Current Psychology (2021) 40:3246–3255
https://doi.org/10.1007/s12144-019-00271-4

Emotion regulation in relation to smartphone use: Process smartphone use mediates the association between expressive suppression and problematic smartphone use

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Published online: 18 April 2019

Abstract
Previous research has shown that problematic smartphone use (PSU) is related to several affect-related psychopathology variables. Emotion dysregulation has been regarded as a central psychological factor associated with that type of psychopathology. In this paper, the association between expressive emotional suppression, a form of emotion dysregulation, with PSU was investigated. Furthermore, we tested if types of smartphone use (process and social use) mediated that association. Three hundred American college students participated in a web-based survey that included the Smartphone Addiction Scale (for problematic smartphone use), Emotion Regulation Questionnaire (assessing suppression), and Process vs. Social Smartphone Usage scale. We found that expressive suppression was correlated with both process smartphone use and PSU severity. Mediation analysis showed that process smartphone use completely mediated relations between suppression and PSU severity. The findings suggest that dysfunctional emotion regulation could lead to more process smartphone use that, in turn, may manifest in PSU severity. Contributions and limitations of the study are discussed.

Keywords Problematic smartphone use · Smartphone addiction · Smartphone use disorder · Emotion regulation · Expressive suppression · Suppression

Introduction

History offers diversity of resources and tools that have aimed to improve everyday life. Smartphones provide users with many productivity and sociability enhancing features and in contemporary times it is difficult to imagine a world without smartphones. Of different usability features, smartphones allow people to connect with the outside world, providing access to knowledge through Internet and facilitating social interaction through social networking sites but also the more traditional communication means, such as phone calls and texting. However, very high engagement in smartphone use has been shown to be negatively related to various domains, including psychological health and social relationships (Bian and Leung 2014; Elhai et al. 2017a; Enez Darcin et al. 2016).

Problematic Smartphone Use

Detrimental outcomes in relation to excessive smartphone use have led researchers to investigate the possible addictive effects of smartphone use (Billieux et al. 2015). This type of smartphone use behavior has been regarded with different names, such as smartphone addiction (Kwon et al. 2013), proneness to smartphone addiction (Rozgonjuk et al. 2016), and smartphone overuse (Inal et al. 2015). While the debate regarding the terminology of this phenomenon is ongoing, it has recently been proposed that the term "problematic smartphone use" (PSU) should be implemented to describe detrimental associations with excessive smartphone use (Panova and Carbonell 2018). Researchers have proposed the differentiation between habitual and problematic

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(addictive) smartphone use (van Deursen et al. 2015). While habitual use is driven by a formed habit to engage in smartphone use (Oulasvirta et al. 2011), e.g., checking for notifications, problematic use has been hypothesized to be a detrimental outcome of habitual use typically used to relieve pain or escape from reality (Huisman et al. 2000).

PSU has been shown to be related to physical discomfort, such as neck problems (Xie et al. 2016), lower sleep quality (Demirci et al. 2015), poorer academic outcomes (Lepp et al. 2015; Rozgonjuk et al. 2018c; Samaha and Hawi 2016), procrastination (Rozgonjuk et al. 2018a), and several psychopathology variables, such as depression, anxiety (reviewed in Elhai et al. 2017a), social phobia (Enez Darcin et al. 2016), and anger (Elhai et al. 2019). However little data exist on how types of smartphone use work in conjunction with emotion regulation skill to impact PSU.

Social and Process Smartphone Use

Smartphones are multi-purpose devices that provide various functionalities, allowing for communication via phone calls, texting and social media platforms, and providing the opportunities to use one's smartphone as a productivity and/or entertainment medium. In fact, one potential distinction in smartphone usage type is categorization of smartphone use to process and social smartphone use (as also recently noted in van Deursen et al. 2015). While process use indicates to the gratifying effects of consuming or prosuming media (Song et al. 2004), social smartphone use leads to rewards and pleasurable experience through social interaction (van Deursen et al. 2015). In other words, while social smartphone use relates to more socially active use (e.g., calling and texting one's contacts, actively reaching out to people, using social networking sites for contacting others), process use refers to activities related to more non-social motives and behaviors (e.g., watching videos, playing games, browsing online). It should also be necessary to distinguish social media use from social smartphone use. As mentioned, social smartphone use refers to more socially focused activities (including phone calls, texting, and some features of social media), whereas social media use may refer to both active and passive behaviors that may reflect social and less-social behavior, respectively (Gerson et al. 2017; Rozgonjuk et al. 2019b; Verduyn et al. 2015, 2017).

While both process and social smartphone use have been shown to be associated with habitual smartphone use, it was process, but not social smartphone use that predicted addictive, or PSU-like smartphone use behavior (van Deursen et al. 2015). Some recent studies have further demonstrated that process smartphone use is more related to PSU and other constructs highly relevant in psychopathology research (Elhai et al. 2017b, c; Rozgonjuk et al. 2019a). One potential explanation is that some people may experience more psychological hardship and those individuals whose social skills may be less-developed, may be more prone to social isolation and socially avoidant behavior. This may, in turn, result in more non-social smartphone use and problematic engagement in digital technology use. On the other hand, research on social smartphone use is more mixed. While it has been demonstrated that there is higher social media and social networking sites use in lonely individuals (Gao et al. 2016), and social media use could be helpful in tackling loneliness (Pittman and Reich 2016), these studies typically do not discriminate between (socially more) active and passive social media use. Yet, it has been demonstrated that passive social media use is related to negative affect related constructs (Gerson et al. 2017; Rozgonjuk et al. 2019b; Verduyn et al. 2015, 2017). Based on this, our focus is on the process smartphone use in the current paper.

Dysfunctional Emotion Regulation

As mentioned earlier in this text, PSU has been found to be associated with several mood and anxiety disorders (Elhai et al. 2017a; Enez Darcin et al. 2016; Wolniewicz et al. 2018). A key factor in these disorders is emotion regulation (Aldao et al. 2010). Emotion regulation is defined as changes associated with activated emotions (Cole et al. 2004), and the ability to respond to emotional experiences in a socially tolerable way that allows for the delay in spontaneous reactions (Cole et al. 1994). In other words, it is the process of emotion modulation for a better adaptation with the environment (Gross and John 2003). Among one of the more studied and well-defined emotion regulation strategies is expressive suppression (Gross and John 2003). It involves inhibiting one's emotion-expressive behavior (e.g., facial expressions), and is considered a dysfunctional strategy (Gross 1998). While the person may control some of their emotional, e.g., facial, expressions this does not result in decreasing or alleviating negative affect and emotional arousal (Niedenthal et al. 2006). The lingering and potentially accumulating unresolved negative affect may, in turn, drive cognitive biases about oneself, possibly impairing one's ability to form emotionally close relationships and may contribute to avoidant and anxious relational behaviors (Cutuli 2014; John and Gross 2004; Sheldon et al. 1997). In line with this, it has been found that more expressive suppression is associated with poorer physiological (increased blood pressure), affective (less emotional responsiveness), and social-behavioral (disrupted communication and inhibited relationship formation) outcomes (Butler et al. 2003). Not surprisingly, therefore, expressive suppression has been shown to be a vulnerability factor for several mental disorders, such as major

depression, anxiety, and substance use disorders (Aldao et al. 2010; Ehring et al. 2010; Joormann and Gotlib 2010).

Research on the relationship between emotion regulation (suppression specifically) and smartphone use is scarce, with one previous study reporting small positive correlation between suppression and PSU (Elhai et al. 2016). Understanding how emotion regulation contributes to PSU would be helpful in elucidating how people develop PSU patterns. As mentioned, maladaptive emotion regulation contributes to mental health problems. Because PSU has been shown to be related to anxiety and mood disorders (reviewed in Elhai et al. 2017a), and emotion regulation may be a key factor contributing these disorders, PSU may be a result of dysfunctional emotion regulation.

Theory

Our hypothesized research model, in which process smartphone use mediates the relationship between expressive suppression and PSU (H3), is in coherence with a recently proposed Compensatory Internet Use Theory (CIUT; Kardefelt-Winther 2014). According to CIUT, maladaptive coping with stressful events and situations may lead some people to compensate their poor coping ability with higher engagement in digital technology use (originally the Internet, but also social media, smartphones, etc). CIUT also posits that this compensatory mechanism in itself is not pathological, but it may result in higher levels of problematic engagement in digital technology use in some individuals. Some recent studies have also applied this explanation in studies regarding associations between mood disorder symptoms and PSU (Elhai et al. 2018a; Wang et al. 2015; Zhitomirsky-Geffet and Blau 2016). In addition, a study has demonstrated that process smartphone use mediates the relationship between psychopathology and PSU (Elhai et al. 2017c), providing further justification for our proposed research model.

Another, more comprehensive approach is the Interaction of Person-Affect-Cognition-Execution (I-PACE) model of specific Internet use disorders (Brand et al. 2014; Brand et al. 2016). This model presents the interplay between predisposing factors (e.g., genetics, personality traits, psychopathology), as well as dysfunctional coping strategies in developing problematic use of Internet-based technologies. CIUT could be viewed as part of the I-PACE model, as the dysfunctional coping is central in both frameworks. Coherent with the I-PACE approach, we hypothesize that expressive suppression as a dysfunctional coping strategy may lead to more process smartphone use, potentially resulting in higher levels of PSU in some individuals. The I-PACE model has also been used in conceptualizing PSU in some recent studies (Duke and Montag 2017; Montag et al. 2016).

Research Aims and Hypotheses

The purpose of this study is to see (1) how emotion dysregulation (expressive suppression) tendency relates to PSU, and (2) how do types of smartphone use potentially mediate these relationships. We have posed the following hypotheses, accompanied with corresponding elaborations.

H1: *Expressive suppression is positively correlated with the levels of PSU.* Increased smartphone use has previously been associated with maladaptive emotion regulation (Elhai et al. 2016), therefore it should be correlated with suppression, a dysfunctional emotion regulation strategy that is also a vulnerability factor in several types of psychopathology (Aldao et al. 2010; Ehring et al. 2010; Joormann and Gotlib 2010).

H2: *Process smartphone use is positively correlated with the levels of PSU*. Process and social smartphone features may contribute to habitual smartphone use, but we expect process (but not social) smartphone use to predict the levels of PSU, based on the findings in van Deursen et al. (2015). Process smartphone use has also been found to be more related to PSU (Elhai et al. 2017b). Although smartphone use could enhance social interactions by allowing people to call and text each other, and communicate via social networking sites, it could be that some individuals do not engage in many social interactions due to social anxiety and/or poor social skills. Because one of the needs of people is social connectedness (Ryan and Deci 2000), this poor ability to interact with others might cause significant distress that could also result in social isolation (De Silva et al. 2005). In addition, engaging in social interactions might be perceived as risky because of potential rejection; it has been shown that habitual use of expressive suppression is related to risk aversion (Heilman et al. 2010), potentially contributing to lower behavioral activation and social isolation. It has also been demonstrated that those susceptible to stress in social interactions tend to develop PSU (Lachmann et al. 2018).

H3: *Process smartphone use mediates the relationship between expressive suppression and PSU*. We hypothesize that people who are using more dysfunctional approach to cope with the distress (e.g., suppressing their emotions), tend to engage more in process smartphone use. This could be due to wanting to escape the real-life, and/or to entertain themselves. In a study by Hoffner and Lee (2015), it was found that more habitual use of emotional suppression was associated with smartphone process use. This, in turn, may result in more PSU, as frequent engagement in (process) smartphone use may drive excessive/problematic behavior.

Material and Methods

Participants and Procedure

Participants were recruited in fall 2016 from the research pool of a large American Midwestern university's psychology department (hosted on Sona Systems' platform). The study protocol was approved by the university's institutional review board, in accordance with the Helsinki declaration. Those participants willing were routed to an online consent statement hosted on psychdata.com. No monetary compensation was provided, but participants received required course research points for participation. Three hundred undergraduate university students (age ranged from 18 to 38 years, M = 19.45, SD = 2.17; 229, or 76%, female) participated in a web survey study. 235 (78.33%) of them were Caucasian, 36 (12%) African-American, 14 (4.67%) Hispanic-Latinos, 13 (4%) Asian-American, and 16 (5.33%) participants indicated either "other" or "unknown" (responses were not mutually exclusive, e.g., combination of responses of Caucasion and Hispanic-Latino, African-American and Hispanic-Latino, or other were also possible).

Instruments

Socio-Demographics

We asked about participants' age, gender, ethnicity, marital status, and employment status. In addition, the following scales were used:

The Smartphone Addiction Scale (SAS) The SAS is one of the measures for PSU that has 33 items using a Likert scale, with responses ranging from 1 = "Strongly disagree" to 6 = "Strongly agree" (Kwon et al. 2013). It has six subscales ("daily-life disturbance", "positive anticipation", "withdrawal", "cyberspace-oriented relationship", "overuse", "tolerance") but can also be used as a unidimensional measure, with very good internal reliability (Cronbach's alpha = .97 in Kwon et al. (2013); Cronbach's alpha for the sample of this study = .93) and verified concurrent validity against other scales measuring problematic smartphone and internet use (Demirci et al. 2014; Kwon et al. 2013). We reworded several items into a first-person voice for greater accessibility and consistency for participants, such as rewording "Missing planned work due to smartphone use" to "I missed planned work due to smartphone use" (Duke and Montag 2017). Sample items include: "I get irritated when bothered while using my smartphone", and "I am using my smartphone longer than intended".

Emotion Regulation Questionnaire (ERQ) The ERQ is a 10-item self-report measure for emotion regulation strategies; specifically, it measures use of cognitive reappraisal and expressive suppression on a 7-point Likert-type scale, with the scale responses ranging from 1 = "Strongly disagree" to 7 = "Strongly agree" (Gross and John 2003). In this study, we only focused on expressive suppression, and used only the corresponding subscale. Internal reliability is good, with Cronbach's alpha ranging .68 to .76 for expressive suppression subscale (Gross and John 2003). Cronbach's alpha for the sample in this study was .75. In addition, convergent validity has been verified against measures of mood, coping, and rumination (Gross and John 2003). Sample items include "I keep my emotions to myself" and "When I am feeling negative emotions, I make sure not to express them".

Process Vs Social Smartphone Usage (PSSU) Scale The PSSU assesses two aspects of smartphone use, namely the use of process, or process features (e.g., entertainment), and social features (e.g., communication); this distinction has been used in technology literature (Song et al. 2004). The PSSU consists of 12 items using a 5-point Likert-type scale, with responses ranging from 1 = "Strongly disagree" to 5 = "Strongly agree" (van Deursen et al. 2015), with good internal reliability for the process use subscale (Cronbach's alpha = .89 in van Deursen et al. (2015); .80 for the sample of this study), and social use subscale (Cronbach's alpha = .73 in van Deursen et al. (2015); also .73 for the sample of this study). Five-item social smartphone use subscale includes: "I use my smartphone to call other people" and "I use my smartphone to maintain relationships". Sample items for seven-item process smartphone use subscale includes: "I use my smartphone because it's entertaining" and "I use my smartphone in order to escape from real-life".

Statistical Analyses

We used maximum likelihood estimation to estimate nominal amounts of missing item-level data for the scales (Graham 2009), with a few participants typically missing 1–2 items per scale. Missing data estimation was done in IBM SPSS Statistics version 25.0 (IBM Corp 2017).

Descriptive statistics and correlations were computed in R software version 3.5.3 (R Core Team 2019). Structural equation modelling and mediation analysis were conducted in Mplus version 8 (Muthén and Muthén 2017). Confirmatory factor analysis (CFA) was conducted for the SAS, ERQ suppression subscale, and PSSU in order to investigate the goodness-of-fit of the measurement model. Weighted least squares estimation with a mean-adjusted chi-square (WLSM) was used, treating items of the scales as ordinal data, thus involving a polychoric covariance matrix and probit regression coefficients (DiStefano and Morgan 2014). This estimator has been chosen because the scales of our measures are ordinal/categorical, and WLSM has been shown to be superior in comparison to some other common statistical analysis methods, such as those based on maximum likelihood

estimation (Tarka 2017). We modeled the SAS items with a higher-order factor, consisting of six latent first-order factors. We used common benchmarks to assess model fit: the comparative fit index (CFI), the Tucker-Lewis index, and the root mean square error of approximation (RMSEA). A very good model fit would be indicated by CFI and TLI values of higher than .95 and RMSEA value of less than .06 (Hu and Bentler 1999). CFI and TLI values of approximately .90 (Kline 2015) and RMSEA value of up to .10 could also be considered to have a fair fit (Hooper et al. 2008; MacCallum et al. 1996).

We used similar approach in structural equation modelling (SEM). SAS higher-order factor score, suppression subscale, and PSSU variables (process vs social) were modelled as latent variables. All items were included in SEM, and only the latent variables are presented in Fig. 1. We also included age and gender as covariates, as previous studies have found that these characteristics are associated with PSU (Elhai et al. 2017a; Rozgonjuk et al. 2016; van Deursen et al. 2015). In addition, age and gender were also included as covariates for expressive suppression, as it has been previously shown that these constructs are associated (Shiota and Levenson 2009; Welborn et al. 2009). We used the cross-products of direct effects to compute mediation/indirect effects, using the Delta method for computing indirect effect standard errors, with non-parametric bootstrapping across 1000 samples (MacKinnon 2008).

Results

Descriptives and Correlations

The descriptive statistics and Spearman correlations are presented in Table 1.

As evident from Table 1, levels of PSU positively correlated with both types of social and process smartphone use, with considerable effect sizes.[1] There was also a significant correlation between PSU and expressive suppression. In addition, process smartphone use was correlated with expressive suppression, but social features of smartphone use were not.

[1] Due to the relatively high correlation between PSU and process smartphone use, we ran an exploratory factor analysis (EFA; using WLSMV estimator and oblique rotation) including the items of SAS and process smartphone use subscale. The results showed that, in general, process use scale loaded to one factor and SAS items loaded to other factors yielded in EFA. All but two items had a standardized factor loading of .35 or higher in process use scale; however, only one of these low-loading items fit to another factor better (factor loading of .36). Furthermore, only two items of SAS loaded to the factor strongly associated with process use (factor loadings .39 and .36); however, these items had higher loadings on other factors (.67 and .62, respectively). Therefore, although PSU and process use are highly correlated, these could still be considered as two separate scales.

Primary Results

CFA for the measurement model showed that the six-factor SAS with one higher-order factor had an adequate fit overall, $\chi^2(205, N = 300) = 3440.43$, $p < .001$, CFI = .93, TLI = .92, RMSEA = .14 [90% CI: .14 to .15]. The fit indices for PSSU two-factor model were $\chi^2(62, N = 300) = 604.01$, $p < .001$, CFI = .92, TLI = .90, RMSEA = .19 [90% CI: .17 to .20], and for the ERQ suppression subscale was $\chi^2(29, N = 300) = 43.72$ $p < .001$, CFI = .97, TLI = .91, RMSEA = .27 [90% CI: .20 to .33].

Regarding the structural model, we first started with a model that included expressive suppression as the predictor, both latent social and process smartphone use as mediators, and levels of PSU as the outcome. This model did not demonstrate good fit, as $\chi^2(302, N = 300) = 9131.08$, $p < .001$, CFI = .85, TLI = .85, RMSEA = .13 [90% CI: .15 to .15]. Next, we removed the social use of smartphones from the model, as we were specifically interested if process smartphone use would mediate the relationship between expressive suppression and levels of PSU. It has previously been shown that process, rather than social, smartphone use mediates the association between psychopathology and the levels of PSU (van Deursen et al. 2015). In addition, we included age and gender as covariates for expressive suppression and PSU. For this model, displayed in Fig. 1, we found adequate fit overall, with $\chi^2(978, N = 300) = 5895.56$, $p < .001$, CFI = .90, TLI = .90, RMSEA = .13 [90% CI: .13 to .13]. The standardized coefficients with bootstrapped standard errors for this model are presented in Fig. 1.

Results from Fig. 1 demonstrate that process smartphone use was strongly related to PSU severity, after controlling for age and gender. Furthermore, suppression (also controlled for age and gender) was related to process smartphone use. Younger age and female gender predicted the levels of PSU. Mediation findings show that process use of smartphones mediated relations between expressive suppression and levels of PSU, B = .051, beta = .090, SE = .044, z = 2.053, $p = .040$. However, some caution regarding interpretation of the results is needed, as the model fit did not reach ideal cut-off values on measured indices, as proposed by Hu and Bentler (1999). Although some sources have proposed that TLI as low as .80 could be acceptable (Hooper et al. 2008), and a CFI value of .90 could also indicate adequate fit (Hu and Bentler 1999), the RMSEA values are exceeding the suggested cut-off point.

Discussion

The aim of this study was to investigate how emotion dysregulation and smartphone use are associated. Specifically, we first examined if these constructs are related to each other; then, we tested a mediation model that included expressive

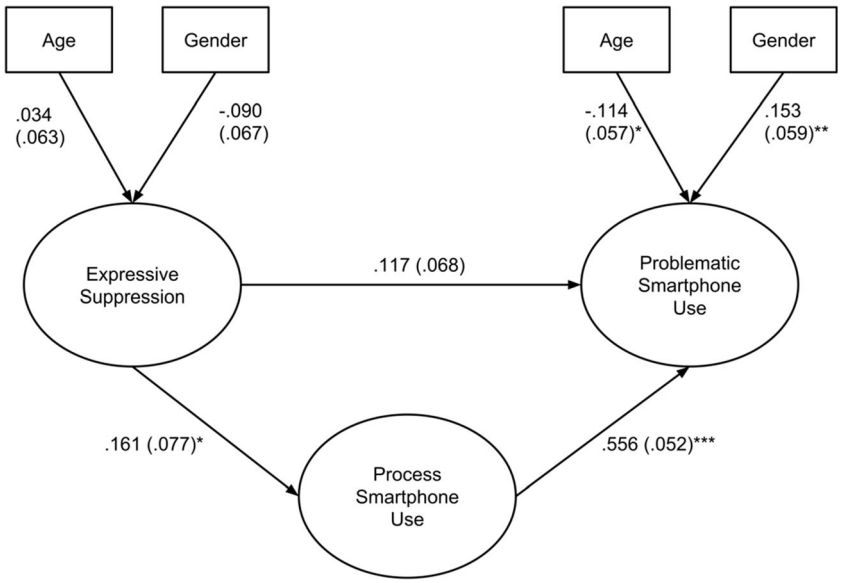

Fig. 1 The graphical depiction of structural regression results. *Notes*. Standardized coefficients with standard errors (bootstrapped over 1000 samples). Estimation method: weighted least squares with mean-adjusted chi-square (WLSM). ** $p < .01$, *** $p < .001$

suppression as the predictor, process smartphone use as the mediator, and levels of PSU as the outcome variable.

Main Findings

According to our first hypothesis (H1), we expected that levels of PSU would be correlated with expressive suppression. Our findings provide support for this hypothesis, as suppression was positively associated with PSU severity both in bi- and multivariate analyses. These constructs that could be described as dysfunctional and maladaptive were expected to correlate, as expressive suppression is a vulnerability factor in several psychological disorders (Aldao et al. 2010; Ehring et al. 2010; Joormann and Gotlib 2010). PSU, too, has been assocaited with several mental disorders where dysfunctional emotion regulation is central, e.g., depression and anxiety (Elhai et al. 2017a). In addition, one study also demonstrated that there is a small effect in the relationship between suppression and PSU (Elhai et al. 2016) and that higher levels of expressive suppression are related to more problems with substance abuse and addictions (Fucito et al. 2010; Mohajerin et al. 2013). Therefore, logically, these constructs should be correlated, and our results support this hypothesis that PSU as a potentially addictive behavior relates to dysfunctional emotion regulation. These results also cohere with and could potentially be explained by CIUT (Kardefelt-Winther et al. 2017) and I-PACE (Brand et al. 2016), as poor emotion regulation (predisposing factor) may lead to compensatory behavior (higher engagement in digital technology use), potentially escalating in problematic behavior (PSU).

We also expected that levels of PSU would correlate with process smartphone use (H2), and that process smartphone use would mediate the relationship between expressive suppression and levels of PSU (H3). These hypotheses found support from the data. It seems that people who internalize their emotions tend to use more of the process functionalities of their smartphones – and such use might lead to higher levels of PSU. In addition, the mediating effect of process smartphone use could be potentially explained by engagement in social isolation or behavioral avoidance. Previously, expressive suppression has been found to be related to inhibited relationship formation and disrupted communication in social

Table 1 Descriptive statistics and correlations between the variables

	M	SD	Min	Max	1	2	3
PSU	93.47	25.30	34	164.28	–		
Expressive suppression	15.25	5.26	3.60	28	.156** (189**)	–	
Social smartphone use	21.31	3.02	5	25.47[a]	.235*** (.238***)	−.002 (−.019)	–
Process smartphone use	26.83	4.31	9	35	.532*** (.570***)	.148* (.170*)	.544*** (.703***)

$N = 300$. PSU = Problematic Smartphone Use. [a] although the maximum value for the five-item scale is 25, the value in the table was obtained due to data imputation procedure. Correlations (computed as standardized covariances) between latent variables are presented in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$

relationships (Butler et al. 2003). This phenomenon could potentially be associated with social isolation and preferences for process activities; indeed, missing process smartphone features have been related to expressive suppression, whereas missing interpersonal contact and social support were not (Hoffner and Lee 2015). In addition, susceptibility to interpersonal stress has recently been associated with higher levels of PSU (Lachmann et al. 2018), further supporting the argument that higher engagement with digital technology, and especially the process features of these technologies, could be influenced by distress related to social situations. This is also consistent with CIUT (Kardefelt-Winther et al. 2017) and I-PACE (Brand et al. 2016), as poor ability to cope with stressful events, or dysfuntional emotion regulation, may lead some individuals to use their technology to better cope with the feelings. In some people, this compensatory mechanism may results in PSU.

It should also be mentioned that female gender and younger age predicted the levels of PSU in the mediation model. These findings are consistent with previous studies that have found these socio-demographics to be associated with higher engagement in problematic technology use (Rozgonjuk et al. 2016; van Deursen et al. 2015).

Contribution and Limitations

The study has both theoretical contributions and clinical implications. The results add yet another layer of knowledge into relationships between PSU and dysfunctional psychological coping. According to our findings, PSU is accompanied by dysfunctional emotion regulation. Furthermore, our study proposes the dynamics of how expressive suppression may, through social avoidance/isolation, lead to more use of process smartphone features that could escalate in PSU behavior. Expressive suppression in association with both PSU and types of smartphone use has been thus far relatively unexplored, and our study provides novel results to fill this gap in literature.

In terms of clinical implications, this study may explain how expressive suppression, or dysfunctional emotion regulation, is related to problematic technology use. Excessive smartphone use, especially including spending time using process features of smartphones could be an indication that the person may have emotion regulation difficulties that are a vulnerability factor for several types of psychopathology, including behavioral addictions (Aldao et al. 2010) and mood disorders, such as major depression (Ehring et al. 2010). Therefore, a person's excessive engagement with digital technology might be a symptomatic manifestation of a wider problematic mental health condition. For instance, limiting the technology use of a person with PSU might treat the symptom, but the underlying culprit might go unattended and problematic behavior might manifest in other areas. This topic is important, as it helps in understanding if there is an identifiable pathway to explain why and how people differing in emotion regulation excessively use technology. Knowing this information could be useful in planning potential interventions in order to improve the emotion regulation skills and accompanying maladaptive coping mechanisms in distressed individuals.

Some limitations of this study should be acknowledged. First, we used a convenience sample of college students with higher proportion of female students. This might limit the generalizability of findings. Second, results rely on self-report assessments rather than objective measures of smartphone use or structured clinical diagnoses. This may introduce some common method bias, e.g., social desirability bias (Lowry et al. 2016; Turel et al. 2011). Future studies should include objectively measured smartphone use data, as recent research papers have demonstrated that the relationships with psychological constructs may depend on smartphone use patterns (Elhai et al. 2018b; Rozgonjuk et al. 2018b; Wilcockson et al. 2018). Although objectively measured data may be superior in comparison with self-reports, it should also be noted that PSU is a more complex condition that may not necessarily be well-reflected in objectively measured smartphone use. This may be because high engagement may not necessarily mean that the person is a problematic user (Billieux 2012; Brand et al. 2014, 2016; Davis 2001). Therefore, relying on the assumption that excessive smartphone use is linearly reflected in objectively measured smartphone use data may result in poor discrimination between high smartphone use engagement and problematic behavior. Third, the cross-sectional study design cautions interpretation of findings carefully in terms of causality. Although theoretically it would make sense to believe that dysfunctional emotion regulation is an antecedent of more (and problematic) smartphone use, repeated-measures and longitudinal study designs would be useful in order to determine the exact causal mechanism of these associations. Finally, the proposed model's fit statistics did not indicate ideal fit, and RMSEA values reported are higher than suggested in the literature. Therefore, interpretations of these study results should be made with caution.

Future research should address the mentioned limitations. Results could find stronger validation if replicated in a community sample, by implementing objective smartphone and/or behavioral measures, and a longitudinal, repeated-measures study design. In addition, it ought to be investigated if social isolation/behavioral avoidance is, indeed, the explanation in the relationships between process smartphone use, PSU, and expressive suppression. It should also be tested if these results are replicable across different digital technologies (e.g., problematic Internet and/or computer use), platforms (e.g., in social networking sites), and cultures. Finally, higher engagement levels with digital technologies have been shown to be related to interactivity design (Teng et al. 2018); it could be that

process smartphone features that foster more interactive experiences could provide higher engagement in and preference for these types of applications, substituting social contact.

Conclusions

In this study, we investigated how dysfunctional emotion regulation (expressive suppression) is related to types of smartphone (process vs social) use and PSU. Our findings indicate to a possible explanation that higher expressive suppression is related to more non-social smartphone use which could escalate in PSU. These results could potentially be used in mental health problem awareness, screening, and intervention.

Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical Approval The Ethical Approval was provided by the University of Toledo Social Behavioral Institutional Review Board.

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