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The influence of depressive symptoms and fear of missing out on severity of problematic smartphone use and Internet gaming disorder among Chinese young adults: A three-wave mediation model

Guangzhe Yuan^a, Jon D. Elhai^{b,c}, Brian J. Hall^{d,*}^a Department of Psychology, University of Macau, Macao (SAR), People's Republic of China^b Department of Psychology, University of Toledo, 2801 W. Bancroft Street, Toledo, OH 43606, USA^c Department of Psychiatry, University of Toledo, 3000 Arlington Ave., Toledo, OH 43614, USA^d Global and Community Mental Health Research Group, New York University Shanghai, Shanghai, People's Republic of China

HIGHLIGHTS

- Depression symptoms related to severity of Internet gaming disorder (IGD) and problematic smartphone use (PSU).
- Fear of missing out (FoMO) partially mediated the relationship between depression symptoms and PSU severity.
- IGD severity partially mediated the association between depression symptoms and PSU severity.

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ABSTRACT

Internet gaming disorder (IGD) and problematic smartphone use (PSU) symptoms are associated with increased depression symptom severity across studies. The current study aimed to examine the fear of missing out (FoMO) as a possible mediator in this relationship. We employed a three-wave longitudinal design among 341 Chinese university students. Results indicated that depression severity was significantly related to increased symptoms of PSU and IGD symptoms. FoMO significantly mediated the linkage between depression and PSU severity. IGD symptoms also partially mediated the relation between FoMO and PSU severity. This longitudinal study demonstrates the key role of FoMO in the linkage between psychopathology symptoms and Internet-related overuse.

1. Introduction

Video games are popular among youth worldwide (Gnambs, Stasielowicz, Wolter, & Appel, 2020), and when used in moderation, they are useful for stress relief, having fun, and to socialize with others. Internet gaming when used excessively becomes pathological, and Internet gaming disorder (IGD) may result (King & Delfabbro, 2019). According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), IGD is characterized as “persistent and recurrent use of the Internet to engage in games, often with other players, leading to clinically significant impairment or distress” (American Psychiatric Association, 2013; p. 795). Estimates suggest that around 2.0% of young adults may experience IGD (e.g., Chiu, Pan, & Lin, 2018; Wartberg et al., 2017; Wu, Chen, Tong, Yu, & Lau, 2018). Emerging evidence demonstrates that

IGD symptoms are related to psychological health, social functioning, and behavioral problems, such as symptoms of depression (Choi et al., 2017; Wang, Cho, & Kim, 2018; Yen, Lin, Chou, Liu, & Ko, 2019), anxiety (Bonnaire & Baptista, 2019; Stavropoulos & Adams, 2017; Wang et al., 2017), low self-esteem (Beard & Wickham, 2016; Beard, Haas, Wickham, & Stavropoulos, 2017; Lemmens & Valkenburg, 2015), aggressive behaviors (Evren, Evren, Dalbudak, Topcu, & Kutlu, 2019; Liang, Yu, Chen, Xie, Wu, Xing, & Dou, 2019; Zhai et al., 2020), and poor sleep quality (Hawi, Samaha, & Griffiths, 2018; Lam, 2014; Satghare et al., 2016). However, most of this research is based on cross-sectional studies, with only a few longitudinal studies examining risk or protective factors predicting IGD symptoms over time. Given the negative consequences of IGD, it is crucial to explore the possible psychological mechanisms of IGD symptoms utilizing longitudinal designs.

Associations between mental health problems and IGD symptoms

* Corresponding author at: New York University Shanghai, 1555 Century Avenue, Pudong, Shanghai 200122, People's Republic of China.

E-mail address: brianhall@nyu.edu (B.J. Hall).

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have been evaluated in non-clinical and clinical samples (i.e., IGD treatment-seekers). For instance, in a sample of 263 patients with IGD and 153 without IGD, [Hyun et al. \(2015\)](#) tested a hierarchical regression model and found that psychopathological symptom severity (depression, anxiety, attention deficit hyperactivity disorder, and impulsivity) were significantly linked to IGD symptoms. [Beck \(1976\)](#) claimed that depressive individuals have thoughts about the self as essentially unlovable or worthless, but online games provide a way of compensating for these deficiencies, which enable them to develop a sense of acceptance and belonging ([King & Delfabbro, 2019](#)). Therefore, depression is considered one of the most influential risk factors for IGD ([Carli et al., 2013](#)).

More importantly, the predominant conceptualization is that mental health symptoms can drive excessive internet use, rather than the reverse ([Brand, Young, Laier, Wöfling, & Potenza, 2016](#); [Kardefelt-Winther, 2014](#)), which was supported by previous empirical research findings ([Gámez-Guadix, 2014](#); [Liu, Liu, & Yuan, 2020](#); [Strittmatter et al., 2016](#); [Wartberg, Zieglmeier, & Kammerl, 2020](#)). The fear of missing out (FoMO) is a mental health-related construct which may drive excessive internet technology use.

In the literature, the term “FoMO” has been defined as the fear involving worry and concern that other people are having more rewarding experiences, or acquiring more useful information, than the individual ([Przybylski, Murayama, DeHaan, & Gladwell, 2013](#)). Previous research suggested that FoMO might be a product of depression symptoms. The social selection hypothesis posits that psychological distress adversely affects people’s social position or factors related to one’s social position, such as stressful life events ([Hurst, 2007](#)). A longitudinal study found that people with elevated depressive symptoms were likely to report experiencing high levels of stressful life events ([Kim, Conger, Elder, & Lorenz, 2003](#)). People with depressive symptoms and stressful experiences tend to report that they are unable to join social activities due to depressed mood, lack of energy and lack of interest ([de Wit et al., 2010](#); [Holtfreter, Reising, & Turanovic, 2017](#)). They may miss important or enjoyable activities due to depressive symptom severity ([Steger & Kashdan, 2009](#)), and feel apprehensive about worsening symptoms rendering them unable to join in pleasurable activities with others ([Qian, Cao, & Huang, 2019](#)), which might make them afraid to miss some valuable events/activities and what others have done, resulting in high levels of FoMO ([Beyens, Frison, & Eggermont, 2016](#)).

Additionally, FoMO includes apprehension of missing rewarding and pleasurable experiences, with the unmet social needs to connect with others via social network ([Przybylski et al., 2013](#)), which is conceptualized to be caused by depressive symptoms ([Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017](#); [Wegmann, Oberst, Stodt, & Brand, 2017](#)). Unmet social needs play a major role in problematic Internet/technology use ([Dempsey, O’Brien, & Tiarniyu, 2019](#); [King & Delfabbro, 2016](#); [Wegmann et al., 2017](#)), suggesting that FoMO may be a crucial variable in the relationship between depression and excessive Internet/technology usage. Moreover, vulnerable people with negative emotions and FoMO are prone to view Internet games as an approach of gaining positive social feedback and acceptance ([King & Delfabbro, 2019](#)), since video games can provide a rewarding environment to escape from reality and cope with apprehension of missing pleasurable experiences ([King & Delfabbro, 2019](#)). Individuals who quit online cooperative games before game partners leave may experience FoMO or feel guilty ([Przybylski et al., 2013](#)). In order to deal with worrying about not maintaining their online social status and character level progression in line with the gaming group, gamers may feel the need to play regularly to avoid FoMO and be likely to continue playing with partners, leading to more IGD symptoms ([King & Delfabbro, 2019](#); [Przybylski et al., 2013](#)). Thus, FoMO might play a mediating role in the association between depression and excessive Internet use (e.g., IGD and problematic smartphone use).

Three lines of research suggest that FoMO might be a potential

mediating mechanism underlying the relationship between depressive symptoms and Internet overuse such as IGD symptoms. First, recent studies have found that severity of depression is positively related to FoMO ([Elhai, Gallinari, Rozgonjuk, & Yang, 2020](#); [Elhai, Yang, Fang, Bai, & Hall, 2020](#); [Sela, Zach, Amichay-Hamburger, Mishali, & Omer, 2020](#); [Wolniewicz, Rozgonjuk, & Elhai, 2020](#)). Second, several researchers have pointed out a positive association between FoMO and internet overuse such as IGD ([Duman & Ozkara, 2019](#); [Elhai, Yang, & Montag, 2020](#); [King & Delfabbro, 2019](#)). Third, depressive symptoms are positively associated with IGD symptoms ([Burleigh, Stavropoulos, Liew, Adams, & Griffiths, 2018](#); [Griffiths, Kuss, Billieux, & Pontes, 2016](#); [Li, Liau, & Khoo, 2011](#); [Ryu et al., 2018](#)). Therefore, FoMO might play an essential role in the relationship of depression and IGD symptoms. In this study, we explored the possible mediating role of FoMO on the association between depression and IGD severity, utilizing a longitudinal study design.

In order to understand IGD, knowledge of the potential factors and mechanism for such internet technology overuse is necessary. Previous research indicated that problematic smartphone use (PSU) severity shares similar characteristics with other types of internet overuse (e.g., IGD), and the high accessibility and various smartphone applications would contribute to such overuse ([Lin, Lin, & Yang, 2017](#)). Recently, research on PSU has notably increased ([Panova & Carbonell, 2018](#)) and found that PSU severity is associated with a wide variety of indicators of psychosocial functioning including psychopathology symptoms ([Boumosleh & Jaalouk, 2017](#); [Contractor, Weiss, & Elhai, 2019](#); [Elhai, Dvorak, Levine, & Hall, 2017](#)), social relationship functioning ([Elhai, Levine et al., 2018](#); [Hawi & Samaha, 2017](#); [Kim & Koh, 2018](#)), and academic performance ([Samaha & Hawi, 2016](#); [Xu et al., 2019](#); [Yang, Asbury, & Griffiths, 2019](#)). Similar to IGD, both depression severity and FoMO are found related to PSU severity ([Demirci, Akgönül, & Akpınar, 2015](#); [Elhai, Levine, Alghraibeh, Alafnan, Aldraiweesh, & Hall, 2018](#); [Elhai, Levine, O’Brien, & Armour, 2018](#); [Elhai, Tiarniyu, & Weeks, 2018](#); [Elhai, Yang, & Montag, 2019](#); [Wolniewicz et al., 2020](#)). Although a recent study found no longitudinal cross-lagged associations between FoMO and PSU among Italian adolescents ([Lo Coco et al., 2020](#)), many studies have found that FoMO related to PSU severity in various samples of Chinese young adults ([Elhai, Yang, Fang, Bai, & Hall, 2020](#); [Elhai, Yang, Rozgonjuk, & Montag, 2020](#); [Han, Liu, & Xiao, 2019](#)). A recent review paper also pointed out that FoMO usually evidences large associations with PSU ([Elhai, Yang, & Montag, 2020](#)). As previously mentioned, there may be a close relationship between depressive symptoms and FoMO, and thus FoMO might mediate the linkage between depression and PSU severity among Chinese young adults.

No study explored how PSU is related to IGD symptoms. As an exploratory aim of the study, we attempted to examine PSU as a potential mediator in the association between PSU and IGD symptoms. [Liu, Lin, Pan, and Lin \(2016\)](#) found that individuals who use smartphones for playing games scored significantly higher on a measure of Internet addiction than non-gamers, suggesting increased PSU might lead to more susceptibility to IGD symptoms due to the frequent smartphone. Moreover, people grow tolerance toward games on smartphones ([King & Delfabbro, 2019](#)). It is possible that depressed individuals who need more and bigger types of gaming and online socialization may gravitate to the larger screens like computers that are more commonly associated with IGD symptoms and have many more features in gaming than you can find on a smartphone application, because of the small screen and limited features on smartphones. Therefore, PSU might be a potential mediator between depressive symptoms and IGD symptoms.

1.1. Theoretical links

The theoretical foundations for the proposed research are Compensatory Internet Use Theory (CIUT; [Kardefelt-Winther, 2014](#)) and the Interaction of Person-Affect-Cognition-Execution (I-PACE) model ([Brand et al., 2016](#)), which could accommodate FoMO as a

potential mediator of the association between depression and both PSU and IGD severity.

According to CIUT (Kardefelt-Winther, 2014), excessive, or problematic Internet/technology use is a maladaptive coping strategy utilized to alleviate negative emotions. CIUT posits that many individuals attempt to relieve psychological distress by engaging in excessive technology usage (such as PSU and IGD) after experiencing stressful events. Thus, individuals experiencing affective psychopathology symptoms, such as depression, are more likely to increase technology use to reduce their stress and regulate negative emotions. Several studies have used CIUT to conceptualize depressive symptoms as driving problematic Internet/technology use (Elhai, Levine, O'Brien, & Armour, 2018; Elhai, Yang, Fang, Bai, & Hall, 2020; Rozgonjuk, Levine, Hall, & Elhai, 2018). Based on this model, we hypothesized depression as a possible predictor of IGD and PSU severity.

The I-PACE model presents a comprehensive theoretical framework that attempts to explain the mechanism of Internet-related overuse. It highlights three components in the development of internet overuse, including individual's core characteristics, responses to individual's core characteristics related to resilience and risk variables, and consequences of gaming or another Internet applications (Brand et al., 2016). Core characteristics includes biopsychological constitution, personality, psychopathology, social cognitions, and specific motives for usage. The second component (affective and cognitive responses) consists of four factors, which are: Internet-related cognitive and attention bias, expectancies about Internet usage, coping style, and inhibitory control and craving, which are conceptualized to mediate or moderate associations between the first component (core characteristics) and the third component (consequences of gaming or another Internet applications) (Brand et al., 2016, 2019). The I-PACE model explicitly discusses affective and cognitive responses like internet-related cognitive biases to be products of psychopathology, influencing excessive internet use, and mediate relations between psychopathology and excessive internet use (Elhai, Yang, & Montag, 2019). This theory has been empirically supported in studies of IGD and other internet overuse behaviors (Dhir, Yossatorn, Kaur, & Chen, 2018; Duke & Montag, 2017; Elhai, Yang, Fang, Bai, & Hall, 2020; Saunders et al., 2017).

1.2. The current study

While it is theoretically plausible that FoMO could mediate the relationship between depression severity and both PSU and IGD symptoms, no empirical research has examined this specific linkage. In this study, we employed a 12-month longitudinal design (three waves with assessments six months apart) to investigate the association between depression severity and PSU/IGD via the possible mediating variable of FoMO among Chinese youth. Since relatively few studies have explored the relation between PSU and IGD symptoms, we compared four alternative mediation models (Fig. 1) to identify which best fits the data. Hypothesized Model 1 (Fig. 1a) proposes FoMO to fully mediate the relations between depression and PSU/IGD severity. Hypothesized Model 2 (Fig. 1b) proposes FoMO to partially mediate the relations between depression and both PSU and IGD severity. Hypothesized Model 3 (Fig. 1c) proposes FoMO and PSU severity to mediate the relation between depression and IGD symptoms. Hypothesized Model 4 (Fig. 1d) proposes FoMO and IGD to mediate the relation between depression and PSU severity.

2. Method

2.1. Participants and procedure

Data were drawn from a longitudinal research study on the psychological adjustment and mental health among Chinese young adults. Participants were recruited from University of Macau in Macao (SAR)

China with the support of the student affairs office. At the baseline of the study there were 9782 Chinese students studying at the university (Hall et al., 2019), of whom 1809 agreed to participate in the longitudinal study via the university email system through which students received the research advertisement. In this study, data were collected in 3 waves, 6-months apart: (wave 1) Autumn semester, 2017 (valid $N = 1809$; 66.1% female; $M_{age} = 19.90$, $SD = 2.57$), (wave 2) Spring semester, 2018 (valid $N = 981$; 70.4% female; $M_{age} = 20.85$, $SD = 2.80$), (wave 3) Autumn semester, 2018 (valid $N = 341$; 75.7% female; $M_{age} = 21.24$, $SD = 2.72$). The final sample included 341 participants who completed the measures at three waves.

This study was approved by the Research Ethics Committee of the University of Macau. All participants were informed of the study purpose and procedures and provided consent to participate. Self-report questionnaires were distributed electronically to all students at the University of Macau by email at three time periods (September 21, 2017 – December 6, 2017; April 3, 2018 – May 3, 2018; September 3, 2018 – October 3, 2018). A lottery with a cash prize of 100 Macau Patacas (approximately USD \$13.00) for 50 people was offered as an incentive for study participation at every wave.

2.2. Measures

2.2.1. Internet gaming disorder

IGD symptoms were evaluated by the Chinese version of the Internet Gaming Disorder Questionnaire (Petry et al., 2014). In this study, we used this scale to measure participants' IGD severity within the past year at wave 3. The questionnaire includes nine items, each rated on a dichotomous yes/no scale in which a "yes" response was scored as 1 and a "no" response was scored as 0. Examples of the items include, "Do you feel the need to engage in Internet games with increasing amounts of time in order to achieve satisfaction?", "Have you deceived family members, therapists, or others regarding the amount of Internet gaming?", and "Do you feel irritable, anxious, or sad when Internet gaming is taken away?". Higher total score of the scale represents higher level of IGD symptoms. The Chinese version of the Internet gaming disorder questionnaire has been validated in Chinese samples (Petry et al., 2014; Sigerson, Li, Cheung, Luk, & Cheng, 2017). In this study, the scale demonstrated adequate internal consistency (Cronbach's α was 0.82).

2.2.2. Problematic smartphone use

We used the Chinese version of Smartphone Addiction Scale-Short Version (SAS-SV; Kwon, Kim, Cho, & Yang, 2013) to assess current PSU severity at wave 3. The SAS-SV asks participants to rate ten items on a 6-point scale from 1 (Strongly disagree) to 6 (Strongly agree). Sample items include, "Missing planned work due to smartphone use", "The people around me tell me that I use my smartphone too much", and "Having my smartphone in my mind even when I am not using it". Higher total score of the scale represents greater level of PSU. In previous studies of Chinese samples, the SAS-SV showed good reliability and construct validity (Luk et al., 2018; Xiang, Wang, & Ma, 2019). In the present study, the scale demonstrated adequate internal consistency (Cronbach's α was 0.92).

2.2.3. Depression

The symptoms of depression at wave 1 were measured by the Chinese version of the Depression Anxiety Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995). The depression subscale consists of 7 items, each rated on a four-point scale from 0 (never) to 3 (almost always). Examples of the items include, "I felt that life was meaningless", "I was unable to become enthusiastic about anything", and "I felt I was not worth much as a person". Higher total score of the scale represents more severe depression. This subscale was applied to Chinese samples with good validity and reliability (Wang et al., 2016; Yang et al., 2017). In this study, the scale demonstrated adequate internal consistency

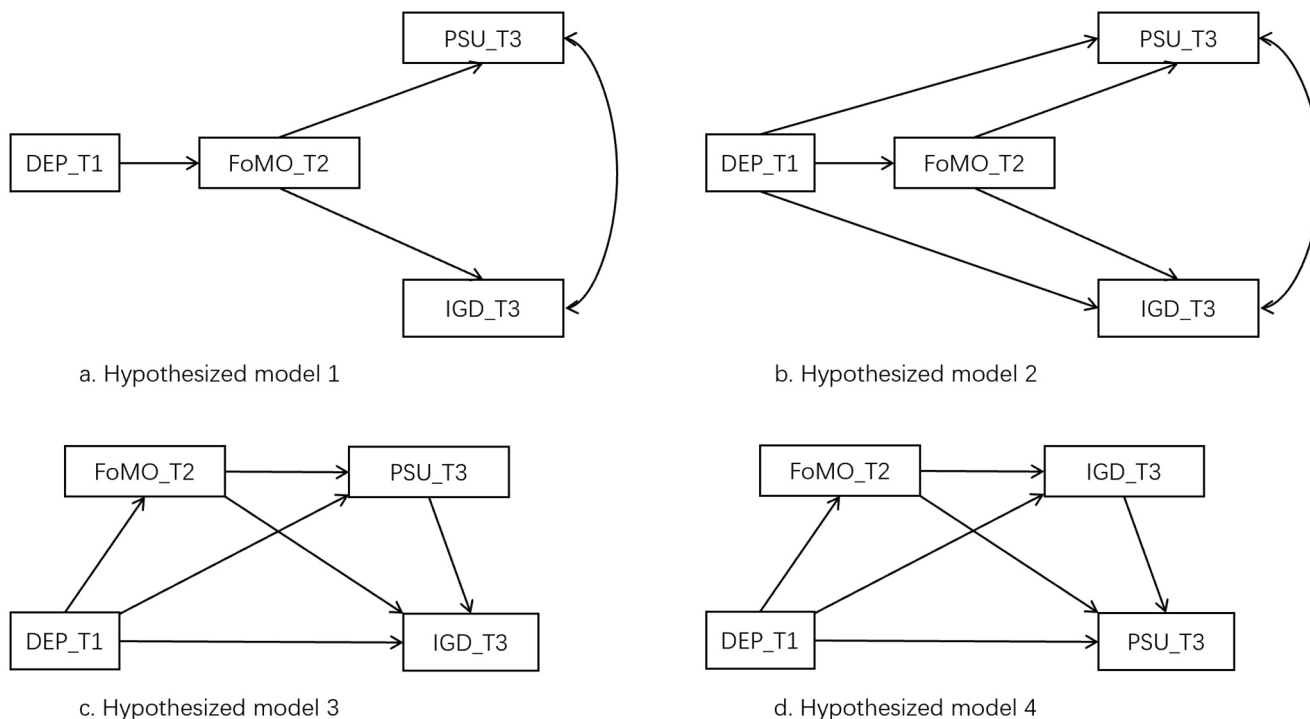


Fig. 1. Hypothesized models Note: DEP = depression, FoMO = fear of missing out, PSU = problematic smartphone use, IGD = Internet gaming disorder.

(Cronbach’s α was 0.89).

2.2.4. FoMO

FoMO at wave 2 was measured by the Chinese version of the FoMO scale (Przybylski et al., 2013) which is a 10-item questionnaire, with response options ranging from 1 (Not at all true of me) to 5 (Extremely true of me). Sample items include, “I get worried when I find out my friends are having fun without me”, “Sometimes, I wonder if I spend too much time keeping up with what is going on”, and “When I go on vacation, I continue to keep tabs on what my friends are doing”. Higher total score of the scale represents higher level of FoMO. This scale has shown good reliability and construct validity in Chinese samples (Xie, Wang, Wang, Zhao, & Lei, 2018; Zhang, Jiang, Ding, & Hong, 2019). In this sample, the scale demonstrated good internal consistency (Cronbach’s α was 0.93).

2.3. Data analysis

The analyses were conducted using SPSS 23.0 and Amos 21.0. No missing data were evident since consenting participants were prompted to complete all items. We summed each scale’s items for a total score. Our model’s variables were normally distributed; the highest skewness value (in absolute size) was 1.72 (IGD), and for kurtosis was 2.60 (FoMO).

Descriptive analysis and correlations were computed for the study variables. A structural equation modelling (SEM) approach was used to analyze the longitudinal mediation relationships between depression, FoMO, PSU, and IGD symptoms. Furthermore, we added age and gender into hypothesized models as covariates, as they may be associated with PSU and IGD severity (Elhai, Yang, Fang, Bai, & Hall, 2020; Müller et al., 2015). We compared four hypothesized models to identify which best fits the data in the current study. To test the hypothesized mediation effect for statistical significance using AMOS, bootstrapping was applied using 5000 bootstrapped replications. Maximum likelihood estimation was used to estimate the parameters. The indices that measured the model’s goodness-of-fit included the ratio of χ^2 to the degree of freedom, Tucker-Lewis index (TLI), comparative fit index

(CFI), standard root mean square residual (SRMR), and root mean square error of approximation (RMSEA). For an index to be acceptable, the ratio of χ^2 to the degree of freedom should not exceed 5.0, TLI and CFI should exceed 0.90, SRMR should be smaller than 0.06, and RMSEA should be smaller than 0.08 (West, Taylor, & Wu, 2012).

3. Results

Table 1 provides descriptive statistics including means, standard deviations and intercorrelations of the study variables, which show significant correlations between depression, FoMO, PSU, and IGD symptoms.

According to Elhai, Yang, Fang et al.’s (2020) study, we modeled four study variables as observed variables in SEM. We then tested four alternative mediation models in which age and gender were inserted as covariates. Table 2 shows the fit indices of all four hypothesized models, and the result of the χ^2 difference test that showed Model 3 & 4 are significantly better than Model 1 & 2. Based on Table 2, we chose hypothesized model 4 as the final model since the model fit results of Model 4 are better than Model 3. Fig. 2 illustrates the path coefficients of the model, which indicates that depression severity had an indirect effect on PSU severity through FoMO (the size of indirect effect = 0.144). IGD symptoms partially mediated the relation between depression severity and PSU severity (the size of indirect effect = 0.011).

Table 1 Means, standard deviations, and correlations among study variables.

	M \pm SD	1	2	3	4
1. T1 Depression	7.64 \pm 8.10	-			
2. T2 FoMO	25.05 \pm 9.30	0.315***	-		
3. T3 PSU	35.23 \pm 10.58	0.254***	0.248***	-	
4. T3 IGD	1.30 \pm 1.98	0.256***	0.114*	0.299***	-

Note: FoMO = fear of missing out, IGD = Internet gaming disorder, PSU = Problematic smartphone use.

*** $p < .001$; * $p < .05$.

Table 2
Fit indices for hypothesized model.

Hypothesized Model	χ^2	<i>p</i>	<i>df</i>	χ^2/df	CFI	TLI	SRMR	RMSEA (90% CI)	Δ
1	83.074	0.000	10	8.307	0.520	0.280	0.101	0.147 (0.118–0.177)	–
2	35.391	0.000	8	4.424	0.820	0.663	0.059	0.100 (0.068–0.135)	$\Delta\chi^2(2) = 47.683, p < .001$
3	13.323	0.065	7	1.903	0.958	0.911	0.039	0.052 (0.000–0.093)	$\Delta\chi^2(1) = 22.068, p < .001$
4	11.255	0.128	7	1.608	0.972	0.940	0.039	0.042 (0.000–0.086)	–

4. Discussion

The present three-wave longitudinal research was designed to examine the possible mediating role of FoMO in the linkage between depression and both PSU and IGD symptoms in a sample of Chinese university students. The current study is the first longitudinal study to highlight the significant mediating role of FoMO as a potential underlying mechanism that can explain the association between depressive symptoms and both PSU and IGD symptoms.

Consistent with CIUT (Kardefelt-Winther, 2014) and previous studies (e.g., Demirci et al., 2015; Hyun et al., 2015), the results showed that depression at baseline had a direct and positive relation to both PSU and IGD symptoms over time. This finding indicates that individuals reporting more severe depressive symptoms, compared with others with less depression severity, may be more likely to engage in excessive smartphone use and Internet games.

The direct association between depression and PSU severity was still significant when the mediator FoMO was inserted into the linkage, revealing that FoMO partially mediated this relationship, which is consistent with the I-PACE model (Brand et al., 2016) and prior research (Elhai, Gallinari, Rozgonjuk, & Yang, 2020). This finding suggests that depressive symptoms might exacerbate the level of FoMO (Elhai, Yang, Fang, Bai, & Hall, 2020), and in turn increase PSU levels (Elhai, Levine, Alghraibeh et al., 2018). One possible reason is that individuals with depression may attempt to alleviate their mood by focusing on others' experiences and trying to fit in with them (Nunstedt, Nilsson, Skärsäter, & Kylén, 2012), but in doing so FoMO could exacerbate internet use and lead to functional impairments of such use (Elhai, Yang, Rozgonjuk, & Montag, 2020). This finding supports the I-PACE model (Brand et al., 2016) suggesting FoMO as a cognitive bias variable that may mediate the association between psychopathology and excessive Internet usage (Elhai, Yang, Fang, Bai, & Hall, 2020; Wegmann et al., 2017; Wolniewicz et al., 2020; Wolniewicz, Tiamiyu, Weeks, & Elhai, 2018). This partial mediation result also suggests that

there are some other possible mediators in this linkage, such as social usage frequency (Elhai, Levine, Dvorak, & Hall, 2017), boredom proneness (Elhai, Vasquez, Lustgarten, Levine, & Hall, 2018), and mindfulness (Elhai, Levine, O'Brien, & Armour, 2018).

However, inconsistent with our hypothesis and past research (Duman & Ozkara, 2019), we discovered that FoMO did not predict IGD symptoms in the model, showing that FoMO was not significant as a mediator between depression and IGD symptoms. One possible explanation is that people with high levels of depressive symptoms and high levels of FoMO might tend to play games for relaxation or fun rather than achievement or advancement to relieve depressive symptoms (King & Delfabbro, 2019). These people are at less risk of development IGD symptoms (King & Delfabbro, 2019). In other words, different from smartphones that are most often utilized for necessary social interactions (e.g., messaging, email, phone calls, video calls), videogaming could just as easily be done without socializing intent (King & Delfabbro, 2019). Therefore, FoMO may especially drive problematic smartphone use, but it may only drive IGD for some individuals (not as a strong relationship for FoMO with IGD).

It is interesting that we found PSU severity partially mediated relations between depression and IGD symptoms. This finding indicates that people with high levels of depressive symptoms may tend to spend more time on Internet games, and then be overuse smartphones. It is possible that individuals with a high levels of depressive symptoms would play Internet games for relieving depression and escaping from real-life problems (Stetina, Kothgassner, Lehenbauer, & Kryspin-Exner, 2011). This behavior, however, could hardly relieve their depressive symptoms (King & Delfabbro, 2019), and in turn lead to more problematic smartphone use to have fun (Liu et al., 2016).

In our mediation model, we should also note that gender was a significant predictor of PSU severity, supporting previous findings (Elhai, Levine, O'Brien, & Armour, 2018; Elhai, Yang, Fang, Bai, & Hall, 2020). However, we did not find age related to PSU severity. Age has been found related to PSU severity (Elhai et al., 2020; Elhai, Yang,

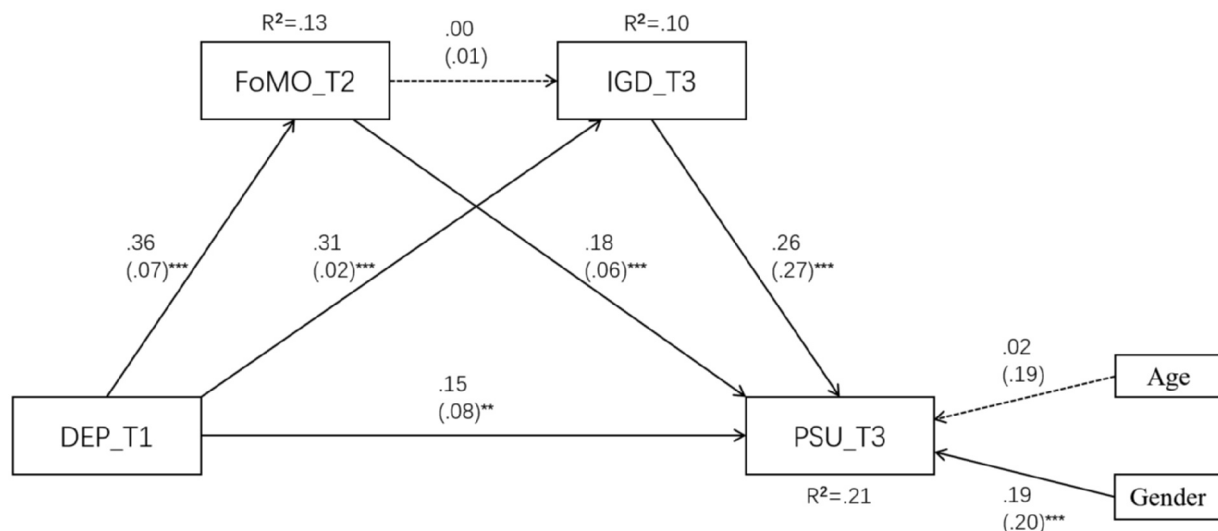


Fig. 2. Mediation model with standardized path coefficients, SEs (in parentheses) and significance levels added Note: Dashed lines represent insignificant paths. DEP = depression, FoMO = fear of missing out, PSU = Problematic smartphone use, IGD = Internet gaming disorder. *** $p < 0.001$, ** $p < 0.01$.

Fang, Bai, & Hall, 2020), but not in others (Elhai, Levine, O'Brien, & Armour, 2018; Wolniewicz et al., 2020).

Several study limitations need to be acknowledged. First, causal inferences related to the temporal nature and directed influences of associations between depression, FoMO, PSU, and IGD symptoms cannot be drawn without experimental designs, although data from this study are longitudinal with three waves (Fried & Cramer, 2017; Lazarov, Suarez-Jimenez, Levi, Coppersmith, Lubin, Pine, Bar-Haim, & Abend, 2019). Second, associations between the study variables might be affected by systematic error as all variables were measured by self-report scales (Richardson, Simmering, & Sturman, 2009), which might lead to some potential bias in estimating relationships. Future studies should consider objective measure of technology use that would be more accurate (Elhai, Tiamiyu et al., 2018; Rozgonjuk et al., 2018). Third, the mediation model did not control for the initial levels of the dependent variables, which should be considered in the future research.

Despite the limitations, findings of this study have several important implications for future research and clinical practice. The current study highlights the important role of FoMO in the association between depression with both PSU and IGD symptoms. Elhai et al.' study (2018) highlights the key role of mindfulness in the relationship to excessive technology use. Therefore, Mindfulness-based therapy, a popular form of cognitive treatment that could alleviate depressive symptoms (Hofmann & Gómez, 2017; Hofmann, Sawyer, Witt, & Oh, 2010), which was shown to be useful among Chinese students (Hall et al., 2018), and may decrease FoMO (Baker, Krieger, & LeRoy, 2016), should be considered as an effective approach to treat smartphone addiction and IGD.

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CRediT authorship contribution statement

Guangzhe Yuan: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing - original draft. **Jon D. Elhai:** Conceptualization, Investigation, Methodology, Writing - review & editing. **Brian J. Hall:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing - original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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