supporting Hypothesis 1. For multivariate models, depression was the second strongest correlate of problematic use, and the strongest correlate of continuum of use – both of which were inverse relationships. Given the strong relationship between depression and anxiety (Cummings, Caporino, & Kendall, 2014; Lamers et al., 2011), it is possible that we had suppressor effects for depression, given its inverse relationships with problematic use. Also, behavioral activation reversed regression coefficient signs between Tables 2 and 3. Our revised analyses that only included depression or anxiety continued to demonstrate an inverse relationship for depression. In fact, the few problematic smartphone use studies examining both variables in regression models also found small coefficients despite large bivariate associations (Demirci et al., 2015), or a strong positive relationship for one variable but an inverse relationship for the other (Lu et al., 2011). Alternatively, it is possible that excessive smartphone use distracts from depressive emotional content – especially if the smartphone use is socially-focused (Park & Lee, 2012). Of course, depressed people may simply be less involved with their smartphones for a variety of reasons (e.g., generally low behavioral activation, ruminative thought, etc.).

Possible mechanisms for relations between problematic smartphone use and psychopathology may involve behavioral activation (Hypothesis 8) as well as suppressive emotion regulation (Hypothesis 9), based on mediation testing. That is, overusing one's smartphone does not account fully for depression or anxiety; rather, other intervening variables may play a role. Specifically, less behavioral activation and (for depression only) more emotion suppression appear to account for this relationship. Problematic smartphone use may interfere with other pleasurable activities and disrupt social activities thereby reducing behavioral activation and subsequently increasing depression. It is possible that emotional suppression, a correlate of problematic use, disrupts adaptive processing of emotions, which in turn is associated with greater depression. However, those with greater depression may rely on emotional suppression through smartphone use, which is difficult to disentangle from a cross sectional study. (It should be noted that the behavioral activation's indirect coefficients were positive in value, because cross-products were each negative.).

Limitations of this study include the lack of structured diagnostic interviews to diagnose mental disorders, and cross-sectional surveying. Additionally, we used Mturk users we financially compensated, who are younger, less racially diverse, more educated and technology-savvy than the general population, thus limiting generalizability (Shapiro et al., 2013). Furthermore, the depression and anxiety scales were highly correlated, which could pose a collinearity problem. Nonetheless, findings contribute to the study of correlates of smartphone addiction by discovering important, but mostly previously neglected, variables such as FoMO and need for touch.

The current study indicates that FoMO and need for touch are significant predictors of maladaptive smartphone use. In addition, some aspects of self-regulation (i.e., behavioral activation and suppressive emotion regulation) appear to mediate the links between emotional pathology and problematic smartphone use.

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