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Boredom proneness and rumination mediate relationships between depression and anxiety with problematic smartphone use severity

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Abstract
Problematic smartphone use (PSU) symptoms are related to mental health symptoms, such as depression and anxiety. However, less investigated are current psychopathology-related processes in mediating these relationships. We analyzed boredom proneness and rumination, two variables involving negative affectivity, as possible mediators between mental health and PSU severity. We recruited 1097 Chinese university students to complete online questionnaires measuring levels of PSU, smartphone use frequency (SUF), depressive and anxious symptoms, boredom proneness and rumination. Structural equation modeling demonstrated that boredom proneness and rumination were significantly related to both SUF and PSU severity. SUF inversely mediated relations between boredom proneness and PSU severity, but positively accounted for relations between rumination and PSU levels. This is one of few studies testing boredom proneness or rumination in relation to PSU severity. Boredom proneness and rumination may be important variables involving negative affectivity, explaining why some depressed or anxious individuals overuse their smartphones.

Keywords Anxiety · Boredom proneness · Depression · Smartphone addiction · Rumination

Introduction

Despite the efficiency advantages of using a smartphone, overuse is a serious problem for many people. Excessive smartphone use is especially related to mental health symptoms, including depressive and anxious symptoms (Elhai et al. 2019a; Thomée 2018). However, less is known about more contemporary constructs that are important in psychopathology research and may relate to excessive smartphone use.

Excessive smartphone use is often labeled as "problematic smartphone use" (PSU) in research. PSU involves disproportionate overuse of a smartphone with concomitant symptoms common in substance use disorders, including social or job-related impairment (Duke and Montag 2017; Montag and Walla 2016), and withdrawal from non-use (Billieux et al. 2015a). Other similar terms exist for PSU in the literature (Elhai et al. 2019a), but we refer to this construct as "PSU" in this paper. We emphasize that PSU is not a recognized

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disorder in DSM-5 or ICD-11 (Carbonell et al. 2018; for a deeper discussion on terminology and taxonomy of Internet Use Disorders including its mobile form of PSU, see Montag et al. 2020). Therefore we caution against over-pathologizing normative behaviors such as (healthy) smartphone use (Billieux et al. 2015c). Yet PSU is a serious condition for many people, involving overuse and associated impairment.

Compensatory Internet Use Theory (CIUT) (Kardefelt-Winther 2014) is relevant to our investigation. CIUT hypothesizes that overuse of the internet (e.g., PSU) is an unhealthy attempt to relieve negative emotion and satisfy social needs. CIUT has been borne out in research on PSU (Elhai et al. 2018b; Long et al. 2016). A more comprehensive theoretical model that incorporates numerous pathways to internet overuse is the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al. 2016; Brand et al. 2019). I-PACE is a fairly comprehensive framework explaining excessive internet use, which proposes several influencing factors. First, personal factors within I-PACE include biological variables, personality traits, and psychopathology, which may influence excessive internet use (Lachmann et al. 2019; see Peterka-Bonetta et al. 2019, linking personality traits to PSU. Second, reactions to such personal factors are important in I-PACE, and include risk or buffering paths to excessive internet use, such as cognitive bias, coping, and disinhibition (Wegmann et al. 2017; Brand et al. 2016). Such response/reaction variables can exacerbate or lessen how personal factors influence internet overuse. Thus, I-PACE's response variables are thought to account for associations between personal variables and internet overuse (Brand et al. 2016). Finally, I-PACE's responses may drive use of specific types of internet features or applications, with healthy satisfaction, or problematic use as the outcome. I-PACE has been borne out of data in numerous papers (Lemenager et al. 2018; Oberst et al. 2017).

There are numerous paths toward developing PSU (Billieux et al. 2015a), such as excessive reassurance (Billieux et al. 2015b), impulsive-antisocial (Billieux et al. 2008), and extraversion pathways (Bianchi and Phillips 2005). However, little work has been conducted mechanistically regarding how poor mental health drives PSU. Recently, research into PSU's association with psychopathology has grown (Sohn et al. 2019; Elhai et al. 2019b). Most studies confirm PSU's association with depressive and anxious symptoms (Elhai et al. 2017; Thomée 2018; Montag et al. 2016b). And other psychopathology-relevant constructs have been examined in conjunction with PSU (Elhai et al. 2020a; Sohn et al. 2019). Studying more contemporary constructs can uncover mechanisms involved in the development of PSU, beyond simply examining depression and anxiety. Two important contemporary constructs that are relevant to PSU are boredom proneness (Skues et al. 2016) and rumination (Samtani and Moulds 2017).

Boredom proneness involves attentional and impulse control difficulties leading to experiencing boredom, often involving negative affect (Struk et al. 2017). Therefore, boredom proneness correlates with anxious and depressive psychopathology (Elhai et al. 2018a; Goldberg et al. 2011; Sommers and Vodanovich 2000). Directionality has been studied using experiments and ecological momentary assessment, suggesting that negative affect influences boredom-related lack attention (Sommers and Vodanovich 2000; Mercer and Eastwood 2010). In fact, negative affect is conceptualized as a primary cause of experiencing boredom (Eastwood et al. 2012). In the context of technology overuse, boredom proneness is theorized to be an aversive state relieved by many people through overusing their smartphones, given how accessible a smartphone is (Wegmann et al. 2018). Lepp et al. (2017) also found boredom and PSU severity correlated. Furthermore, boredom proneness accounted for associations between depressive/anxious symptoms with excessive smartphone and internet use (Elhai et al. 2018a; Wegmann et al. 2018).

One additional relevant contemporary psychopathology construct is rumination. Rumination is an unhealthy coping process of managing emotion by stressing undesirable self-related thoughts, rather than emotion processing (Samtani and Moulds 2017). Rumination correlates with numerous mental disorders (Aldao et al. 2010) and long ago was conceptualized to drive problematic internet use (Davis 2001). Finally, Elhai et al. (2018c) observed a strong relationship between rumination and PSU symptoms after covarying for demographic variables. Billieux et al. (2015b) discussed how interpersonal-related rumination can drive unlocking one's phone to search for push notifications. Rumination represents an unhealthy way to manage emotion (Samtani and Moulds 2017), and should be related PSU (Kardefelt-Winther 2014). In fact, unhealthy coping is a major pathway to problematic technology use (Brand et al. 2019).

In our study, depression and anxiety fall within I-PACE's personal variables that influence PSU. Boredom proneness and rumination are response variables involving cognitive bias and dysfunctional coping, respectively, related to PSU. In fact, these response variables can serve as mediators between personal variables and PSU severity, within the context of I-PACE. In CIUT, boredom proneness and rumination represent negative emotion, and excessive internet use (e.g., PSU) would be aimed at alleviating such negative emotion.

Aims

This study is one of the first examinations of boredom proneness or rumination related to PSU severity. We examined both boredom proneness and rumination as mediators between depression/anxiety symptoms and increased smartphone use frequency/PSU. This topic is essential in understanding why

many people with depression or anxiety symptoms may engage in excessive technology use. While prior studies only investigated this topic in one country (the US) (Elhai et al. 2018c; Elhai et al. 2018a), it is important to assess if findings replicate in other countries, and we therefore conducted our study in China. Processes involved in technology overuse are shown to be different in Asian countries (Montag and Becker 2020; Montag et al. 2016a). People in China primarily use two smartphone apps (Wechat and Alipay) to engage in most everyday activities on their phone, and most Western software applications are blocked there (Montag et al. 2018). Also, China is a collectivist culture emphasizing reciprocal social interactions, which is different than the more typical individualist culture of the West (Lisha et al. 2017).

Hypotheses

Our hypotheses are in part guided by CIUT's conceptualization (Kardefelt-Winther 2014) that negative emotion drives internet overuse (e.g., PSU) to alleviate such emotion. Our hypotheses are especially guided by I-PACE's conceptualization (Brand et al. 2016) of psychopathology variables (e.g., depression and anxiety severity), and affective/cognitive response variables (e.g., boredom proneness and rumination) as risk factors for increased levels of internet use (e.g., smartphone frequency) which in turn can develop into excessive use such as PSU. Our mediation hypotheses fit with I-PACE's conceptualization that affective/cognitive variables account for (or mediate) relations between psychopathology variables and excessive internet use. We posed the following hypotheses, represented in Fig. 1.

H1. Boredom proneness should be positively related to greater smartphone use frequency (H1a) and PSU (H1b).

Boredom involves problems with attentional control (Eastwood et al. 2012). Individuals with greater boredom proneness should have less attention dedicated to significant tasks (e.g., academic study), and instead engage in fun/pleasurable phone usage (Billieux et al. 2015a). Boredom-related variables were previously supported in association with excessive use of technology (Lepp et al. 2017; Skues et al. 2016; Wolniewicz et al. 2020), such as PSU (Lepp et al. 2017).

H2. Rumination should be positively related to smartphone use frequency (H2a) and PSU severity (H2b).

Rumination includes a negative self-thought focus (Samtani and Moulds 2017). Many people ruminate about their interpersonal relationships (Kashdan and Roberts 2007), and engage in frequent phone checking for related notifications (Billieux et al. 2015b). Habit formation (of phone checking) has been found key in developing problematic smartphone use (Oulasvirta et al. 2012).

H3. Boredom proneness would account for (or mediate) the relationship between depression (H3a) and anxiety (H3b) symptoms with increased levels of PSU.

Boredom proneness correlates with depression and anxiety symptoms (Goldberg et al. 2011; Sommers and Vodanovich 2000), and could be a key variable explaining why some depressed/anxious people engage in increased use and PSU (Wolniewicz et al. 2020).

H4. Rumination should account for relations (as a mediator) between severity of depression (H4a), anxiety (H4b), and boredom proneness (H4c) with increased levels of PSU.

Depression and anxiety prospectively relate to boredom proneness and rumination (Samtani and Moulds 2017). Because boredom causes mind-wandering (Eastwood et al. 2012), which should be evident in rumination, rumination should in turn influence PSU severity. In addition, rumination may drive habitual phone checking (Billieux et al. 2015a),

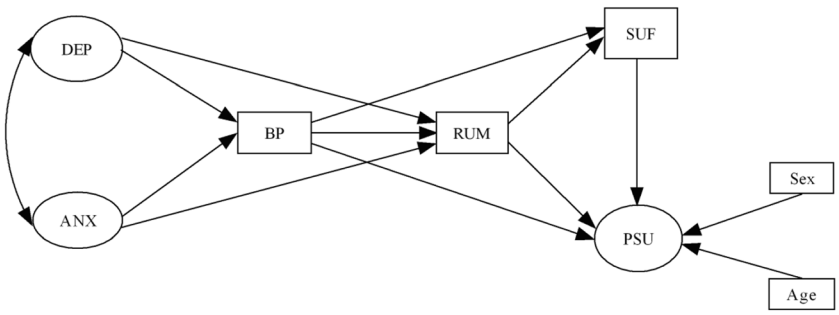

Fig. 1 Hypothesized model of depression and anxiety severity predicting boredom proneness and rumination, and boredom proneness and rumination predicting smartphone use frequency and problematic smartphone use (adjusting for age and gender). PSU = Problematic smartphone use (measured by SAS); SUF = Smartphone use frequency; DEP = Depression; ANX = Anxiety; BP = Boredom proneness; RUM = Rumination. The circles represent latent factors, while squares/rectangles represent observed variables

resulting in automated behavior and leading to PSU (Orbell and Verplanken 2000). Thus, rumination could serve as a mediator between levels of depression, anxiety and boredom proneness with PSU severity.

> H5. Frequency of smartphone use would account for the relationship (or mediate) between both boredom proneness (H5a) and rumination (H5b) severity with increased levels of PSU.

Smartphone use frequency is conceptualized as an intermediary variable between psychopathology and PSU severity (Elhai and Contractor 2018; Kim et al. 2015). And studies support boredom and rumination in increasing the frequency of smartphone use, and habit formation of smartphone checking behavior (Oulasvirta et al. 2012). Such smartphone checking behavior can turn into excessive, PSU for some individuals (Oulasvirta et al. 2012), especially those with low frustration tolerance or distress tolerance (Elhai et al. 2018a).

Method

Participants and Procedure

In April 2019, we conducted a web-based survey at a large Eastern Chinese university. We obtained ethics board approval prior to conducting the project. College psychology faculty assisted in recruiting student subjects through local web-based messaging/social media. Those interested were shown a consent statement, directed to an online survey. We administered all measures in Chinese. 1238 individuals participated. 141 (11.4%) were excluded for inattentive responding, discussed below. In the effective sample of 1097 participants, age ranged from 16 to 25 years, and averaged 19.38 years (SD 1.18). Most (898, 81.9%) were women, with 199 (18.1%) men.

Instruments

We first collected data on age and sex. Next, we administered the following scales online.

Smartphone Addiction Scale-Short Version (SAS-SV)

Kwon et al. (2013) developed the SAS-SV, assessing PSU severity, involving health and interpersonal impairment, tolerance, and withdrawal components. 10 Likert-type items are included ranging from "1 = Strongly disagree" to "6 = Strongly agree." The SAS-SV has been validated against smartphone use frequency and excessive internet use (Lopez-Fernandez 2017). We used the Chinese version (Chen et al. 2017). Our effective sample's coefficient alpha was .89.

Smartphone Use Frequency Scale (SUF)

The SUF (Elhai et al. 2016) has 11 items tapping use of specific smartphone features, with responses ranging from "1 = Never" to "6 = Very often." Activities inquired are: (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. We added educational learning, an item relevant to this population. Internal reliability for the original, English SUF is adequate, correlating with PSU measures (Elhai et al. 2016). We used the Chinese version, recently validated (Elhai et al. 2020b). Coefficient alpha in our sample was .75.

Depression Anxiety Stress Scale-21 (DASS-21)

The DASS-21 (Lovibond and Lovibond 1995) includes 21 items comprising depression, anxiety, and stress symptoms, each with seven-item subscales. Items are rated over the past week, with Likert-type responses range from "0 = Did not apply to me" to "3 = Applied to me very much or most of the time." We utilized the depression and anxiety subscales in analyses. These subscales are reliable (Lovibond and Lovibond 1995), and valid (Antony et al. 1998; Brown et al. 1997). We used the Chinese version (Wang et al. 2016). In our sample, coefficient alphas were .87 (depression) and .84 (anxiety).

Boredom Proneness Scale (BPS)

The BPS (Kass and Vodanovich 1990) is a 28-item measure of boredom proneness, assessing trait boredom. Response options range from "1 = Highly disagree" to "7 = Highly agree." The scale is reliable and valid (Struk et al. 2017). We used the scale's Chinese version (Liu et al. 2014; Li et al. 2016). Coefficient alpha for our sample was .75.

Ruminative Responses Scale (RRS)

The RRS (Nolen-Hoeksema et al. 2008) has 22 items in assessing rumination, rated on a scale from "1 = Almost never" to "4 = Almost always." The RRS is reliable and valid (Nolen-Hoeksema et al. 2008). We used the Chinese scale (Han and Yang 2009). Coefficient alpha was .95.

Analysis

We used R software, version 3.6.2 (R Core Team 2019), using the following R packages: fmsb (internal consistency), careless (inattentive responding), pastecs (descriptive statistics), and apatables (scale intercorrelations). We did not have missing data, as we required responses for all items. Of the initial sample of 1238 subjects, we excluded 141 (11.4%) individuals for inattentive responding (Curran 2016), providing the same numeric response consecutively to many items. For the remaining effective sample ($N = 1097$), we computed scale scores from item responses. Scale scores and age had normal distributions, with the highest skewness value of 1.3 and kurtosis of 2.0.

Next, we conducted separate confirmatory factor analyses (CFA) of our psychological variables, using Mplus 8.3 software. We used weighted least squares estimation and a mean- and variance-adjusted (WLSMV) chi-square, probit loadings and a polychoric correlation matrix for PSU, rumination, depression and anxiety (DiStefano and Morgan 2014). We treated the remaining CFA/measurement models' items as continuously-scaled, with maximum likelihood estimation and robust standard errors (MLR), linear loadings and a Pearson covariance matrix (Bryant and Satorra 2012). One-factor models were each used for PSU (Kwon et al. 2013), SUF (Elhai et al. 2016), anxiety (Wang et al. 2016), depression (Wang et al. 2016), and boredom proneness (Struk et al. 2017). A higher-order factor with three lower-order constructs was used for rumination (Erdur-Baker and Bugay 2010). We assessed fit using the following benchmarks: (a) comparative fit index (CFI) ≥ .95, (b) Tucker-Lewis Index (TLI) ≥ .95, and (c) root mean square error of approximation (RMSEA) ≤ .06, and d) standardized root mean square residual (SRMR) < .08 (Hu and Bentler 1999).

Then, we estimated a structural equation model (see Fig. 1), using WLSMV estimation. We statistically adjusted for paths pointing to levels of PSU with covariates, including age and gender. We tested the structural model for associations among depression/anxiety (predictor variables), boredom proneness and rumination (as mediators), and PSU severity and smartphone use frequency (dependent variables). We also tested alternative specifications of this model, discussed below. The measurement models that we report are for anxiety, depression and PSU. The boredom proneness, rumination and SUF variables were measured as observed scale scores, because of their poor fit from CFA (shown below), and to maintain power given model complexity. When we attempted model testing with latent variables for boredom proneness, rumination and SUF, our models did not converge and resulted in a non-positive definite matrix—likely due to the fully latent model's requirement for a large amount of statistical power.

Next, we used mediation testing to assess boredom proneness in accounting for relations between depression and PSU symptoms (H3a), and between anxiety and PSU symptoms (H3b). We also tested rumination as mediating between depression and PSU (H4a), between anxiety and PSU (H4b), and between boredom proneness and PSU (H4c). We additionally tested SUF as a mediator between the boredom proneness-PSU relationship (H5a), and between rumination and PSU (H5b). These indirect effects were assessed by estimating the cross-product of two direct paths. We used the Delta method to compute mediation effect standard errors, with 1000 non-parametric bootstrapped replications (MacKinnon 2008).

Results

Descriptive Findings

Scale descriptive statistics (mean, SD) and differences across sexes are displayed in Table 1. Females scored higher than males on PSU ($p = .003$) and SUF ($p < .001$). Correlations between primary variables are displayed in Table 2. Except for non-significant correlations between SUF and both depression and boredom proneness, all other variables were significantly intercorrelated.

SEM Results

As indicated above, the SUF measurement model did not fit well, MLR χ^2 (36, $N = 1097$) = 324.872, p < .001, CFI = 0.844, TLI = 0.810, RMSEA = 0.068 (90% CI: 0.061 to 0.075), SRMR = 0.052. Boredom Proneness showed evidence of poor fit, MLR χ^2 (84, N = 1097) = 3583.792, p < .001, CFI = 0.552, TLI = 0.517, RMSEA = 0.092 (90% CI: 0.089 to 0.095), SRMR = 0.121.

The PSU measurement model yielded some evidence of adequate fit, WLSMV χ^2 (62, N = 1097) = 927.237, p < .001, CFI = 0.941, TLI = 0.919, RMSEA = 0.157 (90% CI: 0.149 to 0.166), SRMR = 0.043. The rumination measurement model also yielded some evidence of adequate fit, WLSMV χ^2 (91, N = 1097) = 2742.053, p < .001, CFI = 0.932, TLI = 0.923, RMSEA = 0.106 (90% CI: 0.102 to 0.109), SRMR = 0.048. The depression measurement model resulted in adequate fit, WLSMV χ^2 (28, $N = 1034$) = 91.541, p < .001, CFI = 0.992, TLI = 0.987, RMSEA = 0.071 (90% CI: 0.058 to 0.085), SRMR = 0.022. Additionally, the anxiety measurement model fit well, WLSMV χ^2 (28, N = 1097) = 220.968, p < .001, CFI = 0.971, TLI = 0.956, RMSEA = 0.116 (90% CI: 0.103 to 0.130), SRMR = 0.043 (We should note that RMSEA in these models suggested poor fit, which is expected in models using ordinal data; Shi et al. 2020).

Table 1 Means, and standard deviations for the primary variables, and differences across sexes

	Sample M	SD	Male M	SD	Female M	SD	F(1097)	p
PSU	37.36	9.54	35.54	10.28	37.77	9.33	8.96	.003
SUF	49.88	7.72	47.66	8.72	50.37	7.39	20.49	<0.001
DEP	4.10	4.07	5.42	4.68	3.80	3.87	26.35	<0.001
ANX	5.12	3.99	6.02	4.25	4.92	3.91	12.40	<0.001
BP	107.48	13.03	109.51	13.26	107.03	12.95	5.91	.015
RUM	45.90	11.94	47.99	12.47	45.44	11.78	7.46	.006

PSU Problematic smartphone use (measured by SAS), *SUF* Smartphone use frequency, *DEP* Depression, *ANX* Anxiety, *BP* Boredom proneness, *RUM* Rumination, *M* Mean, *SD* Standard deviation

Thus, except for boredom proneness and SUF, the remaining measurement models had some evidence of adequate fit, so we used those latent measurement models in SEM, while modeling boredom proneness and SUF as observed variables. However, our models did not converge until additionally treating rumination as a summed observed variable.

We tested Fig. 1's model, which fit reasonably well based on most indices, WLSMV χ^2 (137, N = 1097) = 1918.915, p < .001, CFI = 0.952, TLI = 0.947, RMSEA = 0.062 (90% CI: 0.059 to 0.065), SRMR = 0.094. Figure 2 displays standardized parameter estimates. Boredom proneness was significantly inversely associated with SUF, β = −0.091, $p = 0.007$ (rejecting H1a), but was positively associated with PSU severity, β = 0.406, $p < 0.001$ (supporting H1b). Rumination had significant associations with SUF, β = 0.149, p < 0.001, and PSU severity, β = 0.197, p < 0.001 (supporting H2). PSU severity was significantly associated with sex, β = 0.240, $p = 0.006$, but not with age, β = 0.026, $p = 0.352$.

Mediation Results

Table 3 demonstrates mediation testing results. Boredom proneness mediated relations between depression and PSU severity, β = 0.287, SE = 0.094, z = 3.062, $p = 0.002$ (supporting H3a), but not between anxiety and PSU severity, β = −0.031, SE = 0.095, z = −0.329, $p = 0.742$ (rejecting H3b). Rumination mediated relations between anxiety and PSU severity, β = 0.159, SE = 0.058, z = 2.747, p = 0.006 (supporting H4b), but not between depression and PSU severity, β = −0.016, SE = 0.042, z = −0.386, $p = 0.699$ (rejecting H4a), nor between boredom proneness and PSU severity, β = −0.017, SE = 0.015, z = −1.174, $p = 0.240$ (rejecting H4c). SUF inversely mediated relations between boredom proneness and PSU severity, β = −0.024, SE = 0.010, z = −2.409, $p = 0.016$ (rejecting H5a), but positively mediated relations between rumination and PSU severity, β = 0.039, SE = 0.011, z = 3.639, p < 0.001 (supporting H5b).

Table 2 Correlations among the Primary Study Variables' Scale Scores

Variable	1	2	3	4	5	6
1. PSU	–					
2. SUF	.27**	–				
3. DEP	.31**	.00	–			
4. ANX	.34**	.06*	.81**	–		
5. BP	.37**	−.03	.50**	.44**	–	
6. RUM	.26**	.10**	.57**	.58**	.44**	–

PSU Problematic smartphone use (measured by SAS), *SUF* Smartphone use frequency, *DEP* Depression, *ANX* Anxiety, *BP* Boredom proneness, *RUM* Rumination. * $p < .05$. ** p < .01

Discussion

We augmented findings from traditional studies on PSU focusing primarily on depression and anxiety (Elhai et al. 2017; Wolniewicz et al. 2018), by examining other mental health constructs as mediating variables between depression/anxiety with PSU severity. Specifically, we examined boredom proneness and rumination as mediating variables. We used a Chinese sample of students, because prior relevant studies were only conducted in Western countries (the US) (Elhai et al. 2018c; Elhai et al. 2018a). Despite primary use of different social networking apps in China (Montag et al. 2018), and a collectivist culture (Lisha et al. 2017), prior U.S. findings replicated well in the present Chinese sample.

We first found that boredom proneness was inversely correlated with frequency of smartphone use, thus rejecting H1a (which hypothesized a positive association). This finding is different from previous studies in which boredom-related variables associated positively with technology use frequency (Aleksandar et al. 2015; Oulasvirta et al. 2012; Martin et al. 2015). In our study, all participants were college students, perhaps often feeling bored and unable to adequately use their phones during their university classes (Bolkan and Griffin 2017). Therefore, greater boredom proneness perhaps caused

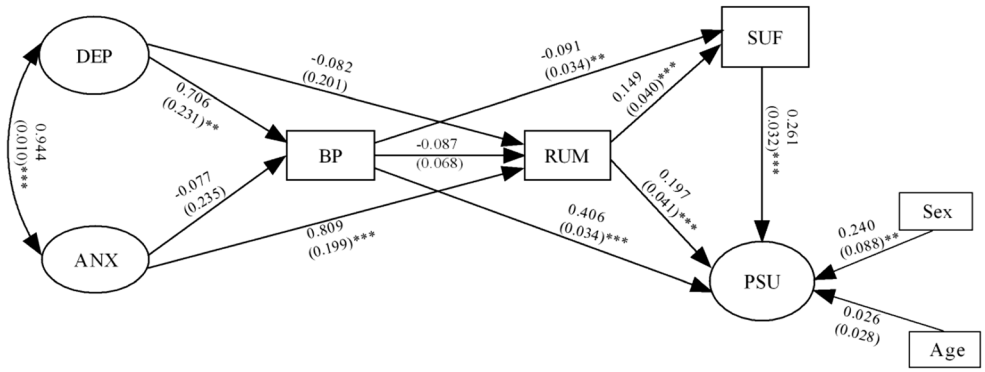

Fig. 2 Structural model of depression and anxiety severity predicting boredom proneness and rumination, and boredom proneness and rumination predicting smartphone use frequency and problematic smartphone use (adjusting for age and gender), with standardized path coefficients and SEs (in parentheses). PSU = Problematic smartphone use; SUF = Smartphone use frequency; DEP = Depression; ANX = Anxiety; BP = Boredom proneness; RUM = Rumination. Circles represent latent factors, while squares represent observed variables. *$p < .05$, **$p < .01$, ***$p < .001$

decreased frequency of smartphone use. However, boredom proneness was positively correlated with PSU severity, supporting H1b. This finding is consistent with CIUT (Kardefelt-Winther 2014), in which negative emotion (such as boredom proneness) drives internet overuse (Lepp et al. 2017).

Rumination positively related to both frequency of smartphone use and PSU severity (supporting H2), consistent with I-PACE in conceptualizing maladaptive coping styles as driving excessive internet use (Brand et al. 2016). That is, rumination, representing a maladaptive cognitive coping response variable in I-PACE, can lead an individual to use specific types of internet features (e.g., smartphone), which for some people can grow into PSU. Findings also fit with CIUT (Kardefelt-Winther 2014) in proposing PSU as a strategy to relieve undesirable emotion. This finding in line with prior work on rumination related to PSU severity (Elhai et al. 2018a, b, c).

We also found that boredom proneness mediated relations between severity of depression and PSU, supporting H3a. CIUT (Kardefelt-Winther 2014) can explain the occurrence that many people with depressive symptoms relieve emotion through PSU (Elhai et al. 2018b; Wolniewicz et al. 2020). However, we should note that many people living with depression can function well despite their condition (Karsten et al. 2013; Naicker et al. 2013). In our study, depression was associated with boredom proneness, which in turn was related to PSU severity (H1). This finding is consistent with previous studies (Sommers and Vodanovich 2000; Struk et al. 2017; Lepp et al. 2017). Boredom proneness may be important in understanding how some people with depressive disorders engage in PSU (Elhai et al. 2018a) – perhaps serving as a mechanism because of boredom-related attentional deficits (Skues et al. 2015; Wolniewicz et al. 2020).

Table 3 Mediation results, with standardized estimates displayed

Indirect	β	SE	z	P
Depression- > BP- > PSU	0.287	0.094	3.062	0.002
Depression- > RUM- > PSU	−0.016	0.042	−0.386	0.699
Anxiety- > BP- > PSU	−0.031	0.095	−0.329	0.742
Anxiety- > RUM- > PSU	0.159	0.058	2.747	0.006
BP- > RUM- > PSU	−0.017	0.015	−1.174	0.240
BP- > SUF- > PSU	−0.024	0.010	−2.409	0.016
RUM- > SUF- > PSU	0.039	0.011	3.639	0.000

PSU Problematic smartphone use (measured by SAS), *SUF* Smartphone use frequency, *DEP* Depression, *ANX* Anxiety, *BP* Boredom proneness, *RUM* Rumination

Furthermore, in the present study rumination mediated associations between anxiety and PSU severity, supporting H4b. This mediation finding is consistent with I-PACE in theorizing response variables such as rumination in an intermediate role between personal factors and PSU severity (Brand et al. 2016). In our SEM analyses, anxiety associated with rumination, which in turn related to PSU severity (H2). Rumination may drive some individuals – especially those predisposed to anxiety disorders – to engage in PSU through excessive online social communication with significant others and loved ones, aiming to obtain reassurance and self-worth (Billieux et al. 2015a; Elhai et al. 2020c). Therefore, rumination may be important in explaining why some anxious individuals overuse their smartphones.

We also found that smartphone use frequency inversely mediated the relations between boredom proneness and PSU severity (H5a). However, smartphone use frequency mediated relations between rumination and PSU severity, supporting H5b. This result supports greater smartphone use as mediating between mental health symptoms and PSU (Elhai and Contractor 2018; Van Deursen et al. 2015).

We found a female gender-PSU severity association, consistent with prior work (De-Sola Gutierrez et al. 2016; Wang et al. 2015). We did not find an age-PSU relationship,

inconsistent with some prior work (Van Deursen et al. 2015; Luk et al. 2018), but unsurprising given the limited age range in our student sample.

The present study has implications for the scientific study of PSU. First, studying negative affectivity-related psychopathology constructs (such as boredom proneness and rumination), may be helpful in understanding the phenomenology of PSU. Additionally, boredom and rumination involve inability to regulate emotion. Mindfulness interventions are effective ways of helping people regulate emotion, and may have the potential to offset some severity of PSU experienced by smartphone users (Van Dam et al. 2018).

Limitations include the use of university students from China, limiting generalizability. Furthermore, we cannot infer causality based on our cross-sectional data. Additionally, we assessed smartphone use through self-report, while objective measurement would be more accurate (Lin et al. 2015; Montag et al. 2015; Rozgonjuk et al. 2018a, b). Beyond that, we mention that PSU could be seen as mobile form of problematic Internet use or Internet Use Disorder (Montag et al. in press) and it is unlikely that the device itself is the culprit explaining overuse. As with alcoholics who are not dependent on bottles, but rather are dependent on alcohol (Panova and Carbonell 2018), in particular social media and (Freemium-) game apps might be among the key-apps resulting in smartphone overuse (Leung et al. 2020; Sha et al. 2019; Montag et al. 2019a, b; Elhai et al. 2020d).

Finally, we used standardized scales measuring depression and anxiety, rather than using structured diagnostic interviews for such mental disorders which would have greater accuracy. Nonetheless, our results are important in explaining the possible mechanisms behind why some depressed or anxious individuals excessively engage in smartphone use. Boredom proneness and rumination may represent such mechanisms. Future research could examine how other negative affectivity-related psychopathology constructs relate to excessive smartphone, internet and social media use.

Data Availability The dataset generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Compliance with Ethical Standards

Conflict of Interest The authors report no conflicts of interest with this paper's study.

Outside the scope of the present paper, Dr. Elhai notes that he receives royalties for several books published on posttraumatic stress disorder (PTSD); is a paid, full-time faculty member at University of Toledo; is a paid, visiting scientist at Tianjin Normal University; occasionally serves as a paid, expert witness on PTSD legal cases; and receives grant research funding from the U.S. National Institutes of Health and Department of Defense. Dr. Montag mentions that he has received (to Ulm University and earlier University of Bonn) grants from agencies such as the German Research Foundation (DFG). Dr. Montag has performed grant reviews for several agencies; has edited journal sections and articles; has given academic lectures in clinical or scientific venues or companies; and has generated books or book chapters for publishers of mental health texts. For some of these activities he received royalties, but never from the gaming or social media industry. Dr. Montag mentions that he is currently part of a discussion circle (Digitalität und Verantwortung: https://about.fb.com/de/news/h/gespraechskreis-digitalitaet-und-verantwortung/) debating ethical questions linked to social media, digitalization and society/democracy at Facebook. In this context, he receives no salary for his activities. Finally, he mentions that he currently functions as independent scientist on the scientific advisory board of the Nymphenburg group. This activity is financially compensated.

References

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review, 30*(2), 217–237. https://doi.org/10.1016/j.cpr.2009.11.004.

Aleksandar, M., Martin, P., and Nuria, O. (2015). Boredom-computer interaction: Boredom proneness and the use of smartphone. In Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15). Association for Computing Machinery, New York, 837–841. https://doi.org/10.1145/2750858.2807530.

Antony, M. M., Bieling, P. J., Cox, B. J., Enns, M. W., & Swinson, R. P. (1998). Psychometric properties of the 42-item and 21-item versions of the depression anxiety stress scales in clinical groups and a community sample. *Psychological Assessment, 10*(2), 176–181. https://doi.org/10.1037/1040-3590.10.2.176.

Bianchi, A., & Phillips, J. G. (2005). Psychological predictors of problem mobile phone use. *Cyberpsychology & Behavior, 8*(1), 39–51. https://doi.org/10.1089/cpb.2005.8.39.

Billieux, J., Van der, L. M., & Rochat, L. (2008). The role of impulsivity in actual and problematic use of the mobile phone. *Applied Cognitive Psychology, 22*(9), 1195–1210. https://doi.org/10.1002/acp.1429.

Billieux, J., Maurage, P., Lopez-Fernandez, O., Kuss, D. J., & Griffiths, M. D. (2015a). Can disordered mobile phone use be considered a behavioral addiction? An update on current evidence and a comprehensive model for future research. *Current Addiction Reports, 2*(2), 156–162. https://doi.org/10.1007/s40429-015-0054-y.

Billieux, J., Philippot, P., Schmid, C., Maurage, P., De Mol, J., & Van der Linden, M. (2015b). Is dysfunctional use of the mobile phone a behavioural addiction? Confronting symptom-based versus process-based approaches. *Clinical Psychology & Psychotherapy, 22*(5), 460–468. https://doi.org/10.1002/cpp.1910.

Billieux, J., Schimmenti, A., Khazaal, Y., Maurage, P., & Heeren, A. (2015c). Are we overpathologizing everyday life? A tenable blueprint for behavioral addiction research. *Journal of Behavioral Addictions, 4*(3), 119–123.

Bolkan, S., & Griffin, D. J. (2017). Students' use of cell phones in class for off-task behaviors: The indirect impact of instructors' teaching behaviors through boredom and students' attitudes. *Communication Education, 66*(3), 313–329.

Brand, M., Young, K. S., Laier, C., Wolfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific internet-use disorders: An interaction of person-affect-cognition-execution (I-PACE) model. *Neuroscience and Biobehavioral Reviews, 71*, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033.

Brand, M., Wegmann, E., Stark, R., Muller, A., Wolfling, K., Robbins, T. W., & Potenza, M. N. (2019). The interaction of person-affect-

cognition-execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internetuse disorders, and specification of the process character of addictive behaviors. *Neuroscience and Biobehavioral Reviews, 104*, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032.

Brown, T. A., Chorpita, B. F., Korotitsch, W., & Barlow, D. H. (1997). Psychometric properties of the depression anxiety stress scales (DASS) in clinical samples. *Behaviour Research and Therapy, 35*(1), 79–89. https://doi.org/10.1016/S0005-7967(96)00068-X.

Bryant, F. B., & Satorra, A. (2012). Principles and practice of scaled difference chi-square testing. *Structural Equation Modeling: A Multidisciplinary Journal, 19*, 372–398. https://doi.org/10.1080/10705511.2012.687671.

Carbonell, X., Chamarro, A., Oberst, U., Rodrigo, B., & Prades, M. (2018). Problematic use of the internet and smartphones in university students: 2006-2017. *International Journal of Environmental Research and Public Health, 15*(3). https://doi.org/10.3390/ijerph15030475.

Chen, B., Liu, F., Ding, S., Ying, X., Wang, L., & Wen, Y. (2017). Gender differences in factors associated with smartphone addiction: A cross-sectional study among medical college students. *BMC Psychiatry, 17*(1), 341. https://doi.org/10.1186/s12888-017-1503-z.

Curran, P. G. (2016). Methods for the detection of carelessly invalid responses in survey data. *Journal of Experimental Social Psychology, 66*, 4–19. https://doi.org/10.1016/j.jesp.2015.07.006.

Davis, R. A. (2001). A cognitive-behavioral model of pathological internet use. *Computers in Human Behavior, 17*(2), 187–195. https://doi.org/10.1016/S0747-5632(00)00041-8.

De-Sola Gutierrez, J., Rodriguez de Fonseca, F., & Rubio, G. (2016). Cell-phone addiction: A review. *Frontiers in Psychology, 7*, 175. https://doi.org/10.3389/fpsyt.2016.00175.

DiStefano, C., & Morgan, G. B. (2014). A comparison of diagonal weighted least squares robust estimation techniques for ordinal data. *Structural Equation Modeling: A Multidisciplinary Journal, 21*(3), 1–14. https://doi.org/10.1080/10705511.2014.915373.

Duke, É., & Montag, C. (2017). Smartphone addiction, daily interruptions and self-reported productivity. *Addictive Behaviors Reports, 6*, 90–95.

Eastwood, J. D., Frischen, A., Fenske, M. J., & Smilek, D. (2012). The unengaged mind: Defining boredom in terms of attention. *Perspectives on Psychological Science, 7*(5), 482–495. https://doi.org/10.1177/1745691612456044.

Elhai, J. D., & Contractor, A. A. (2018). Examining latent classes of smartphone users: Relations with psychopathology and problematic smartphone use. *Computers in Human Behavior, 82*, 159–166. https://doi.org/10.1016/j.chb.2018.01.010.

Elhai, J. D., Levine, J. C., Dvorak, R. D., & Hall, B. J. (2016). Fear of missing out, need for touch, anxiety and depression are related to problematic smartphone use. *Computers in Human Behavior, 63*, 509–516. https://doi.org/10.1016/j.chb.2016.05.079.

Elhai, J. D., Levine, J. C., Dvorak, R. D., & Hall, B. J. (2017). Problematic smartphone use: A conceptual overview and systematic review of relations with anxiety and depression psychopathology. *Journal of Affective Disorders, 207*, 251–259. https://doi.org/10.1016/j.jad.2016.08.030.

Elhai, J. D., Vasquez, J. K., Lustgarten, S. D., Levine, J. C., & Hall, B. J. (2018a). Proneness to boredom mediates relationships between problematic smartphone use with depression and anxiety severity. *Social Science Computer Review, 36*(6), 707–720. https://doi.org/10.1177/0894439317741087.

Elhai, J. D., Levine, J. C., O'Brien, K. D., & Armour, C. (2018b). Distress tolerance and mindfulness mediate relations between depression and anxiety sensitivity with problematic smartphone use. *Computers in Human Behavior, 84*, 477–484. https://doi.org/10.1016/j.chb.2018.03.026.

Elhai, J. D., Tiamiyu, M. F., & Weeks, J. W. (2018c). Depression and social anxiety in relation to problematic smartphone use: The prominent role of rumination. *Internet Research, 28*(2), 315–332. https://doi.org/10.1108/IntR-01-2017-0019.

Elhai, J. D., Yang, H., & Montag, C. (2019a). Cognitive- and emotion-related dysfunctional coping processes: Transdiagnostic mechanisms explaining depression and anxiety's relations with problematic smartphone use. *Current Addiction Reports, 6*, 410–417. https://doi.org/10.1007/s40429-019-00260-4.

Elhai, J. D., Levine, J. C., & Hall, B. J. (2019b). The relationship between anxiety symptom severity and problematic smartphone use: A review of the literature and conceptual frameworks. *Journal of Anxiety Disorders, 62*, 45–52. https://doi.org/10.1016/j.janxdis.2018.11.005.

Elhai, J. D., Gallinari, E. F., Rozgonjuk, D., & Yang, H. (2020a). Depression, anxiety and fear of missing out as correlates of social, non-social and problematic smartphone use. Addictive Behaviors, 106335.

Elhai, J. D., Yang, H., Fang, J., Bai, Y., & Hall, B. J. (2020b). Depression and anxiety symptoms are related to problematic smartphone use severity in Chinese young adults: Fear of missing out as a mediator. *Addictive Behaviors, 101*, 105962. https://doi.org/10.1016/j.addbeh.2019.04.020.

Elhai, J. D., Yang, H., Dempsey, A. E., & Montag, C. (2020c). Rumination and negative smartphone use expectancies are associated with greater levels of problematic smartphone use: A latent class analysis. *Psychiatry Research, 285*, 112845. https://doi.org/10.1016/j.psychres.2020.112845.

Elhai, J. D., Yang, H., Rozgonjuk, D., & Montag, C. (2020d). Using machine learning to model problematic smartphone use severity: The significant role of fear of missing out. *Addictive Behaviors, 103*, 106261.

Erdur-Baker, Ö., & Bugay, A. (2010). The short version of ruminative response scale: Reliability, validity and its relation to psychological symptoms. *Procedia-Social and Behavioral Sciences, 5*, 2178–2181. https://doi.org/10.1016/j.sbspro.2010.07.433.

Goldberg, Y. K., Eastwood, J. D., Laguardia, J., & Danckert, J. (2011). Boredom: An emotional experience distinct from apathy, anhedonia, or depression. *Journal of Social and Clinical Psychology, 30*(6), 647–666. https://doi.org/10.1521/jscp.2011.30.6.647.

Han, X., & Yang, H. F. (2009). Chinese version of Nolen-Hoeksema ruminative responses scale (RRS) used in 912 college students: Reliability and validity. *Chinese Journal of Clinical Psychology, 17*(5), 550–551.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118.

Kardefelt-Winther, D. (2014). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior, 31*, 351–354. https://doi.org/10.1016/j.chb.2013.10.059.

Karsten, J., Penninx, B. W., Verboom, C. E., Nolen, W. A., & Hartman, C. A. (2013). Course and risk factors of functional impairment in subthreshold depression and anxiety. *Depression and Anxiety, 30*(4), 386–394. https://doi.org/10.1002/da.22021.

Kashdan, T. B., & Roberts, J. E. (2007). Social anxiety, depressive symptoms, and post-event rumination: Affective consequences and social contextual influences. *Journal of Anxiety Disorders, 21*(3), 284–301.

Kass, S. J., & Vodanovich, S. J. (1990). Boredom proneness: Its relationship to type a behavior pattern and sensation seeking. *Psychology: A Journal of Human Behavior, 27*(3), 7–16.

Kim, J., Seo, M., & David, P. (2015). Alleviating depression only to become problematic mobile phone users: Can face-to-face

communication be the antidote? *Computers in Human Behavior, 51*, 440–447. https://doi.org/10.1016/j.chb.2015.05.030.

Kwon, M., Kim, D. J., Cho, H., & Yang, S. (2013). The smartphone addiction scale: Development and validation of a short version for adolescents. *PLoS One, 8*(12), e83558. https://doi.org/10.1371/journal.pone.0083558.

Lachmann, B., Duke, É., Sariyska, R., & Montag, C. (2019). Who's addicted to the smartphone and/or the internet? *Psychology of Popular Media Culture, 8*(3), 182–189. https://doi.org/10.1037/ppm0000172.

Lemenager, T., Hoffmann, S., Dieter, J., Reinhard, I., Mann, K., & Kiefer, F. (2018). The links between healthy, problematic, and addicted internet use regarding comorbidities and self-concept-related characteristics. *Journal of Behavioral Addictions, 7*(1), 31–43. https://doi.org/10.1556/2006.7.2018.13.

Lepp, A., Barkley, J. E., & Li, J. (2017). Motivations and experiential outcomes associated with leisure time cell phone use: Results from two independent studies. *Leisure Sciences, 39*(2), 144–162. https://doi.org/10.1080/01490400.2016.1160807.

Leung, H., Pakpour, A. H., Strong, C., Lin, Y. C., Tsai, M. C., Griffiths, M. D., ... & Chen, I. H. (2020). Measurement invariance across young adults from Hong Kong and Taiwan among three internet-related addiction scales: Bergen social media addiction scale (BSMAS), smartphone application-based addiction scale (SABAS), and internet gaming disorder scale-short form (IGDS-SF9) (study part A). *Addictive Behaviors, 101*, 105969.

Li, X., Xin, T., Shang, W., Liu, Y., Du, Y., Lu, L., & Li, B. (2016). The trial version of the boredom proneness scale in the college students. *Chinese Journal of Clinical Psychology, 06*, 71–75.

Lin, Y. H., Lin, Y. C., Lee, Y. H., Lin, P. H., Lin, S. H., Chang, L. R., Tseng, H. W., Yen, L. Y., Yang, C. C. H., & Kuo, T. B. (2015). Time distortion associated with smartphone addiction: Identifying smartphone addiction via a mobile application (App). *Journal of Psychiatric Research, 65*, 139–145.

Lisha, C., Goh, C. F., Yifan, S., & Rasli, A. (2017). Integrating guanxi into technology acceptance: An empirical investigation of WeChat. *Telematics and Informatics, 34*(7), 1125–1142. https://doi.org/10.1016/j.tele.2017.05.003.

Liu, Y., Chen, J. Z., Song, L. T., Zhao, Y., Yang, X. L., Zhang, P., & Zhou, H. (2014). Reliability and validity of Chinese version of boredom proneness scale. *Chinese Journal of Clinical Psychology, 1*(17).

Long, J., Liu, T. Q., Liao, Y. H., Qi, C., He, H. Y., Chen, S. B., & Billieux, J. (2016). Prevalence and correlates of problematic smartphone use in a large random sample of Chinese undergraduates. *BMC Psychiatry, 16*, 408. https://doi.org/10.1186/s12888-016-1083-3.

Lopez-Fernandez, O. (2017). Short version of the smartphone addiction scale adapted to Spanish and French: Towards a cross-cultural research in problematic mobile phone use. *Addictive Behaviors, 64*, 275–280. https://doi.org/10.1016/j.addbeh.2015.11.013.

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the depression anxiety stress scales (DASS) with the Beck depression and anxiety inventories. *Behaviour Research and Therapy, 33*(3), 335–343. https://doi.org/10.1016/0005-7967(94)00075-U.

Luk, T. T., Wang, M. P., Shen, C., Wan, A., Chau, P. H., Oliffe, J., Viswanath, K., Chan, S. S., & Lam, T. H. (2018). Short version of the smartphone addiction scale in Chinese adults: Psychometric properties, sociodemographic, and health behavioral correlates. *Journal of Behavioral Addictions, 7*(4), 1157–1165. https://doi.org/10.1556/2006.7.2018.105.

MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis*. New York: Routledge Academic.

Martin, P., Tilman, D., Jose, S. P., & Nuria, O. (2015). *When attention is not scarce - detecting boredom from mobile phone usage* (pp. 825–836). New York: Association for Computing Machinery. https://doi.org/10.1145/2750858.2804252.

Mercer, K., & Eastwood, J. (2010). Is boredom associated with problem gambling behaviour? It depends on what you mean by 'boredom'. *International Gambling Studies, 10*, 91–104. https://doi.org/10.1080/14459791003754414.

Montag, C., & Becker, B. (2020). Internet and smartphone use disorder in Asia. *Addictive Behaviors,* 106380.

Montag, C., & Walla, P. (2016). Carpe diem instead of losing your social mind: Beyond digital addiction and why we all suffer from digital overuse. *Cogent Psychology, 3*(1), 1157281.

Montag, C., Błaszkiewicz, K., Lachmann, B., Sariyska, R., Andone, I., Trendafilov, B., & Markowetz, A. (2015). Recorded behavior as a valuable resource for diagnostics in mobile phone addiction: Evidence from psychoinformatics. *Behavioral Science, 5*(4), 434–442.

Montag, C., Duke, É., Sha, P., Zhou, M., Sindermann, C., & Li, M. (2016a). Does acceptance of power distance influence propensities for problematic internet use? Evidence from a cross-cultural study. *Asia-Pacific Psychiatry, 8*(4), 296–301.

Montag, C., Sindermann, C., Becker, B., & Panksepp, J. (2016b). An affective neuroscience framework for the molecular study of internet addiction. *Frontiers in Psychology, 7*, 1906.

Montag, C., Becker, B., & Gan, C. (2018). The multipurpose application WeChat: A review on recent research. *Frontiers in Psychology, 9*, 2247. https://doi.org/10.3389/fpsyg.2018.02247.

Montag, C., Lachmann, B., Herrlich, M., & Zweig, K. (2019a). Addictive features of social media/messenger platforms and freemium games against the background of psychological and economic theories. *International Journal of Environmental Research and Public Health, 16*(14), 2612.

Montag, C., Wegmann, E., Sariyska, R., Demetrovics, Z., & Brand, M. (2019b). How to overcome taxonomical problems in the study of internet use disorders and what to do with "smartphone addiction". *Journal of Behavioral Addictions*, 1–7.

Montag, C., Wegmann, E., Sariyska, R., Demetrovics, Z., & Brand, M. (2020). How to overcome taxonomical problems in the study of internet use disorders and what to do with "smartphone addiction"? *Journal of Behavioral Addictions*.

Naicker, K., Galambos, N. L., Zeng, Y., Senthilselvan, A., & Colman, I. (2013). Social, demographic, and health outcomes in the 10 years following adolescent depression. *Journal of Adolescent Health, 52*(5), 533–538. https://doi.org/10.1016/j.jadohealth.2012.12.016.

Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science, 3*(5), 400–424. https://doi.org/10.1111/j.1745-6924.2008.00088.x.

Oberst, U., Wegmann, E., Stodt, B., Brand, M., & Chamarro, A. (2017). Negative consequences from heavy social networking in adolescents: The mediating role of fear of missing out. *Journal of Adolescence, 55*, 51–60. https://doi.org/10.1016/j.adolescence.2016.12.008.

Orbell, S., & Verplanken, B. (2000). The automatic component of habit in health behavior: Habit as a cue-contingent automaticity. *Health Psychology, 29*(4), 374–383.

Oulasvirta, A., Rattenbury, T., Ma, L., & Raita, E. (2012). Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing, 16*(1), 105–114.

Panova, T., & Carbonell, X. (2018). Is smartphone addiction really an addiction? *Journal of Behavioral Addictions, 7*(2), 252–259.

Peterka-Bonetta, J., Sindermann, C., Elhai, J. D., & Montag, C. (2019). Personality associations with smartphone and internet use disorder: A comparison study including links to impulsivity and social anxiety. *Frontiers in Public Health, 7*.

R Core Team (2019). R: A language and environment for statistical computing. Retrieved from https://www.R-project.org/.

Rozgonjuk, D., Levine, J. C., Hall, B. J., & Elhai, J. D. (2018a). The association between problematic smartphone use, depression and anxiety symptom severity, and objectively measured smartphone use over one week. *Computers in Human Behavior, 87*, 10–17. https://doi.org/10.1016/j.chb.2018.05.019.

Rozgonjuk, D., Saal, K., & Täht, K. (2018b). Problematic smartphone use, deep and surface approaches to learning, and social media use in lectures. *International Journal of Environmental Research and Public Health, 15*(1), 92.

Samtani, S., & Moulds, M. L. (2017). Assessing maladaptive repetitive thought in clinical disorders: A critical review of existing measures. *Clinical Psychology Review, 53*, 14–28. https://doi.org/10.1016/j.cpr.2017.01.007.

Sha, P., Sariyska, R., Riedl, R., Lachmann, B., & Montag, C. (2019). Linking internet communication and smartphone use disorder by taking a closer look at the Facebook and WhatsApp applications. *Addictive Behaviors Reports, 9*, 100148.

Shi, D., Maydeu-Olivares, A., & Rosseel, Y. (2020). Assessing fit in ordinal factor analysis models: SRMR vs. *RMSEA. Structural Equation Modeling, 27*(1), 1–15. https://doi.org/10.1080/10705511.2019.1611434.

Skues, J., Williams, B., Oldmeadow, J., & Wise, L. (2015). The effects of boredom, loneliness, and distress tolerance on problem internet use Among University students. *International Journal of Mental Health and Addiction, 14*. https://doi.org/10.1007/s11469-015-9568-8.

Skues, J., Williams, B., Oldmeadow, J., & Wise, L. (2016). The effects of boredom, loneliness, and distress tolerance on problem internet use among university students. *International Journal of Mental Health and Addiction, 14*, 167–180. https://doi.org/10.1007/s11469-015-9568-8.

Sohn, S., Rees, P., Wildridge, B., Nicola, J. K., & Ben, C. (2019). Prevalence of problematic smartphone usage and associated mental health outcomes amongst children and young people: A systematic review, meta-analysis and GRADE of the evidence. *BMC Psychiatry, 19*, 356. https://doi.org/10.1186/s12888-019-2350-x.

Sommers, J., & Vodanovich, S. J. (2000). Boredom proneness: Its relationship to psychological- and physical-health symptoms. *Journal of Clinical Psychology, 56*(1), 149–155.

Struk, A. A., Carriere, J. S. A., Cheyne, J. A., & Danckert, J. (2017). A short boredom proneness scale: Development and psychometric properties. *Assessment, 24*(3), 346–359. https://doi.org/10.1177/1073191115609996.

Thomée, S. (2018). Mobile phone use and mental health: A review of the research that takes a psychological perspective on exposure. *International Journal of Environmental Research and Public Health, 15*(12), 2692. https://doi.org/10.3390/ijerph15122692.

Van Dam, N. T., van Vugt, M. K., Vago, D., Schmalzl, L., Saron, C. D., Olendzki, A., et al. (2018). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science, 13*(1), 36–61. https://doi.org/10.1177/1745691617709589.

Van Deursen, A. J., Bolle, C. L., Hegner, S. M., & Kommers, P. A. (2015). Modeling habitual and addictive smartphone behavior: The role of smartphone usage types, emotional intelligence, social stress, self-regulation, age, and gender. *Computers in Human Behavior, 45*, 411–420. https://doi.org/10.1016/j.chb.2014.12.039.

Wang, J. L., Wang, H. Z., Gaskin, J., & Wang, L. H. (2015). The role of stress and motivation in problematic smartphone use among college students. *Computers in Human Behavior, 53*, 181–188. https://doi.org/10.1016/j.chb.2015.07.005.

Wang, K., Shi, H. S., Geng, F. L., Zou, L. Q., Tan, S. P., Wang, Y., Neumann, D. L., Shum, D. H. K., & Chan, R. C. (2016). Cross-cultural validation of the depression anxiety stress scale-21 in China. *Psychological Assessment, 28*(5), 88–100. https://doi.org/10.1037/pas0000207.

Wegmann, E., Oberst, U., Stodt, B., & Brand, M. (2017). Online-specific fear of missing out and internet-use expectancies contribute to symptoms of internet-communication disorder. *Addictive Behaviors Reports, 5*, 33–42. https://doi.org/10.1016/j.abrep.2017.04.001.

Wegmann, E., Ostendorf, S., & Brand, M. (2018). Is it beneficial to use internet-communication for escaping from boredom? Boredom proneness interacts with cue-induced craving and avoidance expectancies in explaining symptoms of internet-communication disorder. *PLoS One, 13*(4), e0195742. https://doi.org/10.1371/journal.pone.0195742.

Wolniewicz, C. A., Tiamiyu, M. F., Weeks, J. W., & Elhai, J. D. (2018). Problematic smartphone use and relations with negative affect, fear of missing out, and fear of negative and positive evaluation. *Psychiatry Research, 262*, 618–623. https://doi.org/10.1016/j.psychres.2017.09.058.

Wolniewicz, C. A., Rozgonjuk, D., & Elhai, J. D. (2020). Boredom proneness and fear of missing out mediate relations between depression and anxiety with problematic smartphone use. *Human Behavior and Emerging Technologies, 2*(1), 61–70.