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Boredom proneness and fear of missing out (FOMO) mediate relations between depression and anxiety with problematic smartphone use

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Abstract

Depression and anxiety severity are found in numerous studies to correlate with increased levels of problematic smartphone use. Yet there are less available data on other psychopathology-related correlates of such use. Two potentially important variables related to depression and anxiety, and recently found related to problematic smartphone use severity, are boredom proneness and the fear of missing out (FOMO). Our aims were to 1) assess boredom proneness and FOMO in relation to problematic smartphone use severity, and 2) assess the mediating roles of boredom proneness and FOMO in relationships between depression/anxiety severity with problematic smartphone use severity. We recruited 297 American college students for a web survey, assessing constructs including FOMO, boredom proneness, depression, anxiety, problematic smartphone use, and smartphone use frequency. We tested a structural equation model to assess relations between depression and anxiety severity with boredom proneness and FOMO, and relations between these psychopathology constructs with levels of smartphone use frequency and problematic use. Results demonstrate that FOMO was significantly related to problematic smartphone use severity. FOMO also mediated relations between boredom proneness and problematic smartphone use severity. Furthermore, boredom proneness and FOMO serially mediated relations between both depression and anxiety severity with problematic smartphone use severity. Results are discussed in the context of Compensatory

Internet Use Theory and the I-PACE model in understanding factors driving problematic smartphone use.

Keywords: smartphone addiction; boredom; fear of missing out; depression; anxiety; internet addiction; psychopathology.

1. Introduction

Contemporary communication technologies can greatly enhance one's daily life through facilitating social networking, information browsing, and allowing for constant online availability. However, misusing these tools has been associated with several detrimental outcomes. Recently, problematic smartphone use has received increased empirical attention, involving excessive smartphone use, functional impairment, and symptoms of substance use disorders, such as tolerance and withdrawal (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). Problematic smartphone use is associated with health problems because of musculoskeletal strain (Shan et al., 2013; Xie, Szeto, Dai, & Madeleine, 2016), and mental health problems (Elhai, Dvorak, Levine, & Hall, 2017). Yet aside from depression and anxiety (Elhai et al., 2017), less is known about psychopathology-related variables associated with problematic smartphone use.

In the present paper, our primary aim was to examine psychopathology-related variables only recently tested for relations with problematic smartphone use severity – namely, boredom proneness and the fear of missing out on rewarding experiences (FOMO). Furthermore, using theoretical frameworks to guide analysis, we assessed the roles of boredom proneness and FOMO as mediating variables between depression and anxiety with problematic smartphone use severity.

A theoretical model aimed at explaining excessive internet use, such as problematic smartphone use, is Compensatory Internet Use Theory (Kardefelt-Winther, 2014), in which negative emotion is conceptualized as the driving factor. In this theory, excessive internet use is viewed as an avoidant coping strategy that some people use to avoid and alleviate negative emotion and affect. The theory does not attempt to conceptualize problematic internet use as a type of psychopathology, but rather views it as a natural, though maladaptive, coping method for processing negative emotion. This theory has been supported empirically in studies of problematic smartphone use (Elhai, Tiamiyu, & Weeks, 2018; Long et al., 2016; Zhitomirsky-Geffet & Blau, 2016). The theory would conceptualize that excessive technology use may result from psychopathology, in order to alleviate negative emotion.

A relevant, more comprehensive theoretical model of excessive internet use is the Interaction of Person-Affect-Cognition-Execution (I-PACE) model of excessive internet communications use (Brand, Young, Laier, Wolfling, & Potenza, 2016). I-PACE proposes several factors that influence internet communications use and excessive use. First, personal factors include genetic and biological influences, personality, psychopathology, cognitions, and internet-related use motives that may influence excessive internet use. Second, responses to such personal factors include risk or resilience factors for excessive internet use, such as cognitive bias, expectancies about internet use, coping strategies, inhibitory control, craving and attention bias. (Wegmann,

Oberst, Stodt, & Brand, 2017). Representing risk or resilience factors, such response variables can magnify or buffer the role of personal factors in leading to excessive internet use. Thus, response variables in I-PACE are conceptualized to moderate or mediate relations between personal factors and excessive internet use (Brand et al., 2016). Finally, I-PACE proposes that these responses may lead to choosing a particular type of internet feature or application, which may lead to adaptive gratification, or problematic use. Numerous studies find support for I-PACE in modeling problematic internet use (e.g., Lemenager et al., 2018; Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017).

Our focus is on problematic smartphone use, which is most consistently related to depression and anxiety symptoms (Elhai et al., 2017). Moderate associations have been found with depression severity (e.g., Demirci, Akgonul, & Akpinar, 2015; Smetaniuk, 2014), and mild associations with anxiety (e.g., Demirci et al., 2015; R. Kim, Lee, & Choi, 2015). Depression and anxiety would be conceptualized as psychopathology personal factors in I-PACE that can influence problematic smartphone use. Yet depression and anxiety are sometimes unrelated or inversely related to such problematic use (Elhai et al., 2017). Such inverse or non-significant relationships may be due to varying instrumentation or procedures across studies, or from excluding other important variables that play a role.

Another variable likely implicated in problematic smartphone use is the trait-based tendency to experience boredom, or boredom proneness, which would also be conceptualized as a personal factor in I-PACE. Boredom proneness involves attentional and impulse control difficulties leading to experiencing boredom (Isacescu, Struk, & Danckert, 2017; Struk, Carriere, Cheyne, & Danckert, 2017). Boredom proneness also positively correlates with negative affectivity, including depression and anxiety (Goldberg, Eastwood, Laguardia, & Danckert, 2011; Struk et al., 2017). Directionality of the boredom-negative affectivity relationship has been explored in experimental and experience sampling studies, finding that it is negative affect that drives the inattention involved in boredom rather than the other way around. This finding was observed in experimental studies of negative mood induction with undergraduate participants (Smallwood, Fitzgerald, Miles, & Phillips, 2009; Smallwood & O'Connor, 2011), and in a repeated measures experience sampling study (Poerio, Totterdell, & Miles, 2013). As such, negative affectivity (including depression and anxiety) is conceptualized as a prominent factor causing people to experience boredom (Eastwood, Frischen, Fenske, & Smilek, 2012). Boredom proneness can be conceptualized as an aversive state that many people attempt to relieve by using, and overusing their smartphones, as one's smartphone is easily accessible and provides positive reinforcement (Elhai, Vasquez, Lustgarten, Levine, & Hall, 2018; Wegmann, Ostendorf, & Brand, 2018). Lepp and colleagues found leisure boredom (similar to boredom proneness) associated with

problematic smartphone use (Lepp, Barkley, & Li, 2017). Furthermore, recent work discovered that boredom proneness was a significant mediator accounting for relations between both depression and anxiety with problematic technology use including smartphone use (Elhai, Vasquez, et al., 2018; Wegmann et al., 2018); though we should emphasize that these latter two studies were cross-sectional.

More recently, studies demonstrate that several additional psychopathology-related variables mediate relations between both depression and anxiety with problematic smartphone use. Support has been found for such mediating variables as emotion dysregulation (Elhai, Levine, Dvorak, & Hall, 2016; Elhai, Levine, O'Brien, & Armour, 2018), rumination (Elhai, Tiamiyu, & Weeks, 2018), low self-control (Cho, Kim, & Park, 2017), and decreased behavioral activation (Elhai et al., 2016). In I-PACE, these variables would represent responses to the framework's personal factors, and as such can serve in an intermediary risk or resilience role between personal factors and problematic smartphone use. For example, depression and anxiety (personal variables) may lead to excessive internet use, but especially among individuals who struggle with regulating their emotional distress (response variable) (Elhai, Levine, O'Brien, et al., 2018).

In fact, in I-PACE a prominent response variable to personal factors is FOMO. FOMO involves a) apprehension that others are having rewarding experiences from which one is absent, and b) the desire to stay constantly connected with others

(Przybylski, Murayama, DeHaan, & Gladwell, 2013). FOMO is related to online social network site use (e.g., Beyens, Frison, & Eggermont, 2016; Blackwell, Leaman, Tramposch, Osborne, & Liss, 2017). FOMO correlates with severity of negative affectivity, including depression and anxiety, and boredom proneness (Elhai, Levine, Alghraibeh, et al., 2018; Oberst et al., 2017; Wolniewicz, Tiamiyu, Weeks, & Elhai, 2018). Furthermore, longitudinal data suggest that negative affect (from low self-esteem) prospectively drives FOMO (Buglass, Binder, Betts, & Underwood, 2017). FOMO also correlates with problematic smartphone use (Elhai, Levine, Alghraibeh, et al., 2018; Elhai et al., 2016; Oberst et al., 2017; Wolniewicz et al., 2018). In fact, recent studies discovered that FOMO mediated relations between negative affectivity constructs such as depression/anxiety/boredom proneness and problematic technology (including smartphone) use severity (Elhai, Levine, Alghraibeh, et al., 2018; Oberst et al., 2017; Wegmann et al., 2018). Thus FOMO fits well as a response variable in I-PACE, representing a cognitive bias intermediary variable between personal factors and excessive internet use (Wegmann et al., 2017).

1.1. Research Model

We tested the structural equation model depicted in Figure 1. Depression and anxiety severity were specified to statistically predict boredom proneness, as negative affect influences boredom (Eastwood et al., 2012; Poerio et al., 2013; Smallwood et al., 2009; Smallwood & O'Connor, 2011). Boredom proneness in turn was tested as a

predictor of FOMO, fitting with I-PACE's conceptualization of personal factors influencing response variables (Brand et al., 2016). FOMO was specified to predict smartphone use frequency, in turn predicting problematic smartphone use severity, mapping onto I-PACE's focus on response variables leading to the use of specific internet features, possibly leading to problematic use. In fact, smartphone use frequency is often specified as an intermediary variable between psychopathology and problematic use (Elhai & Contractor, 2018; Elhai, Tiamiyu, & Weeks, 2018; J. Kim, Seo, & David, 2015; van Deursen, Bolle, Hegner, & Kommers, 2015), because increased smartphone use grows into problematic use (Oulasvirta, Rattenbury, Ma, & Raita, 2012; van Deursen et al., 2015). We included demographic covariates of problematic smartphone use (personal factors in I-PACE); younger age (Lu et al., 2011; van Deursen et al., 2015) and female sex (Jeong, Kim, Yum, & Hwang, 2016; Wang, Wang, Gaskin, & Wang, 2015) are associated with problematic use. We also tested model variations, discussed below.

1.2. Hypotheses

H1) **Boredom proneness should positively correlate with FOMO**. Boredom proneness and FOMO share underlying negative affectivity in common (Goldberg et al., 2011; Oberst et al., 2017; Struk et al., 2017; Wolniewicz et al., 2018), and are correlated with each other (Elhai, Levine, Alghraibeh, et al., 2018). In I-PACE, boredom proneness would represent a core personality and/or

psychopathology characteristic. In I-PACE, FOMO would represent a cognitive bias (response variable) influenced by psychopathology – namely, that the individual is missing rewarding experiences that can only be fulfilled by persistently using internet media such as social networking sites (Wegmann et al., 2017). I-PACE conceptualizes core characteristics (such as boredom proneness) as driving such cognitive biases (e.g., FOMO) (Brand et al., 2016).

H2) **FOMO should positively correlate with problematic smartphone use**. FOMO involves negative affect (Przybylski et al., 2013), and is associated with depression and anxiety (Oberst et al., 2017; Wolniewicz et al., 2018). Based on Compensatory Internet Use Theory (Kardefelt-Winther, 2014), the negative emotion among individuals with increased FOMO should drive them to engage in higher problematic smartphone use levels to relieve such negative emotion through digital social relatedness. In I-PACE, FOMO can represent a cognitive bias influencing people to engage in excessive internet use (Wegmann et al., 2017). Prior studies have supported FOMO's relationship with problematic smartphone use severity (Elhai, Levine, Alghraibeh, et al., 2018; Elhai et al., 2016; Oberst et al., 2017; Wolniewicz et al., 2018).

H3) **FOMO should mediate relations between boredom proneness and problematic smartphone use**. Based on H1, boredom proneness should positively correlate with FOMO. Based on H2, FOMO should positively correlate

with problematic smartphone use severity. Boredom proneness has demonstrated associations with problematic internet and smartphone use (Elhai, Vasquez, et al., 2018; Lepp et al., 2017; Wegmann et al., 2017), and this association fits with Compensatory Internet Use Theory's emphasis on such problematic use as a coping strategy to relieve negative affect. FOMO is expected to mediate such association between boredom proneness and problematic smartphone use severity. In I-PACE, core personality and psychopathology variables (such as boredom proneness) can drive cognitive biases (such as FOMO; see H1 for elaboration), in turn leading to problematic technology use such as one's smartphone (Brand et al., 2016). Thus FOMO may represent a mediating mechanism between boredom proneness and problematic smartphone use severity (as cognitive biases are conceptualized as serving such a mediation role in I-PACE), supported in recent work (Elhai, Levine, Alghraibeh, et al., 2018).

H4) **Boredom proneness and FOMO should serially mediate relations between both depression (H4a) and anxiety (H4b) with problematic smartphone use**. Serial mediation involves a chain of two or more mediating variables, where one mediator influences another mediator (Hayes, 2017). Serial mediation is well-suited to I-PACE, because I-PACE includes multiple proposed intermediary pathways toward excessive internet use (Brand et al., 2016). This

hypothesis builds on H3's proposal that FOMO will mediate the relationship between boredom proneness and problematic smartphone use, by including depression and anxiety severity in the model. Depression and anxiety, core psychopathology characteristics in I-PACE, should predict boredom proneness, as such negative affectivity drives the experience of boredom (Eastwood et al., 2012; Poerio et al., 2013; Smallwood et al., 2009; Smallwood & O'Connor, 2011). In fact, Elhai and colleagues discovered that boredom proneness mediated relations between both depression and anxiety with levels of problematic smartphone use (Elhai, Vasquez, et al., 2018). FOMO should in turn serve as an intermediary variable in the depression/anxiety->boredom proneness->problematic smartphone use chain, because experiencing boredom as a result of negative affectivity should drive individuals to seek out rewarding experiences in order to relieve their boredom (Przybylski et al., 2013), subsequently fueling problematic smartphone use. Thus depression and anxiety should predict boredom proneness, in turn predicting FOMO, in turn predicting problematic smartphone use severity. This chain of effects from psychopathology to cognitive bias to excessive internet (i.e., smartphone) use fits well within I-PACE's progression from personal to response variables to excessive use.

2. Method

2.1. Sample and Procedure

We initially recruited 301 undergraduate college students from the psychology research pool of a large Midwestern U.S. university in fall of 2017. The university's institutional review board approved the study before participant recruitment. The study was advertised as a 25–30-minute survey about "use of electronic devices, and your emotions," posted on the university's Sona Systems web portal. Participants who provided consent (using a consent statement) completed a web survey asking about smartphone use and other psychological characteristics (see Measures for details). Four participants missed more than 50% of items on a given scale and were excluded from subsequent analyses.

Therefore, the effective sample comprised 297 individuals, with 214 (72.1%) women and 83 (27.9%) men. Age averaged 19.70 years (SD = 3.96). Most participants identified as Caucasian (n = 239, 80.5%), with minority representation from African-American (42, 14.1%), Hispanic/Latino (20, 6.7%), Asian (12, 4.0%), and Native American (6, 2.0%) backgrounds (note: designations were non-mutually exclusive). Most participants were freshmen (n = 159, 53.5%), or sophomores (n = 100, 33.7%). 148 (49.8%) were employed part-time, 34 (11.4%) full-time, and 115 (38.7%) were not working.

2.2. Measures

We first asked about participants' demographics, including gender, age, schooling, ethnic/racial background, and employment status.

2.2.1. Fear of Missing Out Scale. The FOMO scale (Przybylski et al., 2013) is a 10-item questionnaire, with responses ranging from 1 = *Not at all true of me* to 5 = *Extremely true of me*, measuring anxiety from missing out on social events (e.g., going out with friends). Responses are summed to form a total score. Internal reliability is adequate, with convergent validity against measures of social media engagement, negative mood, poor life satisfaction (Przybylski et al., 2013), and depression, anxiety and negative affect (Elhai et al., 2016; Wolniewicz et al., 2018). Coefficient alpha in this study was .87.

2.2.2. Smartphone Addiction Scale. This 33-item measure (Kwon et al., 2013) measures levels of problematic smartphone use, with response options from 1 = *Strongly disagree* to 6 = *Strongly agree*. The scale consists of six subscales ("Daily Life Disturbances", "Positive Anticipation", "Withdrawal", "Cyberspace-Oriented Relationships", "Overuse", and "Tolerance") that form a higher-order factor of problematic smartphone use. The scale can be used as a multi- or uni-dimensional scale; we summed items for a total score, and analyzed item-level data for factor analysis. Internal consistency is adequate (Kwon et al., 2013); in addition, the scale and its shorter versions converge with other measures of problematic internet and smartphone use (Kwon et al., 2013; Lopez-Fernandez, 2017; Rozgonjuk, Rosenvald, Janno, & Täht, 2016). Coefficient alphas ranged from .67 ("Overuse") to .84 ("Positive Anticipation") for subscales, and .92 overall in the current sample.

2.2.3. Smartphone Use Frequency Scale. This scale (Elhai et al., 2016) is an 11-item measure inquiring about one's frequency of using specific smartphone features, with response options from 1 = *Never* to 6 = *Very often*. Activities inquired were: (1) *video and voice calls (making and receiving)*, (2) *text/instant messaging (sending and receiving)*, (3) *email (sending and receiving)*, (4) *social networking sites*, (5) *internet/websites*, (6) *games*, (7) *music/podcasts/radio*, (8) *taking pictures or videos*, (9) *watching videos/TV/movies*, (10) *reading books/magazines*, and (11) *maps/navigation*. Responses are summed for a smartphone use frequency score. Internal reliability is adequate, with convergent validity against problematic smartphone use measures (Elhai et al., 2016). Coefficient alpha for the current sample was .74.

2.2.4. Boredom Proneness Scale-Short Form. This 8-item measure (Struk et al., 2017) is a short version of the original Boredom Proneness Scale (Farmer & Sundberg, 1986), measuring trait boredom with responses from 1 = *Highly disagree* to 7 = *Highly agree*. Examples of items include "I find it hard to entertain myself," and "Much of the time, I just sit around doing nothing." The scale has adequate internal consistency and construct validity comparable to the original scale (Struk et al., 2017). Internal consistency for the current sample was .87.

2.2.5. Depression Anxiety Stress Scale-21. This scale (Lovibond & Lovibond, 1995) consists of 21 items measuring depression, anxiety, and stress symptoms. Each subscale is measured by seven items, with options from 0 = *Did not apply to me* to 3 =

Applied to me very much or most of the time, regarding symptoms during the past week. We used only the depression and anxiety subscales, with adequate internal consistency (Lovibond & Lovibond, 1995), and convergent validity against similar scales (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Chorpita, Korotitsch, & Barlow, 1997). Coefficient alphas for the current sample were .89 for depression and .82 for anxiety.

2.3. Analysis

Aside from the four participants excluded for excessive missing data (described above), there were minimal missing item-level data for remaining participants (5-10% of participants missed typically 1-2 items per scale). Using IBM SPSS 24 software, we used maximum likelihood procedures to estimate and impute missing items for these remaining participants, separately for each scale (Graham, 2009). We then summed items to generate scale scores. Variable distributions were normal, as skewness and kurtosis did not have absolute values higher than 2.0.

Next, with Mplus 8 software we used confirmatory factor analysis for a measurement model of the dependent variable, problematic smartphone use, with all 33 items. We tested a higher-order measurement model with six first-order latent factors (representing the Smartphone Addiction Scale subscales). The scale's items were treated as ordinal, using a polychoric covariance matrix, probit coefficients for factor loadings, and weighted least squares estimation with a robust mean-adjusted chi-square (DiStefano & Morgan, 2014). Factor loadings were freely estimated, with factor

variances fixed to “1”. Goodness of fit was assessed using benchmarks: (a) comparative fit index (CFI) ≥ .90, (b) Tucker-Lewis Index (TLI) ≥ .90, c) root mean square error of approximation (RMSEA) ≤ .08 (Hu & Bentler, 1999).

We tested the structural model for relationships between depression and anxiety severity (predictor variables), FOMO and boredom proneness as mediators (with boredom proneness statistically predicting FOMO), and problematic smartphone use severity and use frequency (dependent variables). We also tested variations of this model, discussed below. The only measurement model that we report is for problematic smartphone use. All other variables were measured as observed scale scores, to preserve statistical power given the complexity of the model. When we attempted model testing with latent variables for depression, anxiety, FOMO, and boredom proneness, our models did not converge – likely because of the computational intensity and large amount of statistical power required for such fully latent models. Age and sex were also used as observed covariates of problematic smartphone use severity. The same estimation approach was used for the structural as for the measurement model.

Mediation was assessed using indirect effect testing by computing cross-products of direct paths. We used the Delta method with 1000 bootstrapped samples to compute standard errors for indirect effects (Hayes, 2017).

3. Results

Descriptive statistics and correlations between variables are presented in Table 1. Boredom proneness was associated with FOMO (H1). FOMO was associated with levels of problematic smartphone use (H2). In fact, problematic smartphone use was associated with all psychological measures.

The second-order measurement model of problematic smartphone use items demonstrated some (albeit, not complete) evidence for adequate fit, robust $\chi^2(489, N = 297) = 3038.93$, $p < .001$, CFI = .93, TLI = .92, RMSEA = .13 (90% CI: .128 to .137). Standardized factor loadings were uniformly high, with only one loading below .40 (item 25: $\beta = .39$). To preserve space, first-order and second-order factor loadings are available upon request from the last author.

The model from Figure 1 showed some (but not complete) evidence for adequate fit, robust $\chi^2(731, N = 297) = 3661.25$, $p < .001$, CFI = .92, TLI = .91, RMSEA = .12 (90% CI: .112 to .120). Figure 2 displays standardized path coefficients. Boredom proneness was associated with FOMO (H1). Adjusting for covariates, FOMO scores were associated with problematic smartphone use severity (H2). Younger age was related to increased problematic smartphone use levels; sex was not statistically significant. Depression and anxiety scores were associated with boredom proneness.

We tested variations of the model depicted in Figure 1. We tested a model specifying depression and anxiety predicting FOMO and boredom proneness, rather than specifying a path between boredom proneness to FOMO; however, this model did

not converge. We also tested a variation where boredom proneness predicted smartphone use frequency, but model fit was poor (e.g., CFI = .88, TLI = .87, RMSEA = .12). We also tested interactions between boredom proneness and FOMO, but models with such interactions did not converge or resulted in poor fit. Finally, we tested reversed mediation model variations whereby boredom proneness and FOMO predicted depression and anxiety, in turn predicting smartphone use frequency and problematic use, but these models also did not converge.

FOMO scores mediated relations between boredom proneness and problematic smartphone use severity, β = .46, SE = .05, $p < .001$ (H3). The combined effect of boredom proneness to FOMO serially mediated relations between levels of depression and problematic smartphone use severity, β = .18, SE = .06, $p < .001$ (H4a). Boredom proneness and FOMO also serially mediated relations between levels of anxiety and problematic smartphone use, β = .17, SE = .06, p = .005 (H4b). When recomputing mediation analyses by using smartphone use frequency as the dependent variable instead of problematic smartphone use, no mediation effects were significant.

4. Discussion

In the present study, we added to traditional studies on problematic smartphone use focusing primarily on depression and anxiety (Elhai et al., 2017), by expanding the domain of psychopathology-related constructs examined as mediating variables.

Specifically, we tested relations between levels of problematic smartphone use, anxiety and depression, and the roles of boredom proneness and FOMO in these relationships.

We first found that boredom proneness was correlated with FOMO, thus supporting H1. This finding fits with I-PACE regarding personal factors (such as boredom proneness) driving cognitive bias-related response variables such as FOMO. Secondly, results demonstrated support for H2; FOMO scores were associated with problematic smartphone use severity. This relationship between FOMO and problematic smartphone use is consistent with previous findings (Elhai, Levine, Alghraibeh, et al., 2018; Elhai et al., 2016; Oberst et al., 2017; Wolniewicz et al., 2018). The FOMO-problematic smartphone use relationship is also consistent with theory, including I-PACE in proposing that cognitive biases drive problematic internet use (Brand et al., 2016). That is, FOMO, representing a cognitive bias response variable in I-PACE, can influence particular types of internet media use, such as one's smartphone, and such use can become excessive as in the case of problematic smartphone use. Findings also fit with Compensatory Internet Use Theory (Kardefelt-Winther, 2014) in proposing problematic smartphone use as a means to alleviate negative emotion, as FOMO is conceptualized to involve negative emotion (Przybylski et al., 2013) and is prospectively related to negative affectivity (Buglass et al., 2017).

We also found that FOMO mediated relations between boredom proneness and problematic smartphone use, supporting H3. According to H3, we expected this finding

because of I-PACE's proposal that core personality and psychopathology characteristics (such as boredom proneness) drive cognitive biases (such as FOMO), in turn driving problematic internet use. In fact, two types of psychopathology involving negative affect - depression and anxiety – are conceptualized to cause the experience of boredom (Eastwood et al., 2012), found in mood induction experimental work (Smallwood et al., 2009; Smallwood & O'Connor, 2011) and using experience sampling designs (Poerio et al., 2013). Furthermore, the present study demonstrates that the boredom proneness-FOMO relationship mediates associations between both depression and anxiety with problematic smartphone use, supporting H4. This mediation finding is consistent with I-PACE in conceptualizing response variables such as FOMO (as a cognitive bias) in an intermediary role between personal factors (i.e., depression, anxiety and boredom proneness) and problematic smartphone use severity.

Research is growing on relationships between both problematic internet and smartphone use with adverse daily-life outcomes, such as poorer physical and mental health (Burnell & Kuther, 2016; Elhai et al., 2017; Shan et al., 2013; Xie et al., 2016) and academic difficulties (Lepp, Barkley, & Karpinski, 2014; Rozgonjuk, Saal, & Täht, 2018; Samaha & Hawi, 2016). Among the more consistent findings, depression and anxiety severity (personal factors in I-PACE) are related to higher levels of problematic smartphone use (Elhai et al., 2017); however, the mechanisms and dynamics of these relationships are underexplored. Our study suggests that boredom proneness and

FOMO may mediate relations between psychopathology symptoms such as depression and anxiety with problematic smartphone use severity. According to Compensatory Internet Use Theory, coping with negative emotion can lead to excessive internet use (Kardefelt-Winther, 2014). In I-PACE, variables such as boredom proneness and FOMO can influence problematic internet and smartphone use because of psychopathology and cognitive bias, respectively. Our results are in coherence with these theoretical frameworks.

Our study had several limitations that should be considered in interpreting findings. First, we used a college student sample, which is not necessarily representative of, and may not fully generalize to, the larger U.S. population. Second, while we relied upon self-report measures for assessing our psychopathology constructs, structured diagnostic interviews of depression and anxiety would be more rigorous; furthermore, objective smartphone use logs would be more accurate than self-report (Elhai, Tiamiyu, Weeks, et al., 2018; Rozgonjuk, Levine, Hall, & Elhai, 2018). Third, our confirmatory factor analysis and structural equation models did not obtain excellent fit based on prior benchmarks, but they did not overwhelmingly demonstrate poor fit. Nonetheless, while we believe the results are important, the mixed findings regarding model fit should lead us to treat them with some caution. Fourth, we only tested some of the personal background variables from I-PACE; many other personal factors can also drive problematic smartphone use, as discussed above. Some of these

other variables may be confounding variables that could explain statistical relationships in the present study. Finally, our study was cross-sectional, and thus we cannot infer causality based on our findings. Despite our attempt to conceptualize the model's pathways based on theory and prior empirical findings, it is possible that the directionality of some of our paths should be reversed; only experimental or longitudinal studies can clarify this issue in the future.

Our main findings include that FOMO was related to levels of problematic smartphone use, and FOMO mediated relations between boredom proneness and problematic smartphone use severity. This study is innovative in exploring more contemporary constructs of psychopathology-related mediating variables that have not received previous scrutiny. Future research should address these potential limitations by studying a community sample with more objective measures, by examining the actual amount of time people use their smartphones (Elhai, Tiamiyu, Weeks, et al., 2018; Rozgonjuk, Levine, et al., 2018), in a longitudinal study design.

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Figure 1. Hypothesized model.

Notes: FOMO=Fear of missing out; PSU=Problematic smartphone use. Circles represent latent variables; squares represent observed variables. For visual clarity, the latent PSU variable's observed items are not pictured.

Figure 2. Hypothesized model with standardized path coefficients, and standard errors (in parentheses).

Notes: FOMO=Fear of missing out; PSU=Problematic smartphone use. Circles represent latent variables; squares represent observed variables. For visual clarity, the latent PSU variable's observed items are not pictured.

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

Table 1. Descriptive statistics and correlations for the study variables.

Variable	M	SD	Min	Max	1	2	3	4	5	6	7
1. Gender	-	-	-	-	-						
2. Age	19.70	3.96	18	56	-.13*	-					
3. FOMO	23.40	8.06	10	50	.17**	-.16**	-				
4. PSU	91.52	23.95	33	157	.11	-.24***	.53***	-			
5. SUF	49.55	7.25	11	66	.15**	-.13*	.18**	.29***	-		
6. BP	24.08	10.06	8	53	.02	-.08	43***	.47***	.04	-	
7. Depression	4.29	4.71	0	21	.04	-.07	.43***	.34***	.07	.63***	-
8. Anxiety	3.64	4.00	0	20	.11	-.05	.45***	.35***	.02	.51***	.75***

Notes. FOMO = fear of missing out; PSU = problematic smartphone use (measured by SAS); SUF = smartphone use frequency; BP = boredom proneness. * p < .05, ** p < .01, *** p < .001.

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Claire A. Wolniewicz is a Research Administrator in the Department of Internal Medicine and Program Manager for the Clinical Trials Academy at the University of Michigan, Ann Arbor, Michigan, USA. Her area of expertise is in clinical trial design and much of her research is dedicated to technologies in diabetes management and medical decision making.

Dmitri Rozgonjuk was a PhD student in Psychology at the University of Tartu, Estonia, and a Fulbright visiting student researcher at the Department of Psychology at the University of Toledo, Ohio, USA at the time of this research. His main interests include the interplay between digital device and social media usage and subjective well-being, mental health, and academic outcomes. His other interests include personality psychology, technology adoption, and e-governance diffusion.

Jon D. Elhai is a professor of psychology and psychiatry at the University of Toledo in Ohio, USA. He has a program of research on posttraumatic stress disorder, investigating assessment, diagnostic and comorbidity issues with the disorder. He also has a program of research on cyberpsychology and behavioral addictions, examining mental health correlates of problematic Internet and smartphone use, and the adverse effects of interruptive smartphone notifications.

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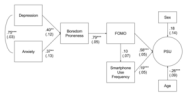

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Running title: Boredom proneness, FOMO, smartphone use

Boredom proneness and fear of missing out (FOMO) mediate relations between depression and anxiety with problematic smartphone use

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