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rumination
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Depression and social anxiety in relation to problematic smartphone use:

the prominent role of rumination

Abstract

Purpose: Previous research has found support for depression and anxiety severity in association with both increased and problematic smartphone use. However, little research has explored transdiagnostic psychopathology constructs as mediators that may account for these relationships. Our primary aim was to test rumination as a possible transdiagnostic (cross-sectional) mediator in these relationships.

Design: We recruited 296 college students to complete relevant web survey measures, including the Patient Health Questionnaire-9 (for depression severity), Social Interaction Anxiety Scale (for social anxiety severity), Ruminative Thought Styles Questionnaire, Smartphone Addiction Scale-Short Version (to measure levels of problematic smartphone use), and a measure of smartphone use frequency.

Findings: We found support for a structural model whereby the severity of depression and social anxiety accounted for variance in rumination, which in turn correlated with problematic smartphone use levels. Rumination accounted for relations between both depression and social anxiety severity with levels of problematic use.

Originality/Value: We discuss the role of rumination as a possible mechanism between anxiety- and depression-related psychopathology levels with problematic smartphone use severity. This study is unique in exploring rumination in the context of problematic smartphone use.

Keywords: Depression; Social Anxiety; Rumination; Communication Theory; Problematic technology use; Smartphone addiction; Smartphone use; Internet addiction

Introduction

In recent years, published studies have examined the construct of problematic smartphone use. Problematic smartphone use is often defined as excessive use of a smartphone, with social or occupational functional impairment, and including dependence and symptoms seen in addictive disorders such as withdrawal and tolerance (Billieux *et al.*, 2015a). Research has examined relations between psychopathology and problematic smartphone use and/or the continuum of smartphone use frequency. Depression and anxiety severity in particular are well-supported in association with problematic smartphone use and use frequency (reviewed in Elhai *et al.*, 2017a). However, little research has explored the role of more contemporary transdiagnostic constructs of psychopathology in studying these relationships.

The most commonly studied psychopathology constructs in relation to problematic smartphone use and usage frequency include variables measuring levels of depression, anxiety, stress and low self-esteem (reviewed in Elhai *et al.*, 2017a). Depression and anxiety severity have demonstrated moderate and small links (respectively) to levels of problematic smartphone use and usage frequency, with effect sizes of .30 to .50 for depression severity (recently in Demirci *et al.*, 2015; Lu *et al.*, 2011; Smetaniuk, 2014), and approximately .20 for anxiety severity (recently, Demirci *et al.*, 2015; Elhai *et al.*, 2016; Kim, R *et al.*, 2015; Lee, Y-K *et al.*, 2014). These findings

generally parallel those from the literature on internet addiction (but not specifically smartphone use) (Ho *et al.*, 2014; Prizant-Passal *et al.*, 2016). However, effect sizes are nonetheless small on average for anxiety, and in some studies for depression severity (Augner and Hacker, 2012; Elhai *et al.*, 2016, 2017b; Kim, J *et al.*, 2015). Some evidence suggests a bidirectional relationship, whereby problematic smartphone use can lead to depression and anxiety severity, and vice-versa (van Deursen *et al.*, 2015; Yen *et al.*, 2012).

Theory and empirical evidence demonstrate a dual system process that underlies addictive disorders, involving a balance between impulsive reward seeking and reflection/inhibition (Bechara, 2005; Volkow and Fowler, 2000). This theory has been supported in research on problematic use of technology, and suggests that deficits in brain circuitry may be responsible for such problematic use (Turel and Qahri-Saremi, 2016; Turel *et al.*, 2016). Relevant to the present paper, depression and anxiety severity, and rumination, may be caused by the same types of brain circuitry deficits found in the addictive disorders.

Furthermore, research on problematic smartphone use thus far has not examined more contemporary "transdiagnostic" psychopathology constructs – that is, constructs which cut across numerous mental disorders. Such constructs are increasingly important in understanding mechanisms involved in the etiology and maintenance of psychopathology (Mansell *et al.*, 2008). Mediating and moderating variables between psychopathology and problematic internet use (albeit not specific to smartphone) have been tested and supported recently (Brand *et al.*, 2016; Jiang, 2014).

In addition to depression and anxiety severity, in the present paper, we focus on

the transdiagnostic construct of rumination. Rumination is a maladaptive method for coping with negative emotion that focuses individuals on their negative self-referencing thoughts rather than the more adaptive processing of their emotion (Mennin and Fresco, 2013). Rumination is a construct that has large relationships with numerous types of psychopathology (Aldao *et al.*, 2010). Rumination is associated with depressed and anxious mood (Joormann and Gotlib, 2010), inhibits recovery from depressed mood and has been found to increase the length of depressive episodes (Nolen-Hoeksema *et al.*, 2008). Rumination is also implicated in social anxiety symptoms (Brozovich and Heimberg, 2008). Rumination is found to have reciprocal relations with psychopathology, whereby depression and anxiety severity predict rumination over time, and vice-versa (McLaughlin and Nolen-Hoeksema, 2011; Nolen-Hoeksema *et al.*, 2007).

Billieux et al. (2015b) discussed how rumination in social relationships can lead to excessive reassurance seeking behavior by habitually checking one's phone for social-related notifications. In fact, excessive reassurance seeking is considered a pathway to problematic smartphone use (Billieux *et al.*, 2015a). Such reassurance seeking is a maintenance factor of depression (Evraire and Dozois, 2011) and anxiety (Cougle *et al.*, 2012; Rector *et al.*, 2011). Furthermore, because rumination is a maladaptive coping method (Mennin and Fresco, 2013), as is problematic smartphone use (Kardefelt-Winther, 2014), these two constructs should be related. In fact maladaptive coping is related to other forms of problematic technology use (Brand *et al.*, 2014).

Aims

Our purpose is to test the relationships between (a) levels of smartphone use and (b) levels of problematic smartphone use with both: (i) depressive symptoms and (ii) anxiety symptoms. We are particularly interested in the extent to which rumination (cross-sectionally) mediates relations between depressive/anxious psychopathology levels and increased/problematic smartphone use. This topic is important in understanding mechanisms that explain why some depressed or anxious individuals engage in problematic use of a smartphone, while others do not.

Theory

We used theory to conceptualize a model of psychopathology, smartphone use frequency and increased problematic use. Uses and Gratifications Theory (UGT) (Blumler and Katz, 1974) explains motivations for the consumption of mass media and technology. When UGT was first developed, it was unique (in contrast to other mass communication theories) in being audience/user-centered, assuming that the user is an active (rather than passive) participant of choosing media to consume. UGT assumes that particular media consumption choices are driven by specific gratifications that the user needs to be met (e.g., socializing, relaxation, etc.) (Blumler and Katz, 1974). Such gratifications in UGT can be driven by individual differences or psychological constructs. UGT has been used to explain the use of particular smartphone features (Grellhesl and Punyanunt-Carter, 2012; Wei and Lu, 2014). UGT has been implemented to explain the use of various types of technology use (Chiang and Hsiao, 2015; Hamari and Sjöblom, 2017; Huang and Hsieh, 2011; Pei-Shan and Hsi-Peng, 2014). UGT has used background characteristics or individual differences to explain increased smartphone use, such as gender, reward seeking, academic performance, behavioral activation,

depression, anxiety, and locus of control (Dhir *et al.*, 2015; Elhai *et al.*, 2017b; Grellhesl and Punyanunt-Carter, 2012; Park *et al.*, 2013). The notion that rumination in interpersonal relationships can drive excessive reassurance seeking (Billieux *et al.*, 2015b), evidenced by increased smartphone use, is in line with UGT's focus on individual differences causing specific media-based gratifications to be met. While UGT can explain increased smartphone use, it does not necessarily explain why some people would engage in *problematic* smartphone use.

Of more precise relevance to this study is Kardefelt-Winther's (2014) recently-developed Compensatory Internet Use Theory (CIUT). This theory could be viewed as an extension of UGT, in understanding variables that drive increased smartphone use and problematic use. CIUT attempts to understand the negative life events and stressors that motivate some people to use (or overuse) technology, as a means to alleviate negative emotion about such stressors. CIUT emphasizes negative life circumstances as the cause, and problematic internet use as the consequent, compensatory behavior aimed at regulating stressor-related negative emotion. Several studies thus far have found empirical support for this theory as related to the study of problematic smartphone use (Long *et al.*, 2016; Wang *et al.*, 2015; Zhitomirsky-Geffet and Blau, 2016).

CIUT fits well with UGT in providing context for the research questions of the present study. Specifically, psychopathology such as anxiety, depression and rumination severity can be conceptualized as background characteristics in UGT that explain increased smartphone use. And within CIUT, problematic smartphone use is conceptualized as a compensatory behavior to regulate depressed and anxious mood.

Research Model

We first tested a model whereby psychopathology levels were specified to predict the frequency of smartphone use, which in turn predicts levels of problematic smartphone use. Similar models have been tested, such as that of J. Kim et al. (2015) testing depression severity as a correlate of the extent and types of smartphone use, in turn predicting problematic use. van Deursen and colleagues tested social stress in association with habitual smartphone use, then predicting increases in problematic smartphone use (van Deursen *et al.*, 2015). And Elhai and colleagues examined depression and anxiety severity as correlates of types of smartphone use frequency, in turn relating to problematic smartphone use severity (Elhai *et al.*, 2017b). However, these models did not include transdiagnostic constructs that may account for relations between depressive/anxious symptoms and smartphone use (e.g., rumination).

Our model is depicted in Figure 1. All variables were estimated as latent factors, with the exception of smartphone frequency for reasons discussed below. We examined depression and anxiety severity factors as correlates of smartphone use based on the aforementioned research, among a sample of college students. We included a specific type of anxiety - social anxiety - as a predictor. People with social anxiety have been found to compensate for their in-person anxiety by socializing excessively online, including with their smartphones (Lee, EB, 2015; Lee, Y-K *et al.*, 2014). We also included rumination in our model, as a variable potentially accounting for relations between depression/social anxiety severity and smartphone use (Billieux *et al.*, 2015b). Because problematic smartphone use and frequency are related to younger age (Lu *et al.*, 2011; van Deursen *et al.*, 2015) and female gender (Jeong *et al.*, 2016; Wang *et al.*,

2015), we statistically adjusted for age and gender. We subsequently tested variations on this model, described below.

Hypotheses

Based on this backdrop of theory and empirical work, we posed the following hypotheses. Each of these hypotheses represents a portion of Figure 1.

Rumination involves focusing on one's negative thoughts (e.g., see Mennin and Fresco, 2013). In social relationships, people who ruminate often do so about aspects of the relationship (Kashdan and Roberts, 2007). While rumination can represent the cognitive aspect of anxiety in social relationships, habitually checking one's smartphone for social notifications can represent the behavioral aspect of such anxiety (Billieux *et al.*, 2015b). Such habitual use is shown to lead to problematic smartphone use (Oulasvirta *et al.*, 2012).

In the context of UGT (Blumler and Katz, 1974) and CIUT (Kardefelt-Winther, 2014), rumination would serve as an individual difference variable that would be gratified by using more social-related technology (e.g., a smartphone's social features) in an attempt to alleviate one's social-related anxiety. Rumination is a maladaptive coping method (Mennin and Fresco, 2013), associated with depression and anxiety (Nolen-Hoeksema *et al.*, 2007; Nolen-Hoeksema *et al.*, 2008). Problematic smartphone use is also an avoidant coping method. Rumination and problematic smartphone use, both as maladaptive coping methods, logically should be correlated.

H1) Rumination should be positively related to smartphone use frequency overall.

H2) Rumination should be positively related to levels of *problematic* smartphone use.

Depression and anxiety, including social anxiety, have been found to relate to increases in smartphone use and problematic use (Elhai *et al.*, 2017a). Depression and anxiety also are found to prospectively predict rumination (McLaughlin and Nolen-Hoeksema, 2011; Nolen-Hoeksema *et al.*, 2007). Rumination has been theorized to lead to habitual smartphone use through excessive reassurance seeking by checking one's phone notifications (Billieux *et al.*, 2015b). And habitual behaviors can become automatic, resulting in many repetitions of the behavior, without antecedent cognition required (Orbell and Verplanken, 2000). Thus, rumination could serve as a mediator between depression and anxiety severity on one hand, and increased smartphone use and problematic use on the other.

Within the context of UGT, rumination would serve as an individual difference variable accounting for the relationship between both depression and anxiety severity (also individual difference variables) and increased smartphone use. And within CIUT, increased problematic smartphone use would be the regulatory process aimed at decreasing depressed and anxious mood.

H3) Rumination would account for relationships between depression severity and smartphone use frequency, as a significant mediating variable.

H4) Rumination would account for relations between depression severity and increased problematic smartphone use, as a significant mediating variable.

H5) Rumination would explain the relationship between social anxiety severity and smartphone use frequency, as a significant mediating variable.

H6) Rumination would explain the relationship between social anxiety severity and increased levels of problematic smartphone use, as a significant mediating variable.

Method

Participants and Procedure

We recruited 299 college students in spring 2016 from a large Midwestern psychology department research pool using its Sona Systems website. Those signing up to participate were routed to an online consent statement and web survey (for those consenting), hosted on psychdata.com. The 20-30-minute survey offered research credit in courses in exchange for participation. Three subjects did not complete more than 50% of items on each of the primary measures and were excluded (resulting in an effective sample of 296 participants).

Among the 296 participants, age averaged 20.00 years (SD = 3.02). A slight majority of participants were women (n = 169, 57.1%). Most participants were of Caucasian racial background (n = 220, 74.3%), with some representation from African Americans (n = 38, 12.8%), Asian Americans (n = 18, 6.1%), and Hispanic/Latino (n = 18, 6.1%). A majority were freshmen (n = 143, 48.3%) or sophomores (n = 91, 30.7%). A slight majority of participants reported working part-time (n = 157, 53.0%) or full-time (n = 35, 11.8%), or were not employed (n = 104, 35.1%).

Instruments

Demographics. We inquired about demographics such as age, gender, race, school and employment.

We also used the following questionnaires, with items listed in Table 1. We summed item responses within each scale in order to form total scores, for the purpose of presenting descriptive scale data, below.

Smartphone Usage. We used the scale by Elhai et al. (2016) to ask about the

frequency of using 11 different smartphone features. We used six-point Likert-type response options ranging from "1 = Never" to "6 = Very often." Elhai et al. (2016) created this measure as an adaptation from several sources (Cheever *et al.*, 2014; Hoffner and Lee, 2015; Smith and Page, 2015, April 1). Elhai et al. found adequate internal consistency; in the present effective sample, coefficient alpha was .79. Elhai et al. discovered a moderate correlation with Kwon et al.'s (2013b) Smartphone Addiction Scale.

Smartphone Addiction Scale-Short Version. We administered the Smartphone Addiction Scale-Short Version (SAS-SV) (Kwon *et al.*, 2013a). We used this scale to measure the range of levels of problematic smartphone use. The SAS-SV includes 10 items using a Likert scale ranging from "1 = Strongly disagree" to "6 = Strongly agree," measuring smartphone use-related health and social impairment, withdrawal and tolerance. Coefficient alpha is reported to be adequate (Kwon *et al.*, 2013a); our sample's coefficient alpha was .88. The SAS-SV has demonstrated convergent validity with other scales measuring problematic internet and smartphone use (Kwon *et al.*, 2013a)

Patient Heath Questionnaire-9 (PHQ-9). The PHQ-9 is a 9-item self-report measure of DSM-5 major depression symptoms over the past two weeks (Kroenke *et al.*, 2001). Response options range from 0 = "Not at all" to 3 = "Nearly every day." Internal consistency is good (reviewed in Manea *et al.*, 2015); our sample's coefficient alpha was .86. High test-retest reliability within 48 hours has been found. Diagnostic validity has been demonstrated (reviewed in Manea *et al.*, 2015).

Social Interaction Anxiety Scale (SIAS). We assessed social anxiety using the

SIAS (Mattick and Clarke, 1998), a 20-item measure with response options ranging from 0 = "Not at all characteristic or true of me" to 4 = "Extremely characteristic or true of me." Good internal consistency has been reported (Rodebaugh *et al.*, 2007); our sample's coefficient alpha was .93. Factorial validity and convergence with other similar measures has been revealed (Rodebaugh *et al.*, 2007). In calculating a total scale score for descriptive purposes, we summed the 17 straightforwardly-worded items, based on suggestions and findings from Rodebaugh et al. (2007).

Ruminative Thought Style Questionnaire (RTSQ). The RTSQ (Brinker and Dozois, 2009) is a self-report measure of ruminative thinking. It includes 20 items rated on a 7-point Likert scale ranging from 1 = "does not describe me at all" to 7 = "describes me very well." We included only the fifteen items retained after confirmatory factor analysis (CFA) in Brinker and Dozois (2009). This measure has demonstrated adequate psychometrics, including internal consistency (Brinker and Dozois, 2009); coefficient alpha in our sample was .95. Convergent validity with similar scales has been revealed (Brinker and Dozois, 2009).

Analysis

About 1% of participants missed more than 50% of items on any given scale, and we excluded those participants from analyses (described above). About 10% of participants were missing between 1-3 items on a given scale. Therefore, we used maximum likelihood (ML) procedures to estimate and impute small amounts of missing item-level data, and then summed responses to form scale scores (Graham, 2009) for descriptive analyses. No skewness value was above 2.0 in absolute size, and the largest kurtosis value was 2.6 (SEs ranged from .29 to .57), thus demonstrating normal

distributions. Multicollinearity was not an issue, with largest obtained correlations of r = .50.

We first conducted separate CFAs of our psychological constructs indicated above, using Mplus 7.4 software. One-factor models were used for assessing the continuum of severity on our psychological constructs: the PHQ-9 for depression (Manea *et al.*, 2015), SIAS for social anxiety (Rodebaugh *et al.*, 2007), smartphone use frequency (Elhai *et al.*, 2016), and SAS-SV for problematic smartphone use (Kwon *et al.*, 2013a) scales; a higher-order factor with five lower-order constructs was used with the RTSQ for rumination (Brinker and Dozois, 2009). We used ML estimation with robust standard errors (MLR; Yuan and Bentler, 2000), treating the variables as continuously-scaled, thus using a Pearson covariance matrix and linear regression coefficients for estimating factor loadings. However, for the depression items, which have only four response options, we used weighted least squares estimation with a mean- and variance-adjusted chi-square (WLSMV), using a polychoric covariance matrix and probit regression coefficients (Wirth and Edwards, 2007). Residual error covariances were fixed to zero. All unstandardized factor loadings were freely estimated, and the factor variance was fixed to a value of 1 for scaling purposes. Fit indices we reported are the comparative fit index (CFI), Tucker-Lewis Index (TLI), root mean square error of approximation (RMSEA), and (for MLR-estimated CFAs only) standardized root mean-square residual (SRMR). Typically an adequately fitting model is indicated by values $\geq$ .90 for CFI and TLI, $\leq$ .08 for RMSEA, and $\leq$ .10 for SRMR (Hu and Bentler, 1999).

Next we estimated a structural equation model (SEM Model A; see Figure 1),

using the same estimation approach we used in CFA. Because of the inclusion of the depression items, for reasons mentioned above, the overall model estimator was WLSMV. We statistically adjusted for paths pointing to smartphone use frequency and levels of problematic smartphone use with covariates, including age (Lu *et al.*, 2011; van Deursen *et al.*, 2015) and gender (Jeong *et al.*, 2016; Wang *et al.*, 2015). Social anxiety and depression were specified to predict rumination. In turn, rumination was specified to predict smartphone use frequency (testing Hypothesis 1) and problematic smartphone use (testing Hypothesis 2). Effect specifications and corresponding hypotheses are listed in Table 3.

Next, we tested rumination in explaining relations between depression severity and smartphone use frequency (Hypothesis 3), and between depression severity and levels of problematic use (Hypothesis 4). We also tested rumination in accounting for relations between social anxiety severity and smartphone use frequency (Hypothesis 5), and between social anxiety and problematic use levels (Hypothesis 6). To test these indirect effects, we calculated the cross-product of direct path coefficients, calculating the indirect effect's standard error using the Delta method, with 1000 bootstrapped samples (MacKinnon, 2008).

We also tested a variation of SEM Model A, adding four paths: from social anxiety and depression severity to both smartphone use frequency and problematic use severity variables (SEM Model B). Finally, we tested another variation of SEM Model A, removing smartphone use frequency from the model (SEM Model C).

Results

We present a correlation matrix of the primary measures, with scale means and

standard deviations, and coefficient alphas in Table 2. Item means and standard deviations are displayed in Table 1. The only non-significant relationships were for smartphone use frequency with both depression and social anxiety scores. Depression and social anxiety were significantly associated with rumination. Rumination was statistically associated with both increased smartphone use frequency and problematic use (Hypotheses 1 and 2, respectively).

Next, we present results from measurement models based on CFA for our variables presented in Figure 1. Standardized factor loadings are presented in Table 1.

The one-factor problematic smartphone use model demonstrated some evidence for adequate fit, MLR χ^2(35, N = 296) = 131.06, p < .001, CFI = .90, TLI = .87, RMSEA = .10 (90% CI: .08 to .11), SRMR = .06. Next, in modeling smartphone frequency using CFA, a one-factor model demonstrated poor fit, MLR χ^2(44, N = 296) = 153.02, p < .001, CFI = .83, TLI = .78, RMSEA = .09 (90% CI: .08 to .11), SRMR = .07.[1]

A one-factor depression model yielded some evidence for adequate fit, WLSMV χ^2(27, N = 296) = 149.16, p < .001, CFI = .96, TLI = .93, RMSEA = .12 (90% CI: .11 to .14). A one-factor social anxiety model fit well, MLR χ^2(119, N = 296) = 329.62, p < .001, CFI = .90, TLI = .89, RMSEA = .08 (90% CI: .07 to .09), SRMR = .05. Finally, a higher-order rumination model with five first-order factors fit well, MLR χ^2(86, N = 296) = 134.57, p < .001, CFI = .98, TLI = .97, RMSEA = .04 (90% CI: .03 to .06), SRMR = .05.

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[1] We also attempted modeling smartphone frequency using WLSMV estimation, treating items as ordinal variables. This model also did not show an indication of good fit, χ^2(44, N = 296) = 211.29, p < .001, CFI = .89, TLI = .86, RMSEA = .11 (90% CI: .10 to .13).

Finally, we used exploratory factor analysis (EFA) to assess for a better fitting smartphone frequency model. We used ML estimation and a promax rotation method. Based on the eigenvalue > 1 rule, we found two factors, χ^2(26, N = 296) = 96.97. However, the second factor's eigenvalue (1.03) barely exceeded the eigenvalue rule, with very low factor loadings.

We next tested the structural model from Figure 1 (SEM Model A) for direct effects. Smartphone frequency was the only primary study variable modeled as an observed, summed score variable, because of poor measurement model fit discussed above. Results are shown in Figure 2. This model fit well, WLSMV χ^2(1365, N = 296) = 2844.11, p < .001, CFI = .94, TLI = .94, RMSEA = .06 (90% CI: .06 to .06). Figure 2 displays standardized parameter estimates for the direct effects between constructs; factor loadings are displayed in Table 1. Adjusting for age and gender, rumination was not significantly associated with increased smartphone use frequency (Hypothesis 1), but was associated with levels of problematic smartphone use (Hypothesis 2). Both social anxiety and depression severity were significantly related to rumination. Test statistics for these hypotheses are presented in Table 3.

We also tested indirect effects in the structural model from Figure 2 (see Table 3 for details). Rumination accounted for relations between depression severity and problematic smartphone use severity (Hypothesis 4). Rumination also explained relations between social anxiety severity and levels of problematic smartphone use (Hypothesis 6). However, rumination did not significantly account for relations between depression severity and smartphone use frequency (Hypothesis 3). And rumination did not explain relations between social anxiety severity and smartphone use frequency (Hypothesis 5).

We additionally tested a variation of SEM Model A (labeled SEM Model B), adding four paths: from both social anxiety and depression severity to both smartphone use frequency and problematic use severity variables (Figure 3). However, this revised model did not enhance fit, WLSMV χ^2_{diff}(4, N = 296) = 3.27, p = .51. The only added

path that was statistically significant was from depression severity to smartphone use frequency; though, this path represented an inverse effect.

Finally, we tested an additional variation of SEM Model A, whereby we removed smartphone use frequency from the model. This model (SEM Model C) did not fit well, WLSMV χ^2(1316, N = 296) = 1374.79, p < .001, CFI = .87, TLI = .87, RMSEA = .03 (90% CI: .03 to .04).[2]

Discussion

In the present paper, we examined the role of rumination in understanding relations between both depression and social anxiety with increased/problematic smartphone use. Several of our hypotheses were supported, demonstrating the impact of rumination in these relationships.

At the bivariate and multivariate levels of analysis, rumination was related to problematic smartphone use (Hypothesis 2) but not to smartphone use frequency in multivariate analyses (failing to support Hypothesis 1). We found support for rumination in explaining relations between depression severity and problematic smartphone use levels (Hypothesis 4), and between social anxiety severity in relation to increased problematic smartphone use (Hypothesis 6). However, rumination did not explain relations between depression severity or social anxiety severity with smartphone use frequency (Hypotheses 3 and 5, respectively). Most previous research has examined relations between smartphone use frequency or increased problematic use with depression (recently in Demirci *et al.*, 2015; Lu *et al.*, 2011; Smetaniuk, 2014) and anxiety (recently, Demirci *et al.*, 2015; Kim, R *et al.*, 2015; Lee, Y-K *et al.*, 2014),

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[2] This model could not be statistically compared to SEM Models A or B. Removing the smartphone use frequency variable made this model non-nested within those other models. Therefore, traditional chi-square difference testing is contraindicated.

evidencing direct effects. We found that social anxiety and depression severity may not solely account for increased problematic use of a smartphone. Rumination may be an important mechanism linking anxious and depressive psychopathology with problematic smartphone use.

Rumination is conceptualized as a maladaptive, avoidant coping mechanism, whereby rumination facilitates the avoidance of focusing on negative emotion (Mennin and Fresco, 2013; Nolen-Hoeksema et al., 2008). Focusing on and processing negative emotions is a healthy, adaptive response to negative affect (Gross, 1998), rather than suppressing emotion through cognitive techniques such as rumination. In fact, processing emotion is a key focus of psychological treatment (Mennin and Farach, 2007; Olatunji et al., 2010).

Rumination's role in problematic smartphone use has been theorized previously (Billieux et al., 2015b), and is supported by our results. Specifically, Billieux et al. (2015b) discussed rumination as a mechanism in interpersonal relationships that can cause excessive reassurance seeking behavior by triggering habitual and constant checking of one's smartphone for social-related notifications. Other forms of maladaptive coping have demonstrated relations with problematic internet use (Brand et al., 2014), relevant to and supporting the present findings. And habitual smartphone checking behavior serves as intermittent positive reinforcement that strengthens problematic smartphone use (Oulasvirta et al., 2012). Thus individuals using rumination as a response to depressed or anxious affect may be more susceptible to increased and problematic smartphone use. Alternatively, it could be that people who are not excessive ruminators, and thus have good emotion regulation skills, can deal with

depression and anxiety using healthy emotion regulation strategies. Such individuals could consequently use a smartphone productively, rather than excessively or without purpose.

Despite finding support for rumination's role in the relationship between psychopathology (depression and social anxiety) and problematic smartphone use severity (Hypotheses 4 and 6, respectively), rumination did not play such a role in the increased frequency of smartphone use (Hypotheses 3 and 5). Thus rumination may be an important mechanism in explaining problem smartphone behaviors, rather than natural variations in smartphone use frequency.

Our results support UGT and CIUT. The individual characteristic of rumination in this case would be a background characteristic in UGT. Integrating these models and applying them here, people who have maladaptive emotion regulation skills, such as using rumination to avoid negative emotion – especially individuals who are already depressed or anxious - may be more likely to inappropriately or excessively use a smartphone in an effort to regulate their negative emotion. Indeed, Hoffner and Lee (2015) found that people who reported that they would especially miss particular smartphone features were more likely to use maladaptive emotion regulation skills.

We should clarify that the concept of "problematic smartphone use" is not without controversy (De-Sola Gutierrez *et al.*, 2016). Only limited empirical evidence supports this construct as an addictive disorder (Billieux *et al.*, 2015a). Additionally, the frequent use of a smartphone is not necessarily a maladaptive behavior, unless it is accompanied by hallmark symptoms of addictive disorders, including functional impairment (Billieux *et al.*, 2015a).

In the present study, we had several limitations. First, we used a convenience sample of college students. Second, we relied on self-report measures of psychopathology and smartphone use. Third, our measures of problematic smartphone use and smartphone use frequency were correlated; in fact, problematic smartphone use, by definition, includes the frequency of smartphone use. Such conceptual and construct-related issues with defining use and problematic use should be considered in light of our study's focus on both, possibly overlapping constructs. Fourth, we did not have longitudinal data to draw causal inferences. Fifth, because brain circuity deficits have been found responsible for problematic technology use (Turel and Qahri-Saremi, 2016; Turel *et al.*, 2016), perhaps these deficits rather than our study variables were responsible for problematic smartphone use in the present study. Keeping these limitations in mind, our findings on rumination as an important construct in explaining smartphone use are novel and contribute to the literature on relations between psychopathology and problematic smartphone use.

This study has implications for theory and practice with regard to problematic smartphone use and relations with psychopathology. Existing models examining smartphone use frequency as a mediator between increased psychopathology and problematic smartphone use (Elhai *et al.*, 2017b; Kim, J *et al.*, 2015; van Deursen *et al.*, 2015) could be extended by incorporating transdiagnostic psychological constructs (Mansell *et al.*, 2008) such as rumination. Such transdiagnostic constructs may help explain why some people with psychopathology develop problematic use of technology, while others do not. From a clinical practice perspective, depressed and anxious patients should be offered interventions aimed at not only managing mood and anxiety,

but that also provide adaptive coping techniques, including better ways to regulate emotion (Mennin and Farach, 2007). Such interventions could offset the possibility that a depressed or anxious patient would engage in problematic technology use.

Future research should directly examine the role of excessive reassurance seeking, as another chain on the link between depressive/anxious psychopathology and excessive smartphone use. Relevantly, social interaction and support should be further examined for its role in problematic smartphone use – especially problematic smartphone-based social network use (Yang *et al.*, 2016). Transdiagnostic constructs such as avoidance, suppression, and anxiety sensitivity (Aldao *et al.*, 2010), could also be explored as potential mechanisms explaining the relations between psychopathology and problematic smartphone use. The nature of the association between smartphone use frequency and problematic use should be further explored. Finally, future research should examine brain circuitry deficits in addition to mental health variables as underlying problematic smartphone use.

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Table 1. Means and Standard Deviations for the Primary Measures, and Standardized Factor Loadings for Items in Measurement Models.

	M	SD	
Smartphone Usage. "How often do you use your smartphone for the following purposes?"			
1. Voice/video calls (making and receiving)	3.98	1.56	
2. Texting/instant messaging (sending and receiving)	5.36	1.11	
3. Email (sending and receiving)	4.24	1.46	
4. Social networking sites	4.99	1.39	
5. Internet/websites	5.17	1.07	
6. Music/podcasts/radio	4.96	1.32	
7. Games	3.37	1.62	
8. Taking pictures or videos	4.76	1.23	
9. Watching video/TV/movies	3.97	1.56	
10. Reading books/magazines	2.61	1.38	
11. Maps/navigation	3.89	1.32	
	M	SD	Loading
Smartphone Addiction Scale-Short Version (SAS-SV). "How much do you agree with these statements about your use of your smartphone?"			
1. I miss planned work due to smartphone use	2.10	1.38	.48
2. I have a hard time concentrating in class, while doing assignments, or while working due to smartphone use	3.02	1.57	.62
3. I feel pain in the wrists or at the back of the neck while using a smartphone	2.07	1.30	.61
4. I won't be able to stand not having a smartphone	3.36	1.62	.58
5. I feel impatient and fretful when I am not holding my smartphone	2.55	1.47	.83
6. I have my smartphone in my mind even when I am not using it	2.38	1.34	.84
7. I will never give up using my smartphone even when my daily life is already greatly affected by it	2.47	1.36	.64
8. I constantly check my smartphone so as not to miss conversations between other people on Twitter or Facebook	2.98	1.63	.66
9. I use my smartphone longer than I had intended	3.73	1.51	.63
10. The people around me tell me that I use my smartphone too much	2.46	1.47	.62
Patient Health Questionnaire-9 (PHQ-9). "Over the *last 2 weeks*, how often have you been bothered by any of the following problems?"			
1. Little interest or pleasure in doing things	.74	.86	.64
2. Feeling down, depressed, or hopeless	.76	.85	.84
3. Trouble falling or staying asleep, or sleeping too much	1.09	1.04	.65
4. Feeling tired or having little energy	1.24	.95	.72

5. Poor appetite or overeating	.89	.99	.63
6. Feeling bad about yourself—or that you are a failure or have let yourself or your family down	.77	.96	.86
7. Trouble concentrating on things, such as reading the newspaper or watching television	.64	.90	.78
8. Moving or speaking so slowly that other people could have noticed? Or the opposite—being so fidgety or restless that you have been moving around a lot more than usual	.39	.74	.82
9. Thoughts that you would be better off dead or of hurting yourself in some way	.27	.64	.71
Social Interaction Anxiety Scale (SIAS). "For each item, please check the number to indicate the degree to which you feel the statement is characteristic or true for you."			
1. I get nervous if I have to speak with someone in authority (teacher, boss, etc.)	1.39	1.12	.59
2. I have difficulty making eye contact with others	.98	1.09	.55
3. I become tense if I have to talk about myself or my feelings	1.66	1.24	.62
4. I find it difficult to mix comfortably with the people I work with	.84	.99	.66
6. I tense up if I meet an acquaintance in the street	1.09	1.06	.69
7. When mixing socially, I am uncomfortable	1.18	1.12	.68
8. I feel tense if I am alone with just one other person	.90	1.06	.59
10. I have difficulty talking with other people	1.00	1.07	.72
12. I worry about expressing myself in case I appear awkward	1.59	1.23	.70
13. I find it difficult to disagree with another's point of view	.99	1.09	.51
14. I have difficulty talking to attractive persons of the opposite sex	1.24	1.25	.56
15. I find myself worrying that I won't know what to say in social situations	1.34	1.19	.80
16. I am nervous mixing with people I don't know well	1.61	1.21	.76
17. I feel I'll say something embarrassing when talking	1.36	1.20	.76
18. When mixing in a group, I find myself worrying I will be ignored	1.38	1.21	.69
19. I am tense mixing in a group	1.20	1.16	.78
20. I am unsure whether to greet someone I know only slightly	1.44	1.20	.69
Ruminative Thought Styles Questionnaire (RTSQ). "Using the scale below, please rate each item in terms of how well it describes you"			
1. I find that my mind often goes over things again and again (RT)	4.90	1.65	.73
2. When I have a problem, it will gnaw on my mind for a long time (RT)	4.75	1.72	.87
3. I find that some thoughts come to mind over and over throughout the day (RT)	4.78	1.57	.91
4. I can't stop thinking about some things (RT)	4.85	1.65	.90

5. When I am anticipating an interaction, I will imagine every possible scenario and conversation (CT)	4.70	1.74	.73
6. I tend to replay past events as I would have liked them to happen (CT)	4.64	1.74	.86
7. I find myself daydreaming about things I wish I had done (CT)	4.57	1.70	.78
8. When I feel I have had a bad interaction with someone, I tend to imagine various scenarios where I would have acted differently (CT)	4.59	1.82	.83
9. When trying to solve a complicated problem I find that I just keep coming back to the beginning without ever finding a solution (PT)	3.56	1.76	.81
11. I have never been able to distract myself from unwanted thoughts (PT)	3.45	1.61	.76
12. Even if I thought about a problem for hours, I still have a hard time coming to a clear understanding (PT)	3.42	1.64	.82
13. It is very difficult for me to come to a clear conclusion about some problems, no matter how much I think about it (PT)	3.42	1.65	.80
14. Sometimes I realize I have been sitting and thinking about something for hours (PT)	3.49	1.78	.79
17. When I am looking forward to an exciting event, thoughts of it interfere with what I am working on (AT)	4.20	1.57	.71
18. Sometimes even during a conversation, I find unrelated thoughts popping into my head (AT)	4.20	1.73	.72

Note. For the RTSQ, the factor on which each item loads is indicated in parentheses next to the item in this Table.

Following are the standardized factor loadings for the first-order RTSQ factors on the second order RTSQ factor: PT=Problem-Focused Thoughts (.94); CT=Counterfactual Thinking (.76); RT=Repetitive Thinking (.70); AT=Anticipatory Thinking (.91).

Table 2. Descriptive Statistics, Zero-Order Intercorrelations, and Coefficient Alphas for the Primary Measures Using Scale Scores.

Variable	M	SD	1.	2.	3.	4.	5.
1. PHQ-9	6.78	5.44	(.86)				
2. SIAS	21.21	13.59	.44***	(.93)			
3. RTSQ	85.42	24.14	.50***	.50***	(.95)		
4. SAS-SV	27.08	10.15	.25***	.22***	.34***	(.88)	
5. SUF	43.32	7.82	-.03	.04	.15*	.16***	(.79)

Note. PHQ-9 = Patient Health Questionnaire-9; SIAS = Social Interaction Anxiety Scale; RTSQ = Ruminative Thought Styles Questionnaire; SAS-SV = Smartphone Addiction Scale-Short Version; SUF = Smartphone Use Frequency. Alpha coefficients appear in parentheses on the diagonal.
* $p < .05$, ** $p < .01$, *** $p < .001$

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Table 3. Hypotheses and Associated Results in the Structural Model.

H1	Effect Specified	Indirect Test Statistic (a*b)	Result	Direct Effect (a)	Direct Effect (b)	Total Effect
1	RTSQ→SUF	N/A	U	.07 (90% CI: -.03 to .17)	N/A	N/A
2	RTSQ→SAS-SV	N/A	S	.40 (90% CI: .29 to .50)	N/A	N/A
3	PHQ-9→RTSQ→SUF	β = .03 (95% CI -.01 to .07), SE = .03, p = .23	U	.44 (90% CI: .34 to .54)	.07 (90% CI: -.03 to .17)	.06
4	PHQ-9→RTSQ→SAS-SV	β = .18 (95% CI: .12 to .24), SE = .04, p < .001	S	.44 (90% CI: .34 to .54)	.40 (90% CI: .29 to .50)	.36
5	SIAS→ RTSQ→SUF	β = .02 (95% CI: -.01 to .06), SE = .02, p = .28	U	.34 (95% CI: .24 to .55)	.07 (95% CI: .24 to .55)	.04
6	SIAS→ RTSQ→ SAS-SV	β = .14 (95% CI: .08 to .20), SE = .04, p < .001	S	.34 (95% CI: .24 to .55)	.40 (90% CI: .29 to .50)	.28

Total effect = Direct Effect (a) + Direct Effect (b) + Indirect Effect; S=Supported; U=Unsupported.
Note. PHQ-9 = Patient Health Questionnaire-9; SIAS = Social Interaction Anxiety Scale; RTSQ = Ruminative Thought Styles Questionnaire; SAS-SV = Smartphone Addiction Scale-Short Version; SUF = Smartphone Use Frequency.

Figure 1. Hypothesized Model of Depression and Anxiety Predicting Rumination, and Rumination Predicting Smartphone Use Frequency and Predicting Problematic Smartphone Use (Adjusting for Age and Gender).

Notes: SIAS = Social Interaction Anxiety Scale; PHQ-9 = Patient Health Questionnaire-9; SAS = Smartphone Addiction Scale-Short Version; SUF = Smartphone Use Frequency. Circles represent latent variables; squares represent observed variables. For visual clarity, the latent variables' observed items are not pictured (see Table 1 for item-to-factor mappings, and factor loadings).

Figure 2. Model A: Structural Equation Model of Depression and Anxiety Predicting Rumination, and Rumination Predicting Smartphone Use Frequency and Predicting Problematic Smartphone Use (Adjusting for Age and Gender), With Standardized Path Coefficients for Direct Effects.

Notes: SIAS = Social Interaction Anxiety Scale; PHQ-9 = Patient Health Questionnaire-9; SAS = Smartphone Addiction Scale-Short Version; SUF = Smartphone Use Frequency. Circles represent latent variables; squares represent observed variables. For visual clarity, the latent variables' observed items are not pictured (see Table 1 for item-to-factor mappings, and factor loadings).

* p < .05, ** p < .01, *** p < .001

Figure 3. Model B: An Adaptation of Model A, Adding Four Paths.

Notes: SIAS = Social Interaction Anxiety Scale; PHQ-9 = Patient Health Questionnaire-9; SAS = Smartphone Addiction Scale-Short Version; SUF = Smartphone Use Frequency. The added four paths are depicted by dashed lines, and their path coefficients are in bold for easy visual discrimination. Circles represent latent variables; squares represent observed variables. For visual clarity, the latent variables' observed items are not pictured (see Table 1 for item-to-factor mappings, and factor loadings).

* $p < .05$, ** $p < .01$, *** $p < .001$