

Williams, J. R., Sindermann, C., Yang, H., Montag, C., & Elhai, J. D. (2023). Latent profiles of problematic smartphone use severity are associated with social and generalized anxiety, and fear of missing out, among Chinese high school students. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, 17(5), Article 7. <https://doi.org/10.5817/CP2023-5-7>

Latent Profiles of Problematic Smartphone Use Severity Are Associated With Social and Generalized Anxiety, and Fear of Missing Out, Among Chinese High School Students

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Abstract

We explored problematic smartphone use (PSU) using latent profile analysis (LPA) and relationships with anxiety variables, including severity of generalized anxiety disorder (GAD), social anxiety disorder (SAD), and Fear of Missing Out (FoMO) in a non-clinical sample. We conducted a web-based survey (during the COVID-19 pandemic from February to March 2020) with high school students ($N = 1,797$; 1,164 female; ages 13–19 years) in Tianjin, China, administering the Smartphone Addiction Scale-Short Version (SAS-SV) to assess PSU, Generalized Anxiety Disorder (GAD-7) Scale, Social Interaction Anxiety Scale (SIAS), and Fear of Missing Out (FoMO) Scale. Using Mplus 8.7, we conducted LPA on SAS-SV item responses to uncover latent profiles and relations with anxiety and fear measures. A three-profile PSU model fit the data according to fit indices and likelihood ratio tests. SAS-SV item responses were lowest in profile 1, moderate in profile 2, and most severe in profile 3. Individual PSU profiles modeled by LPA demonstrated significant differences in social and generalized anxiety severity and FoMO. Controlling for age and sex, adolescents with higher levels of anxiety were more likely to be classified as profiles 2 and 3 rather than profile 1. These findings will hopefully inspire future studies and treatments concerning the severity of PSU as it relates to various psychopathology constructs.

Keywords: problematic smartphone use; latent profile analysis; social anxiety; generalized anxiety; fear of missing out

Editorial Record

First submission received:
December 27, 2022

Revisions received:
July 7, 2023
September 12, 2023

Accepted for publication:
October 4, 2023

Editor in charge:
Maèva Flayelle

Introduction

Smartphones offer many advantages to users including possibilities for efficient information acquisition, improved communication and socialization, enhancing collaboration in work and school settings (Jung, 2014), and facilitating healthcare delivery (M. Lee et al., 2018; Zhao et al., 2016). Nevertheless, individuals can engage in excessive smartphone use that has adverse functional consequences, like poor academic (Sapci et al., 2021) and professional

performance (Duke & Montag, 2017; see also recent association between higher objective smartphone use and lower student performance in the study by Elhai, Sapci et al., 2021; Sunday et al., 2021), as well as relations with impaired and unsafe driving (Kaviani et al., 2020), and phubbing (Xie et al., 2019). Moreover, a vast literature has found several mental health problems correlated with excessive smartphone use (Busch & McCarthy, 2021; Coyne et al., 2019; Elhai, Levine, & Hall, 2019).

In the present paper, rather than focusing on a variable-centered approach (where we analyze sample mean/sum scores across items) to examine constructs correlated with excessive smartphone use, we used a person-centered approach to uncover underlying heterogeneity in excessive smartphone use. In the methods literature, correlational studies using a single sample are referred to as variable-centered studies. Whereas studies using mixture modeling (e.g., cluster analysis, latent profile analysis) to explore underlying subgroups of participants are referred to as person-centered studies (Ferguson et al., 2020). One of the advantages of a person-centered approach is that it overcomes the somewhat imprecise measurement of an entire sample using only mean scores. It is challenging to gain a comprehensive understanding of psychological phenomena by treating a sample as a single set of participants who are all equivalent. Instead, this method allows for within-subjects heterogeneity (McCutcheon, 2002; Weller et al., 2020). As such, while in a variable-centered approach, individuals with the same mean/sum score are treated the same despite potentially showing different scores on item-level, in the person-centered approach, such heterogeneity is specifically investigated. We used latent profile analysis (LPA) to explore underlying subgroups of excessive smartphone use symptom presentations and subsequently examined mental health variables related to the latent profiles. Heretofore, little examination has been conducted that explores the heterogeneity of clinical symptom presentations of excessive smartphone use and anxiety-related correlates of those heterogeneous presentations.

Problematic Smartphone Use

Excessive smartphone use (Claesdotter-Knutsson et al., 2021; Wacks & Weinstein, 2021), smartphone use disorder (Montag & Becker, 2020; Montag et al., 2021), and smartphone/cell-phone addiction (De-Sola Gutiérrez et al., 2016; Rozgonjuk et al., 2022) are frequently referred to as “problematic smartphone use” (PSU) in the literature and will be referred to as PSU in the present article. A common, concise definition is “compulsive use that leads to impaired daily functioning in terms of productivity, social relationships, physical health, or emotional well-being” (Horwood & Anglim, 2018, p. 349). PSU can be conceptualized using an internet use disorders framework, specifically mobile internet use disorders (Montag et al., 2021), which differentiates PSU from non-mobile problematic internet use (PIU) on a stationary computer (perhaps in particular due to constant availability of online content in the case of smartphones). Though activating different brain areas (Horvath et al., 2020; Pyeon et al., 2021; Zheng et al., 2022), PSU is a concept that shares similarities to the maladaptive behavioral aspects of substance use disorders (Billieux et al., 2015; Brand et al., 2019). Numerous studies have shown that PSU severity positively correlates mildly to moderately with many mental disorder symptoms in adults, such as anxiety (Elhai, Levine, & Hall, 2019), depression (Elhai, Gallinari et al., 2020), and stress severity (Long et al., 2016), with similar findings in adolescent samples (Erdem & Sezer Efe, 2022; Extremera et al., 2019; Pereira et al., 2020; Wang & Lei, 2021; Wang et al., 2019; Watson et al., 2021). Hence, although PSU is not a diagnosis in the DSM-5 or ICD-11 manuals, PSU remains a serious problem that is related to adverse functional consequences on affected individuals’ lives (Busch & McCarthy, 2021) and thus is worth exploring.

The prevalence estimates of PSU in varying samples of adolescents ranges from as low as 10% (Lopez-Fernandez et al., 2014), 20%–31% (Long et al., 2016; Sohn et al., 2019), and much higher, nearing 50% (van Velthoven et al., 2018; Yen et al., 2009). In one Swiss study, self-reported PSU was more prevalent in adolescents (15–16 years old) than in young adults 19 years and older (Haug et al., 2015). One recent meta-analysis demonstrates prevalence increases over time in dozens of additional international samples (Olson et al., 2022). For the subjects of the present study, Chinese adolescents, the prevalence of PSU is estimated at 26.2% (Tao et al., 2015). Understanding smartphone technology’s potential effect on adolescents is paramount in raising the next generation of well-rounded young adults.

Many previous studies have examined variable-centered associations between PSU severity and psychological constructs (Busch & McCarthy, 2021; Elhai, Rozgonjuk et al., 2019). PSU severity is particularly associated with higher depression and anxiety severity (Elhai, Levine, & Hall, 2019; Elhai et al., 2017). More recent support has been found for such variables as worry (Elhai, Rozgonjuk et al., 2019), rumination (Elhai, Yang, Dempsey, & Montag, 2020), social anxiety (Peterka-Bonetta et al., 2019), negative primary emotional systems (Rozgonjuk, Davis, &

Montag, 2021), individual differences in emotional (dys)regulation (Grommisch et al., 2020), emotional distress factors, and mechanisms of self-constraint (Oh et al., 2021; H. Yang et al., 2022).

However, only a handful of studies have explored underlying subgroups of PSU or problematic internet use symptom presentations using latent class analysis or LPA. To begin with, Kim et al. (2016) and Mok et al., (2014) examined latent profiles of Korean participants, and J. Chen et al. (2021) examined latent profiles of Chinese college students regarding tendencies of problematic personal computer, smartphone, and internet use severity in relation to psychopathology such as anxiety symptoms. And, in American samples, Elhai, Yang, Dempsey, and Montag (2020) examined latent profiles of undergraduate students regarding PSU symptom presentations. Addressing the constructs in the present study, LPA has been employed to explore the Fear of Missing Out (FoMO) as it relates to anxiety (Elhai et al., 2021a) and anxiety-related personality traits (neuroticism; Rozgonjuk, Sindermann et al., 2021), PSU (Fuster et al., 2017; H. Yang et al., 2022), and social anxiety (Yue et al., 2021). These studies assessing similar covariates to the present work found between two and six latent profiles based on problematic internet or smartphone use, but most commonly found between three and four profiles.. There is, however, a notable lack of literature addressing PSU and generalized anxiety using LPA, and the present study is one of the first studies of which the authors are aware analyzing this question. Latent profiles, as mentioned previously, allow us to identify to what extent these constructs are related to the heterogeneity of PSU. While homogenized variable data is useful, LPA studies to date have shown that not all participants are alike and therefore it begs the question, how are they different? By using LPA, we can begin to answer this question with regard to generalized and social anxiety and to bolster the FoMO literature on a new sample.

Given that anxiety is a well-known correlate of PSU severity (Busch & McCarthy, 2021; Elhai, Levine, & Hall, 2019), anxiety is the focus of the present study. Of note, we were not interested in anxiety as a single construct as investigated previously in relation to PSU severity (Elhai, Yang, Dempsey, & Montag, 2020; S.-Y. Lee et al., 2018; Mok et al., 2014). Instead, we were interested in examining specific types of anxiety for differential relations with latent PSU profiles. Next, we will discuss the different types of anxiety analyzed in the present study.

Generalized Anxiety Disorder

Generalized anxiety disorder (GAD) is primarily characterized by longstanding, excessive anxiety and worry (apprehensive expectation), difficulty controlling worry, and physiological consequences from such anxiety (e.g., fatigue, irritability, muscle tension; APA, 2013). Recent work has begun to demonstrate associations between PSU severity and primary symptoms of GAD, such as worry (De-Sola Gutierrez et al., 2016; Elhai et al., 2016; Guo et al., 2020; Rho et al., 2019). While a vast portion of psychological literature is based on samples of Western, Educated, Industrialized, Rich, and Democratic (WEIRD) populations, as discussed by Henrich et al. (2010), PSU is related to GAD severity, also in non-WEIRD samples (Elhai, Yang, McKay, & Asmundson, 2020; Guo et al., 2020; Islam et al., 2021). Thus, GAD may be of relevance for investigations in relation to PSU severity in non-WEIRD samples.

Social Anxiety Disorder

Social anxiety disorder (SAD) is evidenced by marked fear or anxiety about social situations for fear of negative evaluation (APA, 2013). SAD and PSU severity have been significantly positively associated (Elhai, Levine & Hall, 2019; W. Hong et al., 2019), especially with smartphone users on social media (Enez Darcin et al., 2016). Social anxiety is thought to cause avoidance of in-person social settings, replacing in-person socialization with online social engagement, or using the smartphone for non-social activity (Elhai, Levine, & Hall, 2019). Thus, we included SAD severity in the examination of PSU latent profiles.

Fear of Missing Out (FoMO)

FoMO is a form of cognitive-related anxiety in which one believes that others have rewarding experiences from which the individual is absent and thus involves a persistent desire to stay connected with people in one's social network (Elhai et al., 2021b; Przybylski et al., 2013). Additionally, FoMO can involve a behavioral strategy that seeks to relieve tension and anxiety through compulsive checking of information streams (such as on a smartphone) to maintain social connection (Elhai et al., 2021b; Przybylski et al., 2013). As such, it is important to note that FoMO herein is conceptualized as an internet-related type of cognitive anxiety from a physiological standpoint within the context of the I-PACE Model discussed below (Elhai, Yang, & Montag, 2019; Wegmann et al., 2017) rather than a

fear state. Furthermore, FoMO is consistently positively related to PSU severity (Elhai et al., 2021b) and thus is an important construct due to its likely detrimental impact on productivity (Rozgonjuk et al., 2020). Thus we included FoMO as a covariate of PSU.

Interaction of Person-Affect-Cognition-Execution (I-PACE) Model

The I-PACE theoretical model (Brand et al., 2016, 2019) suggests that complex moderation and mediation effects of four broad main components influence PIU and related behaviors such as PSU. Firstly, predisposing variables involve the model's P-component, the person's core characteristics, including personality/temperament, coping style, childhood experiences, genetics, needs/motives/values, and psychopathology. Secondly, the A-component (affect) addresses expectancies, mood, and cognitive biases that inform how one copes and compensates with stress-inducing and/or anxiety-provoking stimuli. Third, the C-component, overlapping somewhat with the A-component, handles cognitive processes and biases that accompany reactions to moods and stressors and reinforces those maladaptive behaviors meant to alleviate worry, stress, and anxiety. We begin to fill a gap in the literature by investigating specific types of anxiety, including GAD and SAD severity (P-component), and FoMO severity (A/C-component) in relation to PSU severity. Much of the existing literature deals with generic anxiety rather than multiple specific types simultaneously (Elhai, Levine, & Hall, 2019; Elhai et al., 2017). Fourth, the E-component of the model deals with reduced executive function, namely, decision-making and the reduction of inhibitory control in which the individual experiences difficulty discontinuing maladaptive behavior.

Aims, Research Model, and Hypotheses

Aims

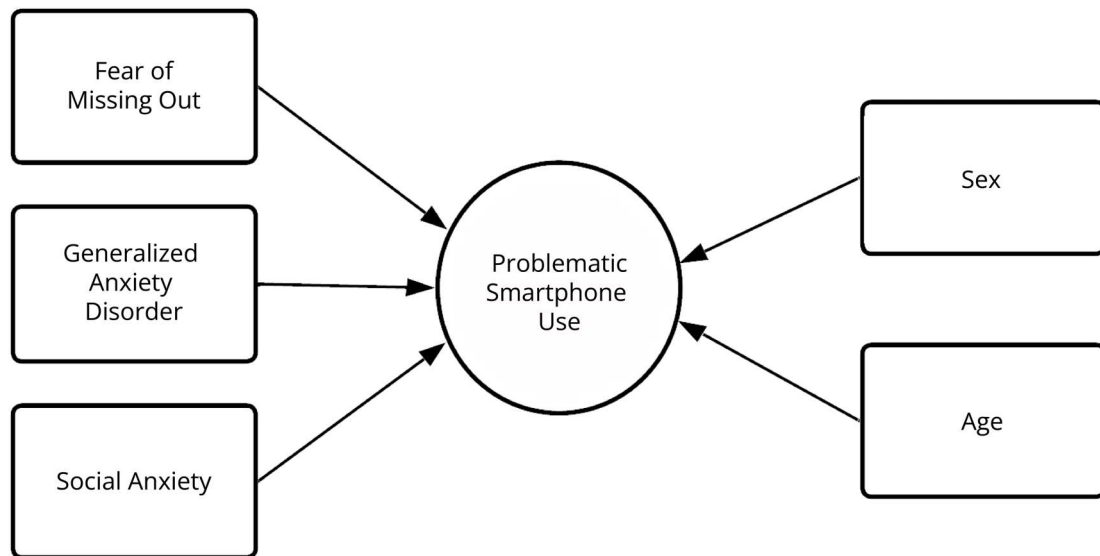
Much research has examined psychopathology in relation to PSU (Busch & McCarthy, 2021; Coyne et al., 2019), but less is known about specific types of anxiety and their differential relations with PSU severity. Further unexplored is within-group heterogeneity (i.e., latent profiles) of PSU and its relations with different types of anxiety. This study examines the nature of self-reported PSU at the individual level. Using LPA, we take a deeper look into associations of anxiety and FoMO with PSU by examining within-group heterogeneity of PSU symptom severity in the total sample.

As Montag and Becker (2020) note, Asia constitutes more than half of the world's population and billions of internet and smartphone users. Focusing on non-WEIRD populations in the observation of psychological phenomena is imperative to ensure that all populations factor into future assumptions and research in this area. Using a sample comprising Chinese adolescents, we will add to the literature by investigating PSU heterogeneity using LPA and relations with specific types of anxiety, including SAD and GAD symptoms (Guo et al., 2020), and FoMO (Lo Coco et al., 2020) in Chinese participants as we outline in the research model below.

Research Model

Based on the I-PACE model, GAD and SAD (P-component), and FoMO (A/C-component) are modeled as psychopathology-related covariates associated with latent PSU profile group membership (see Figure 1). Prior studies have analyzed data similarly using this "person-centered" approach but have yet to incorporate multiple types of anxiety as in the present paper (Elhai, Yang, Dempsey, & Montag, 2020; Elhai, Rozgonjuk et al., 2019; Mok et al., 2014). As for sex and age, S.-Y. Yang et al. (2018) and Claesdotter-Knutsson et al. (2021) both demonstrated that females are especially susceptible to PSU, and the systematic review from Busch and McCarthy (2021) demonstrated that age was a frequent correlate of PSU; therefore, we included both age and sex as covariates.

Figure 1. Model of Covariates and Latent Profile Variable.



Hypotheses

Prior work using similar samples (Elhai, Rozgonjuk et al., 2019; Elhai et al., 2021a; L. Hong et al., 2022a; H. Yang et al., 2022) has mostly demonstrated three to four latent PSU profiles related to some type of anxiety but not using the precise variables here of SAD, GAD and FoMO. As we noted earlier, previous work using LPA reveals that the severity of profiles did, in a majority of cases, show significant relationships between the severity of the latent profiles and scores of measures chosen for covariates.

H1: Three to four latent profiles of PSU will be uncovered in the present dataset.

H2: More severe latent profiles of PSU will be positively related to the severity of FoMO.

H3: More severe latent profiles of PSU will be positively related to GAD severity.

H4: More severe latent profiles of PSU will be positively related to SAD severity.

Methods

Participants and Procedure

For the present study, participants were asked to complete an anonymous online survey using wjx.cn—a Chinese web survey platform. Tianjin Normal University's Psychology Ethics Board granted approval for this study, and both participant assent and informed consent from legal guardians was collected electronically prior to participants' enrollment in the study. Data were collected from February 2020 to March 2020 at the beginning of the COVID-19 pandemic during the lockdown in China. Participants were senior high school students in Tianjin, China (population of 14 million) attending school remotely from home and were offered the opportunity by their teachers to participate in the study. All measures described below were administered to participants in Simplified Chinese characters.

After excluding data of $n = 30$ individuals indicating careless response patterns using methods in the *careless* R package (Yentes & Wilhelm, 2018), $n = 1,797$ participants remained in the final sample. Web survey participants were required to input responses for all items; therefore, we did not have missing data. Participants were adolescents with an average age of 16.80 years ($SD = 0.91$, range 13–19). Most participants were female ($n = 1,164$, 64.8%). Most participants were of Han Chinese ethnicity ($n = 1,689$, 94%).

Measures

Demographics

We collected demographic information from participants on their sex, age, and ethnicity.

Smartphone Addiction Scale-Short Version (SAS-SV)

PSU was assessed using the Chinese version of the SAS-SV (B. Chen et al., 2017), a measure based on the original English and Korean SAS-SV (Kwon et al., 2013). The scale consists of 10 items regarding current smartphone use consequences (e.g., *Missed planned work due to smartphone use*) rated on a 6-point Likert scale from 1 (*Strongly disagree*) to 6 (*Strongly agree*). The Chinese version has demonstrated good psychometrics previously (Luk et al., 2018) and in the present sample (e.g., internal consistency estimate: Cronbach's $\alpha = .902$).

Generalized Anxiety Disorder-7 (GAD-7)

We used the Chinese version (He et al., 2010) of the Generalized Anxiety Disorder 7-item (GAD-7) scale, a self-report measure assessing anxiety and worry symptoms (e.g., *Feeling nervous, anxious or on edge*) over the past two weeks, initially created and validated in English (Spitzer et al., 2006). The scale's items are rated on a 5-point Likert scale from 0 (*Not at all*) to 4 (*Nearly every day*). The Chinese GAD-7 has shown adequate psychometric properties in previous work (He et al., 2010) and the present sample ($\alpha = .919$).

Social Interaction Anxiety Scale (SIAS)

The Social Interaction Anxiety Scale (SIAS) is a 20-item scale on which items are rated from 0 (*Not at all characteristic or true of me*) to 4 (*Extremely characteristic or true of me*) to assess a participant's current cognitive, affective, and behavioral reaction to social interaction situations (e.g., *When mixing socially I am uncomfortable*). This scale has demonstrated good psychometrics across samples (Heimberg et al., 1992). We used the Chinese language version with good psychometrics (Ye et al., 1993), such as the internal consistency estimate in the present sample ($\alpha = .908$). For this study we used only the 17 non-reverse items of the scale (Rodebaugh et al., 2011).

Fear of Missing Out (FoMO) Scale

The FoMO scale (Przybylski et al., 2013) is an instrument consisting of 10 items answered on a rating scale from 1 (*Not at all true of me*) to 5 (*Extremely true of me*). This scale measures the anxiety individuals report about missing out on rewarding experiences with others (e.g., *I fear others have more rewarding experiences than me*). The measure demonstrates good psychometrics (Przybylski et al., 2013). We used the Chinese language version with adequate reliability and validity (Xie et al., 2018) and good Cronbach's α in the present sample (.841).

Analyses

For data management, correlational, and descriptive analyses, we used version 3.6.1 of R software (R Core Team, 2013). We used *careless* (insufficient effort), *corrplot* (bivariate correlations), *fmsb* (internal reliability), *pastecs* (normality and descriptives), and *sjstats* (ANOVA effects) packages. The largest values for skewness and kurtosis were 1.38 and 1.98, respectively, for GAD, suggesting normal variable distributions (Curran et al., 1996).

We used Mplus version 8.3 (Muthén & Muthén, 2018) for LPA of SAS-SV items. We treated SAS-SV items as continuously scaled (Flora & Curran, 2004) using maximum likelihood estimation with robust standard errors (Maydeu-Olivares, 2017). First, we tested unconditional models starting with as few as one profile until no significant fit increase was found for models with more (k) profiles (thus suggesting retaining the model with $k - 1$ profiles). For the best-fitting model, we added the covariates to model PSU latent profile group membership as the dependent variable, using Vermunt's three-step method, which reduces misclassification and enhances accuracy (Collier & Leite, 2017).

Results

Descriptives of the sample can be found in Table 1. Figure 2 shows bivariate Pearson correlations among variables on scale level. Table 2 displays the unconditional LPA models and fit statistics for comparison. The distinction becomes apparent when considering Vuong-Lo-Mendell-Rubin (VLMR) and adjusted Lo-Mendell-Rubin (aLMR) Likelihood Ratio Test (LRT) p -values (Tein et al., 2013). For the LPA, we began by testing a one-profile model and then incrementally tested models with one more class (tested one by one) until we discovered the first non-significant ($p > .05$) result. The first non-significant result appeared on the seven-profile model, leading to an extraction of six total profiles (see Table 2 for adjusted Lo-Mendell-Rubin p -values). To account for the likelihood of inflated Type I error, we performed a familywise correction to obtain a corrected alpha (Lövdén et al., 2018, Schuler et al., 2014). Due to interdependence of the profile solutions, we opted to use the more conservative Bonferroni correction (Abdi, 2007; Dunn, 1961) rather than Holm (1979) or Hochberg (1988) sequential variations. Therefore, we applied a correction (adjusted-alpha = $0.05 / 6 = .008$) with which to ascertain the optimal ($k - 1$ profile) model (see again, Table 2). We accepted the three-profile model after applying the corrected alpha to each solution. When using the corrected alpha, the first non-significant result was the four-profile model (with an obtained p -value larger than the corrected alpha). In fact, no additional solutions are typically considered after a non-significant result is found with fewer profiles (Lo et al., 2001; Nylund et al., 2007). Further, when examining AIC, and BIC after three profiles the values begin to flatten; additionally, the worsening of entropy values further strengthens confidence in the three-profile model. The three-profile model had excellent participant classification of 95% for Profile 1, 94% for Profile 2, and 93% for Profile 3 (see bolded numbers in Table 3).

Table 1. Descriptives of Study Primary Variables.

	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
Age	13	19	16.80	0.91	0.04	-0.12
Smartphone Addiction Scale-Short Version	10	60	32.59	11.11	0.11	-0.42
Generalized Anxiety Disorder-7	0	21	3.88	4.55	1.38	1.98
Social Interaction Anxiety Scale	1	69	22.75	14.58	0.70	-0.20
Fear of Missing Out Scale	10	50	24.45	7.63	1.01	0.70

Figure 2. Pearson Correlation Matrix Heat Map of Primary Variables.



Note. SAS-SV = Smartphone Addiction Scale-Short Version, FoMO = Fear of Missing Out, GAD = Generalized Anxiety Disorder, SIAS = Social Interaction Anxiety Scale. All correlations were positive and were significant at $p < .001$; a darker shade indicates a stronger correlation.

Table 2. Smartphone Addiction Scale Item Latent Profile Analysis Model Comparisons.

# of profiles	BIC	aBIC	Entropy	VLMR	p	aLMR	p	Bonferroni-corrected threshold
	6,6546.41	6,6482.87	NA	NA	NA	NA	NA	NA
2	6,1176.65	6,1078.17	0.87	5,452.19	< .001	5,386.84	< .001	0.008
3	5,9528.53	5,9395.10	0.87	1,730.56	< .001	1,709.8	< .001	0.008
4	5,8826.11	5,8657.73	0.84	784.85	0.021	775.45	0.021	0.008
5	5,8306.95	5,8103.63	0.85	601.59	0.020	594.38	0.020	0.008
6	5,8087.35	5,7849.08	0.86	302.04	0.004	298.42	0.004	0.008
7	5,7921.85	5,7648.64	0.86	247.92	0.345	244.95	0.345	0.008

Note. BIC = Bayesian Information Criterion; aBIC = adjusted BIC; VLMR = Vuong-Lo-Mendell-Rubin likelihood ratio test value; aLMR = adjusted LMR likelihood ratio test value; NA = not applicable (not possible to estimate values for one-profile model).

Figure 3 shows standardized mean SAS-SV item scores for the three-profile model. Three distinct but somewhat parallel profiles (proportion and probabilities shown in Table 3) were demonstrated. Profile 1 (Low PSU severity; $n = 600$, 33.4%) shows the lowest reporting of PSU on the SAS-SV items with a primarily flat appearance. Profile 2 (Moderate; $n = 896$, 49.9%) is similar in that it is primarily flat, with the emergence of dips and spikes for items three, *physical pain*, and nine, *tolerance*, on the scale. However, profile 3 (High; $n = 301$, 16.8%) is the most extreme in both levels of PSU and with defined spikes on several items from the SAS-SV. Physical pain continues to show lower score values in profile 3 compared to other item scores in this profile, but items four, *can't be without*, and five, *impatient and fretful*, as well as item six, *always on my mind*, and nine *tolerance* show notable spikes.

Table 3. Relative Proportions of Latent Profiles With Membership Probabilities.

Profile	Count	Proportion	Profile Membership Probability		
			1	2	3
1	600	33.39%	0.948	0.052	0.000
2	896	49.86%	0.033	0.938	0.029
3	301	16.75%	0.000	0.067	0.933

Figure 3. Three-Profile Smartphone Addiction Scale Latent Profile Analysis Model With Standardized Mean Item Scores (See Appendix for Complete SAS-SV Items).

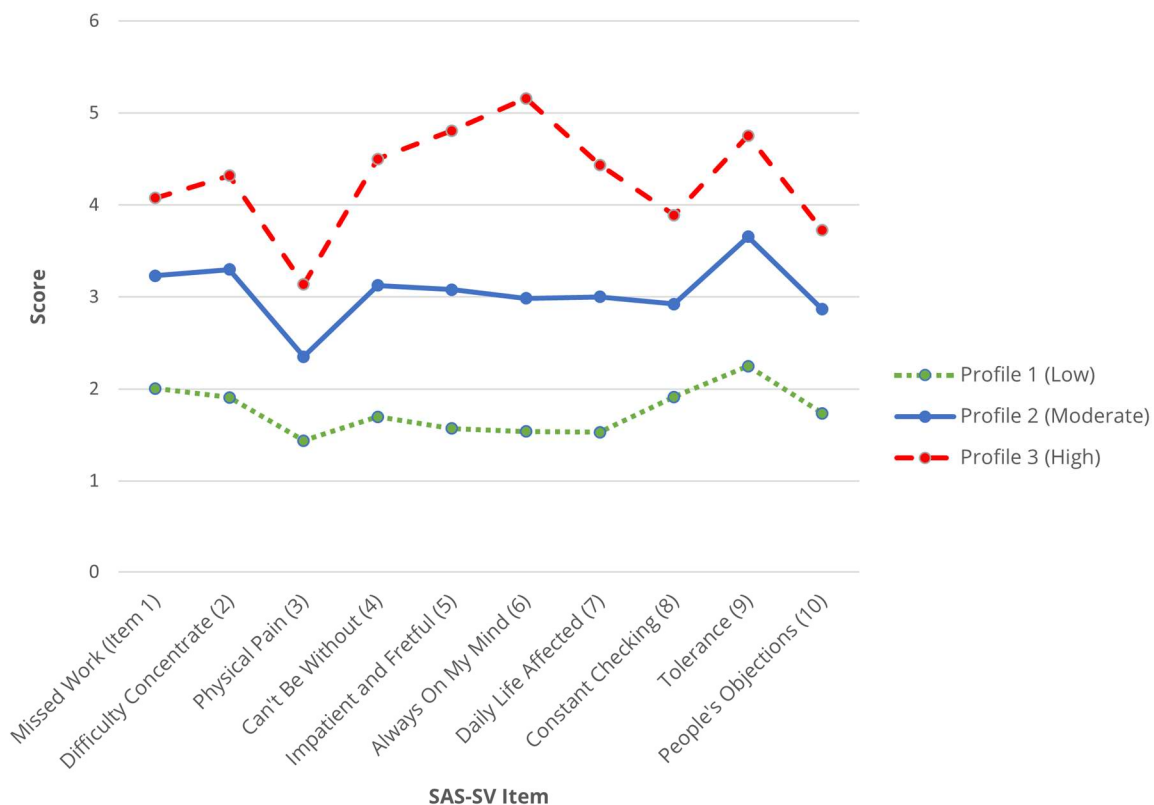


Table 4 displays unstandardized logistic regression coefficients and odds ratios for covariate relationships with SAS latent profile membership. Using profile 1 as the reference profile/class, we found that higher levels of measured covariates (but not sex) are more likely to be found in profile 2 than in profile 1, and more likely in profile 3 than in profile 1. We analyzed other parameterizations as well by modifying the reference profile. FoMO, GAD, and SAD severity were significant in those parameterizations (higher scores in profile 3 than profile 2), and sex remained non-significant. When using profile 2 as the reference, age failed to obtain significance. Odds ratios were slightly higher for FoMO and GAD severity (compared to SAD) in discriminating between more severe and less severe profiles.

Table 4. SAS Latent Profile Membership and Relationships With Covariates Using Multinomial Logistic Regression and the Vermont Three-Step Method.

Covariate	<i>B</i>	<i>SE</i> of <i>B</i>	<i>z</i> -score	<i>p</i>	Odds Ratio
Profile 2 (compared to reference Profile 1)					
Sex	0.19	0.13	1.44	.149	1.21
Age	0.16	0.07	2.38	.017	1.17
Fear of Missing Out	0.07	0.01	6.40	<.001	1.08
Generalized Anxiety Disorder	0.06	0.02	2.50	.012	1.06
Social Anxiety	0.03	0.01	4.13	<.001	1.03
Profile 3 (compared to reference Profile 1)					
Sex	0.31	0.18	1.71	.087	1.37
Age	0.20	0.10	2.13	.033	1.22
Fear of Missing Out	0.14	0.02	9.21	<.001	1.15
Generalized Anxiety Disorder	0.13	0.03	4.70	<.001	1.13
Social Anxiety	0.04	0.01	5.34	<.001	1.04

Note. For sex, *males* = 1, and *females* = 2 (i.e., significant positive regression coefficient indicates a higher profile is associated with the female sex).

Discussion

Analysis of the data collected from Chinese high school students revealed three latent profiles based on severity of PSU symptom ratings, consistent with our hypothesis (H1). All three profiles demonstrated relatively uniform severity levels across PSU items but were not completely parallel. Thus, we found some support for heterogeneity in PSU symptom presentations.

In addition, we found support for H2. FoMO severity was positively related to more severe latent profiles of PSU severity, consistent with prior work in the variable-centered literature on adolescents (Adrian, 2021; Lo Coco et al., 2020), as well as several mediation studies showing FoMO severity is related to PSU severity and other constructs (Wolniewicz et al., 2020; H. Yang et al., 2021; Yuan et al., 2021). In the sense that more severe profiles of PSU are related to more severe symptoms of FoMO, the results here further bolster evidence in support of FoMO's constituency as a cognitive influence on PSU in the I-PACE model (Brand et al., 2016; 2019).

Moreover, we found support for H3 in that reported GAD symptoms were significantly positively related to more severe latent profiles of PSU severity. The present study is the first that evaluated GAD symptoms related to latent profiles of PSU. Again, the I-PACE model provides a paradigm with which we could examine the psychopathology of GAD as a personal characteristic that influences PSU. Several correlational studies have shown that GAD symptoms are associated with PSU severity (Coyne et al., 2019; Guo et al., 2020). As well, recent variable-centered PSU and anxiety studies (Gorday, 2022; Ma, 2022) have demonstrated similar results to the present latent profiles in that anxiety is positively related to PSU. Therefore, it can be useful to look closer at the subgroups (or heterogeneity) within those populations to understand that relationship more thoroughly.

Furthermore, we found support for H4 as the present analysis demonstrated that reported symptoms of SAD were positively related to more severe latent profiles of PSU severity. The literature regarding latent profiles of PSU and SAD is developing, and the present analysis—notably within the paradigm of the I-PACE model—supports existing variable-centered work (Patel, 2022) and is additive to the existing work in the area of latent profiles. Of note, a recent study of Chinese university students (Yue et al., 2021) found that latent profiles of PSU were not significantly related to self-reported symptoms of SAD. As we have previously discussed, latent profiles allow for

a more granular look into a collection of data, its subgroups, and covariates. Because of these fluctuating results, further studies of SAD as a predictor of PSU should be conducted to assess not only social anxiety's relationship to PSU but also possible moderating (W. Hong et al., 2019) and mediating factors (Annoni et al., 2021; Emirtekin et al., 2019; Y.-K. Lee et al., 2016; You et al., 2019) that could be explaining the SAD-PSU relationship.

Lastly, we controlled for sex and age as covariates of latent profiles of PSU severity. Contrary to prior variable-centric works showing females engage in greater PSU severity (Busch & McCarthy, 2021; Claesdotter-Knutsson et al., 2021; S.-Y. Yang et al., 2018), in this study, we found no such significant relationship with PSU latent profiles. It is possible that because a majority of subjects reported being female ($n = 1,164$, 64.8%) in the present work, that a more balanced sample in terms of distribution of sexes would lead to a positive association with sex. We also observed that age was positively related to more severe latent profiles. Though we had a truncated age range of high school students, it is consistent with the literature that as age increases the amount of smartphone use increases as well (Andone et al., 2016; Csibi et al., 2021).

Data collection of a substantial sample ($N = 1,797$) demonstrated strong internal reliability on all measures and, as previously discussed, were normally distributed. However, the study had some limitations. We used self-report measures for GAD, FoMO, and SAD, rather than diagnostic interviews conducted in a clinical setting. Correlational tests cannot determine causation, and the cross-sectional design of the study should be interpreted as such. Also of note, the measures we used to collect data did not have adolescent Chinese versions. Therefore, the measures we employed were the validated adult Chinese versions, and this was a study limitation. This study was conducted at the start of the COVID-19 pandemic from February to March 2020; this may also limit the generalizability of the results.

Despite those limitations, the present study examining latent subgroups of Chinese high school students and relations with multiple anxiety constructs is novel and additive to a growing PSU LPA literature. Examination of latent profiles of PSU and relationships with psychopathology variables, social cognitive variables, sex/gender, and age should develop further. Future research can delve into other populations and additional measures of psychopathology and cognition related to the I-PACE model. As has been suggested in this paper, and by other researchers conducting LPA studies (L. Hong et al., 2022b; Liu et al., 2021; Moggia et al., 2023; Stănculescu & Griffiths, 2022), this kind of person-centered analysis can help to identify anxiety types (rather than anxiety overall) and inform more fine-tuned future treatment plans of those subgroups who might be more susceptible to PSU and other mobile internet use disorders. Extensive literature at the variable-centric level has shed light on this subject, and to continue to define that body of work using LPA can and will serve to refine our knowledge and enlighten strategies for approaching PSU.

Conflict of Interest

The authors report no conflicts of interest with the studies included in this paper.

Outside the scope of the present work, Williams is employed full-time as a technology consultant and people manager at a multinational corporation focusing on information technology, data science, and decarbonization; he is a full-time Ph.D. student at the University of Toledo.

Elhai notes that he receives royalties for several books published on posttraumatic stress disorder (PTSD); is a paid, full-time faculty member at the University of Toledo; occasionally serves as a paid expert witness on PTSD legal cases; and receives grant research funding from the U.S. National Institutes of Health.

For reasons of transparency Montag mentions that he has received grants from agencies such as the German Research Foundation (DFG). 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 gaming or social media companies. Montag mentions that he is part of a discussion circle (Digitalität und Verantwortung: <https://about.fb.com/de/news/h/gesprachskreis-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 an independent scientist on the scientific advisory board of the The Nymphenburg Group (Munich, Germany). This activity is financially compensated. Moreover, he is on the scientific advisory board of Applied Cognition (Redwood City, CA, USA), an activity which is also compensated.

Authors' Contribution

Joshua R. Williams: writing—original draft. **Cornelia Sindermann:** writing—review & editing. **Haibo Yang:** investigation, writing—review & editing. **Christian Montag:** writing—review & editing. **Jon D. Elhai:** conceptualization, data curation, formal analysis, supervision, writing—review & editing.

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Appendix

Smartphone Addiction Scale-Short Version Items

1. Missing planned work due to smartphone use.
2. Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use.
3. Feeling pain in the wrists or at the back of the neck while using a smartphone.
4. Won't be able to stand not having a smartphone.
5. Feeling impatient and fretful when I am not holding my smartphone.
6. Having my smartphone in my mind even when I am not using it.
7. I will never give up using my smartphone even when my daily life is already greatly affected by it.
8. Constantly checking my smartphone so as not to miss conversations between other people on Twitter or Facebook.
9. Using my smartphone longer than I had intended.
10. The people around me tell me that I use my smartphone too much.

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