AKADÉMIAI KIADÓ

Journal of Behavioral Addictions

13 (2024) 1, 102–119

DOI:
10.1556/2006.2023.00081

FULL-LENGTH REPORT

The impact of long-term online learning on social anxiety and problematic smartphone use symptoms among secondary school students with different levels of fear of missing out: Evidence from a symptom network and longitudinal panel network analysis

YANQIANG TAO[1,2], QIHUI TANG[1,2], SHUJIAN WANG[1,2], XINYUAN ZOU[1,2], ZIJUAN MA[3], LIANG ZHANG[4], GANG LIU[5*] and XIANGPING LIU[1,2**]

[1] Faculty of Psychology, Beijing Normal University, Beijing, 100875, China

[2] Beijing Key Laboratory of Applied Experimental Psychology, National Demonstration Center for Experimental Psychology Education, Beijing, 100875, China

[3] School of Psychology, South Normal University, Guangzhou, 510631, China

[4] College Students' Mental Health Education Center, Northeast Agricultural University, Harbin 150030, China

[5] Department of Psychiatry, Affiliated Nanjing Brain Hospital, Nanjing Medical University, Nanjing, 210029, China

Received: March 8, 2023 • Revised manuscript received: September 4, 2023; November 9, 2023 • Accepted: December 16, 2023
Published online: January 9, 2024

ABSTRACT

Background: The advancement of communication technology and the impact of the COVID-19 pandemic have led to an increased reliance on online education. However, the effects of the long-term use of smart devices for online learning on students' social anxiety and problematic smartphone use (PSU) and the role of fear of missing out (FoMO) in this process have yet to be fully explored. *Methods:* This study analysed longitudinal data from 2,356 high school students (female = 1,137 (48.26%), $mean_{age}$ = 13.84, SD_{age} = 1.37) in China, divided into high- and low-FoMO groups based on their scores on the FoMO scale, to examine the impact of four months of online learning on social anxiety and PSU. The Social Anxiety Scale (SAS) and Mobile Phone Addiction Index (MPAI) were used to assess social anxiety and PSU symptoms. *Results:* The undirected symptom networks revealed more bridge symptoms among the students in the high-FoMO group, although their overall symptom scores decreased. The results of the directed cross-lagged panel networks showed that "productivity loss" predicted other symptoms in the low-FoMO group but that "afraid of negative evaluation" was the predictor in the high-FoMO group. Meanwhile, "withdrawal/escape" and "productivity loss" were the symptoms that were most affected by other symptoms in the high-FoMO and low-FoMO groups, respectively. *Conclusions:* The current study therefore sheds light on the changes in social anxiety and PSU symptoms among secondary school students during long-term online learning, as well as the moderating role of FoMO.

KEYWORDS

problematic smartphone use, social anxiety, fear of missing out, network analysis, longitudinal survey

*Corresponding author.
E-mail: dliugang@126.com

**Corresponding author.
E-mail: 89034@bnu.edu.cn

INTRODUCTION

The outbreak of COVID-19 dramatically changed people's daily lives. To control the spread of the pandemic in a timely manner, the Chinese government adopted a strategy called 'Dynamic COVID-zero' in August 2021 (Liu, Liu, & Liang, 2022). The government used measures such as the lockdown of entertainment venues and schools, prohibition of public gatherings, and distance learning to reduce transmission (Zhang, 2022). These measures affected the normal lives of schoolchildren; data shows that more than 1.5 billion students worldwide were influenced by the closure of schools due to the pandemic (UNESCO, 2023). For example, in March 2022, after multiple cases of COVID-19 were detected in Harbin, China, some secondary schools there shifted to online learning (Harbin Municipal People's Government, 2022). It was not until mid-May that Harbin schools gradually resumed offline education (The Paper, 2022). These measures reduced face-to-face interactions and increased the frequency of smartphone use among adolescents (Dong, Yang, Lu, & Hao, 2020; Elhai, McKay, et al., 2021).

Notably, the increasing use of smartphones may have led to "an inability by individuals to regulate smartphone use, leading to negative consequences and clinical impairment in daily life", referred to as "problematic smartphone use" (Billieux, 2012; Panova & Carbonell, 2018), although some scholars prefer the term "smartphone addiction" (Duan et al., 2021; Enez Darcin et al., 2016). There is controversy regarding which terminology should be used. Some scholars believe smartphone addiction may not be an addiction due to the vague criteria thereof, the lack of relevant cases and longitudinal studies, and the lower severity of impairment compared to other addictions (Panova & Carbonell, 2018). Meanwhile, in the information era, smartphones can truly bring some benefits (i.e., increasing convenience and flexibility for school students while breaking down barriers to educational information), whereby simply confusing problematic behaviour with addiction may pathologize common behaviours (Kardefelt-Winther et al., 2017). Thus, even though "smartphone addiction" is also widely used, in the current study, we use the term "problematic smartphone use" (PSU).

A recent meta-analysis of 498 articles (Meng et al., 2022) has revealed that PSU prevalence among adults (aged 18 and above) is slightly higher (26.84%) than among adolescents (aged 12–18) at 21.62%. However, it is essential to recognize that adolescence is a period of rapid growth, learning, adaptation, and significant neurobiological development (Dahl et al., 2018). Consequently, PSU during this critical phase may exert particularly strong negative impacts on various aspects of life, including mental health (Akhtar et al., 2023), education (Sunday, Adesope, & Maarhuis, 2021), and long-term economic success (Patton et al., 2016). Therefore, compared to adults, adolescents may face more substantial challenges and long-term consequences related to PSU across their lifespan (Blakemore, 2019). Moreover, online learning and lockdowns during the pandemic worsened the mental health situation of adolescents (Li, Zhan, Zhou, & Gao, 2021; Masaeli & Farhadi, 2021), causing physical accidents and decreasing academic performance (Elhai, Dvorak, Levine, & Hall, 2016; Lepp, Barkley, & Karpinski, 2014; Samaha & Hawi, 2016).

Since PSU is detrimental, there is increasing interest in more effective interventions, and extensive research is thus investigating its causative factors. Evidence suggests that psychological factors such as social anxiety (Elhai, Tiamiyu, & Weeks, 2018; Kong, Qin, Huang, Zhang, & Lei, 2020; Pera, 2020) and the fear of missing out (FoMO) (Coskun & Karayagız Muslu, 2019; Dempsey, O'Brien, Tiamiyu, & Elhai, 2019; Franchina, Vanden Abeele, van Rooij, Lo Coco, & De Marez, 2018) may be the antecedents of PSU. Additionally, FoMO may moderate the relationship between social anxiety and PSU (Brand et al., 2016). In this study, we aim to determine the bidirectional and directed relationship between different symptoms of social anxiety and PSU during the pandemic based on network analysis and by considering level of FoMO. This study therefore seeks to clarify the detailed relationship among social anxiety, PSU, and FoMO, generating fresh insights for interventions regarding PSU.

Social anxiety and PSU

Social anxiety is one of the most prevalent problems among adolescents (Ran, Li, Zhang, & Niu, 2022; Tang et al., 2022). Notably, a meta-analysis collecting data from 55 papers and including 83,893 participants has shown that the social anxiety level of Chinese adolescents increased yearly from 2002 to 2020 (Xin, Peng, & Sheng, 2022). People with social anxiety show excessive and unreasonable fear of interpersonal interaction and public performance (Harbourt et al., 2013; Ran et al., 2022; Vassilopoulos, Brouzos, Moberly, Tsorbatzoudis, & Tziouma, 2017). Abundant studies show that social anxiety is linked to PSU (Coyne, Stockdale, & Summers, 2019; Elhai et al., 2018; Enez Darcin et al., 2016; Kong et al., 2020; Xiao & Huang, 2022). On the one hand, people with social anxiety are prone to develop PSU. Social anxiety may generate not only negative feelings (e.g., fear and nervousness) but also real problems in adolescents' daily lives (e.g., interpersonal problems with peers) (Ran et al., 2022).

Compensatory internet-use theory (CIUT) suggests that smartphones may be used to escape difficult situations or negative emotions in reality (Kardefelt-Winther, 2014). In addition, for the continuous development of the brain, adolescents are more emotional (Yang, Wang, Elhai, & Montag, 2022), always questing for identity formation and being rebellious towards adults (Caskey & Anfara, 2007). This makes adolescence a period of 'storm and stress', as adolescents always face intrapersonal and interpersonal difficulties (Compas & Wagner, 2017). Furthermore, in this new stage of life, adolescents reduce their dependence on their families, shouldering their pressures and challenges more on their own (Young, Sandman, & Craske, 2019). Given the reasons above, adolescents with social anxiety are

more likely to suffer from negative feelings, experience difficulties and turn to smartphones to escape, which makes them more likely to develop PSU.

We can also consider the relationship between social anxiety and PSU through the lens of self-determination theory (SDT). This theory suggests that everyone has a psychological need for relatedness (Deci & Ryan, 1985). Adolescence is a period that is significantly marked by spending a long time and building connections with peers (Lee, Ho, & Lwin, 2016). Put differently, adolescents' need for relatedness may be stronger. However, due to their fear of interpersonal interaction and public performance, adolescents with social anxiety decrease their participation in these situations, which causes an unsatisfied need for relatedness. Bonetti, Campbell, and Gilmore (2010) have used scales to measure the level of loneliness, social anxiety, and frequency of online communication among adolescents, and their results suggest that people who are lonely and socially anxious more frequently use online communication than normal people or people with only social anxiety. Feeling lonely, socially anxious adolescents use smartphones to contact others to fulfill their need for relatedness, which makes them more susceptible to PSU.

On the other hand, the overuse of smartphones may aggravate social anxiety. A three-level meta-analysis has suggested that PSU might elicit social anxiety (Ran et al., 2022). Another study using field experiments and experience sampling has suggested that using smartphones undermines the enjoyment and benefits of face-to-face interaction (Dwyer, Kushlev, & Dunn, 2018). People who use smartphones to satisfy their needs continue to use smartphones more frequently, which creates a negative circle of PSU and social anxiety. However, whether PSU leads to social anxiety is unknown. A one-year prospective study collecting data from approximately 950 Chinese participants as demonstrated that a score on the baseline phone involvement scale cannot predict a follow-up score on the anxiety scale (Kang et al., 2020), consistent with another longitudinal study (Coyne et al., 2019). In summary, further study is needed.

FoMO moderates the bidirectional relationship between social anxiety and PSU

FoMO is the pervasive apprehension that others might be having pleasurable and rewarding experiences from which one is absent; thus, people who suffer from this fear have a desire to constantly connect with others (Przybylski, Murayama, DeHaan, & Gladwell, 2013). This definition consists of a cognitive aspect of anxiety and a behavioral strategy (Elhai, Yang, & Montag, 2021).

FoMO may moderate the relationship between social anxiety and PSU. First, the relationships among social anxiety, FoMO, and PSU can be explained by the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2016). In this model, specific internet-use disorders such as PSU are regarded as the consequences of different interactional factors, which are classified into different categories. First, the P-component comprises predisposing variables, including biopsychological constitution, personality, and psychopathology. Specifically, in this research, social anxiety is regarded as a predisposing variable. Second, the A- and C-components represent affective and cognitive responses to stimuli, including coping strategy, craving, and internet-related cognitive biases. FoMO, conceptualized as an internet-related cognitive bias (Elhai, Yang, & Montag, 2021), can be considered a moderator between predisposing variables and internet-use disorders. Finally, the E-components include executive functions and inhibitory control, which affect the decision to use internet applications and may lead to internet-use disorders, such as PSU.

In addition, FoMO is a personality trait that varies among individuals (Przybylski et al., 2013). A high level of FoMO is usually correlated with interdependent or relational self-construal, i.e., people are concerned about what the people around them are doing and pay excessive attention to relationship maintenance (Dogan, 2019; Lin et al., 2021). Amid interdependent self-construal, people are afraid of missing information about others or being excluded from their group (Lin et al., 2021). Hence, people with interdependent self-construal are disposed to share their information online using social media (Kim, Kim, & Nam, 2010; J. Li, Xue, Zhao, & Tan, 2022) and tend to develop PSU (Servidio, Koronczai, Griffiths, & Demetrovics, 2022). Given this, we can infer that socially anxious people with a high level of FoMO have interdependent self-construal and focus on relationship maintenance, which leads to their frequent use of smartphones to search for connections with others and their increased likelihood of PSU. Conversely, socially anxious people with a low level of FoMO may have independent self-construal (Lin et al., 2021). They tend to be autonomous and individualistic, focusing more on themselves than on other people (Göker & Tekedere, 2022). However, the relationship between independent self-construal and PSU is still uncertain, warranting further exploration. Some studies suggest that people with independent self-construal are less susceptible to PSU (Hawi & Samaha, 2018). Incompatible with this finding, other research has shown that people with independent self-construal are actually more likely to experience digital game addiction and engage in phubbing (Göker & Tekedere, 2022). Given the above, we suggest that socially anxious people with a low level of FoMO are either not susceptible to PSU or exhibit a pattern of PSU different from that of individuals with a high level of FoMO.

The effects of online learning

An important and effective way to maintain spatial distance and stop the spread of COVID-19, online learning has been mandated in many education systems. Clearly, online learning has advantages including greater flexibility and convenience, boosting students' achievements and increasing their time to engage in quantitative reasoning activities (Dumford & Miller, 2018; Mandasari, 2020). Nevertheless, online learning is also associated with some

negative student outcomes, such as less time spent in collaborative learning and discussion with other students (Dumford & Miller, 2018) and a reduction in academic achievement (Omar, Ali, & Belbase, 2021). Discrepancies in these outcomes of online learning on students may perhaps be related to individual-level variables, such as acceptance of online learning (Robinson, 2019) and personality (Morfaki & Skotis, 2022) or demographic characteristics (Rizvi, Rienties, & Khoja, 2019), warranting further exploration.

People vary in their acceptance of online learning. The technology acceptance model (TAM) was created by Davis (1989) and has been widely used and effectively validated model regarding the acceptance of online learning. According to the TAM, perceived usefulness and perceived ease of use, affected by external variables, predict the attitudes and behaviours related to online learning (Davis, 1989; Salloum, Alhamad, Al-Emran, Monem, & Shaalan, 2019). Research based on the TAM has found that perceived usefulness and perceived ease of use are affected by variables such as computer self-efficacy, perceived enjoyment, and system quality, which affect the acceptance of online learning among students (Salloum et al., 2019). Academic performance is associated with the acceptance of online learning (Robinson, 2019), and there is an association between poor academic performance and mental health problems (i.e., depression and anxiety) (Khesht-Masjedi et al., 2019). Thus, students who are unable to adapt to online learning may experience some changes in their mental health situation or behaviour after long-term online learning. This suggestion is supported by studies showing that online learning and an increased frequency of smartphone use may be positively associated with PSU (Tao et al., 2023). However, the symptom-level relationship between long-term online learning and changes in students' psychological states and the possible effect of FoMO on this process remains relatively unexplored.

The present study

Numerous correlational studies have elucidated the relationship between the abovementioned variables. For example, Dempsey et al. (2019), based on a web survey and data from 296 participants, report that social anxiety, FoMO and problematic Facebook use are related. However, the literature on this topic has two main problems.

First, several studies focusing on PSU and social anxiety have considered these factors individually, as unidimensional wholes, instead of investigating their distinct and specific symptoms. For example, Annoni, Petrocchi, Camerini, and Marciano (2021) use the Social Anxiety Scale and Smartphone Addiction Scale to measure social anxiety and PSU among 240 young adults online, finding that higher scores indicate higher levels of these variables. Consistent with this finding, several studies have also used the summed scores of scales to measure social anxiety and PSU (Enez Darcin et al., 2016; Kim et al., 2006). This method is limited, revealing only the superficial relationships between social anxiety and PSU and thereby obscuring the deeper relationships among symptoms. As symptom network analysis, an increasingly popular method in clinical psychology (Rhemtulla, van Bork, & Cramer, 2022), can reveal the detailed relations among the symptoms of social anxiety and PSU (Borsboom & Cramer, 2013), it is suitable for filling this gap.

Second, in previous studies, limited longitudinal research has considered all the abovementioned variables, thereby both failing to determine the influence of online courses on the relationship between social anxiety and PSU while being incapable of addressing the bidirectional and directed relationship between social anxiety and PSU. Cross-lagged panel network (CLPN) analysis is used in our study, which applies network analysis to longitudinal data, to examine the detailed and bidirectional relationships among the focal variables.

To address the deficit mentioned above, the present study applies symptom network and CLPN analysis to delve deeper into the relationship of social anxiety, FoMO, and PSU before and after long-term online learning. According to our research aims, we propose the following three hypotheses:

Aim 1: Explore the level of social anxiety and PSU before and after four months of online learning.

Hypothesis 1: Several studies have suggested that the pandemic and online education have had a negative impact on both social anxiety and PSU (Duan et al., 2021; Hawes, Szenczy, Klein, Hajcak, & Nelson, 2022; Serra, Lo Scalzo, Giuffre, Ferrara, & Corsello, 2021). Hence, we propose that four months of online learning may impact social anxiety symptoms and PSU symptoms.

Aim 2: Explore the intricate relationships among the symptoms of social anxiety and PSU among high- and low-FoMO groups before and after four months of online learning.

Hypothesis 2: Studies have revealed that the link between social anxiety and PSU is closed (Enez Darcin et al., 2016; Kong et al., 2020) and that FoMO potentially affects social anxiety and PSU (Dempsey et al., 2019; Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017; Servidio, 2021). Hence, we propose that the level of FoMO is associated with the symptom network structures between social anxiety and PSU both before and after four months of online learning.

Aim 3: To explore the dynamic process involving the symptoms of social anxiety and PSU through the CLPN approach while moderating FoMO both before and after long-term online learning among secondary school students.

Hypothesis 3: Long-term online learning may influence students with high levels of FoMO, potentially resulting in an association between their social

anxiety symptoms and the generation of PSU symptoms. However, social anxiety symptoms may not have an impact on subsequent PSU symptoms among students with low levels of FoMO.

METHOD

Participants and procedure

This study collected data from middle and high school students in two waves in Harbin, China, using convenience sampling. The first wave took place in February 2022, obtaining data from 10,104 students using an online questionnaire program on their smartphones (https://www.wjx.cn). The second wave occurred in June 2022 and involved 8,390 students who had been taking online courses for four months. Notably, due to the impact of COVID-19, these students were required to study exclusively through online platforms (i.e., smartphones, tablets, computers, etc.) from their homes, as in-person classroom instruction was not available. As a result, the entire period from February 2022 (the start of online learning at home) to June 2022 (the end of online learning at home) was dedicated to online education.

Combining the datasets from these two waves according to students' phone numbers, 2,356 students were finally recruited. To test the moderating effect of FoMO, we divided the participants into two groups according to their FoMO scale scores. The mean FoMO score was 14.96, and the standard deviation was 6.48. Then, we used the somewhat arbitrary but conventional approach of one standard deviation above and below the mean (Jaccard, Turrisi, & Wan, 1990) and divided these FoMO scores into two groups, namely, the high-FoMO group and the low-FoMO group, referring to the classification method of previous studies (Brunborg, Skogen, & Burdzovic Andreas, 2022; Rogers & Barber, 2019). After sifting, 389 in the high-FoMO group (54.50% females, $mean_{age} = 14.04$, $SD_{age} = 1.47$) and 727 in the low-FoMO group (45.39% females, $mean_{age} = 13.83$, $SD_{age} = 1.33$). Additionally, we examined the significant differences in FoMO levels between the high-FoMO and low-FoMO groups ($t = 92.15$, $p < 0.000$, *Cohen's d* = 7.92). Students and their parents were required to provide their signed informed consent before completing the assessment. Importantly, both the students and their parents understood and agreed that they would not be deprived of any additional incentives. Additionally, the average time taken to complete the survey was approximately 15 min. This research was examined and approved by the ethics committee of *** University (Reference number: 202112220085).

Measures

Fear of missing out (FoMO) scale. The 10-item version of the Fear of Missing Out (FoMO) Scale compiled by Przybylski et al. (2013) is a widely used measurement for assessing FoMO-related behaviours. In the revised Chinese version (Li, Wang, Zhao, & Jia, 2019), based on the criteria of a factor loading not lower than 0.40 and the exclusion of items with multiple loadings, the fifth item (i.e., It is important that I understand my friends' 'in jokes') and sixth item (i.e., Sometimes, I wonder if I spend too much time keeping up with what is going on) of the original scale were removed. As a result, the Chinese version of the questionnaire for FoMO consisted of 8 items. The participants answered 8 Likert-style questions and scored them from 1 ("not at all") to 5 ("always"), with a higher score indicating more severe FoMO symptoms. The adopted FoMO scale exhibited good internal consistency, with a Cronbach's α value of 0.90.

Mobile phone addiction index (MPAI). PSU was assessed by the mobile phone addiction index (MPAI). The MPAI was compiled by Leung (2008). It is a self-report questionnaire composed of 17 5-point Likert-style items. There are four factorial components in the MPAI: inability to control craving (MPAI1, e.g., "You find yourself using your phone for longer than you intended"), feeling anxious and lost (MPAI2, e.g., "If you do not check your messages for a while or your phone is not turned on, you will become anxious"), withdrawal or escape (MPAI3, e.g., "When you feel lonely, you will use your mobile phone to chat with others"), and productivity loss (MPAI4, e.g., "The time you spent on your phone decreases your work efficiency"). Higher scores indicate higher levels of PSU. In this study, the Cronbach's α values for the MPAI were 0.95 and 0.96 in waves 1 and 2, respectively.

Social Anxiety Scale (SAS). The Social Anxiety Scale (SAS) was compiled by La Greca and Lopez (1998). Zhu (2008) has revised it into a Chinese version consisting of 13 items across three dimensions: afraid of negative evaluation (SAS1, e.g., "I always worry that people do not like me"), social avoidance and worry in unfamiliar situations (SAS2, e.g., "When I am among strangers, I feel shy"), and social avoidance and worry in normal situations (SAS3, e.g., "It' too hard for me to invite people to do something with me"). Each item was rated from "1" (complete inconformity) to "5" (complete conformity) in a Likert style. It was proven valid and reliable in Chinese studies (Feng, Ma, & Zhong, 2019). In this study, the Cronbach's α values for the SAS were 0.95 and 0.96 in waves 1 and 2, respectively.

Network analysis

We conducted all analyses using R version 4.2.1 (R Core Team, 2022). The symptom networks were estimated using the extended Bayesian information criterion (EBIC) graphical least absolute shrinkage and selection operator (LASSO) method (Epskamp & Fried, 2018). Cross-lagged panel network (CLPN) analysis was performed to explore the interrelationship between PSU and social anxiety symptoms with the help of the glmnet package (Friedman, Hastie, & Tibshirani, 2010). The node centralities were characterized

by the expected influence (*EI*) in the cross-sectional networks and by the out-expected influence (*OEI*) and in-expected influence (*IEI*) in the CLPNs. Bridge symptoms represent the channel linking different disorders (Jones, Ma, & McNally, 2021). Referring to previous research (Sánchez Hernández, Carrasco, & Holgado-Tello, 2021), we chose bridge symptoms based on the criterion of standardized values of bridge EI ≥ 1. The accuracy and stability of the networks were validated using bootstrapping approaches implemented in the R package bootnet 1.4.3 (Epskamp, Borsboom, & Fried, 2018). Specifically, we used a case-dropping procedure to estimate the stability of centrality indices, as this can provide the correlation stability coefficient (*CS-C*). Generally, *CS-C* should be ≥0.25 (Epskamp & Fried, 2018). This detailed data analysis is described in the supplementary material.

Sensitivity analysis

To rectify any potential bias resulting from unequal group sizes (the low-FoMO group of 727 individuals and high-FoMO group of 389 individuals), we randomly selected a sample of 389 individuals from the low-FoMO group and generated a new symptom network and a CLPN using the small-sized sample. We then calculated the main metrics for the small sample network and compared them to those of the original low-FoMO network. If the network metrics from a small randomly selected sample are not significantly different from those of the original network, then it can be assumed that the sample size will not have a significant effect on the network metrics. In the second step, we conducted a network comparison test between the small-sized resample network of the low-FoMO group and the original network of the high-FoMO group. If the test results of this procedure are consistent with the results of the network comparison test between the original low-FoMO network and the original high-FoMO network, it can be assumed that the current conclusions do not have significant bias due to sample size.

Ethics

This research was examined and approved by the ethics committee of Beijing Normal University (Reference number: 202112220085). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

RESULTS

Descriptive statistics and *t* test results

The sample's sociodemographic information is shown in Table S1 in the supplementary material. Item checking revealed that no items were poorly informative or redundant. The *means*, *standard deviations*, *skewness*, *kurtosis*, and *t* test results of all dimensions among the two groups are shown in Table 1. All scores in the high-FoMO group were higher than those in the low-FoMO group in both waves 1 and 2. The *t* test results for the data from the two waves showed that in the high-FoMO group, all symptom scores decreased significantly after 4 months (see Table S2). In the low-FoMO group, scores on the SAS2 ("anxiety in unfamiliar situations") and all MPAI symptoms increased significantly (see Table S2).

Symptom network structures

Four SAS-MPAI symptom networks (2 groups*2 waves) are shown in Fig. 1 and Fig. S1. All weighted adjacency matrices are shown in Tables S3–S6.

Table 1. Descriptive information and *t*-test results of the two groups

		Low FoMO (N = 727)					High FoMO (N = 389)					*t*-test	
		Mean	*SD*	*Skew*	*Kurtosis*	Cronbach's α	*Mean*	*SD*	*Skew*	*Kurtosis*	Cronbach's α	*p*	*Cohen's d*
T1	SAS1	1.67	0.96	1.46	1.55	0.95	3.22	1.04	−0.19	−0.28	0.93	<0.001	1.57
	SAS2	2.03	1.05	0.70	−0.47	0.89	3.25	1.03	−0.15	−0.18	0.88	<0.001	1.17
	SAS3	1.58	0.90	1.62	2.20	0.89	2.64	0.99	0.15	−0.23	0.73	<0.001	1.13
	MPAI1	1.45	0.67	2.07	4.88	0.92	2.50	0.96	0.58	−0.25	0.89	<0.001	1.35
	MPAI2	1.28	0.60	2.80	9.31	0.86	2.26	1.07	0.64	−0.55	0.85	<0.001	1.23
	MPAI3	1.40	0.72	2.28	5.61	0.87	2.81	1.17	0.35	−0.79	0.83	<0.001	1.56
	MPAI4	1.36	0.65	2.24	5.74	0.84	2.58	1.09	0.45	−0.52	0.82	<0.001	1.47
T2	SAS1	1.83	1.04	1.08	0.41	0.95	2.79	1.20	0.12	−0.84	0.95	<0.001	0.87
	SAS2	2.12	1.12	0.65	−0.44	0.91	2.95	1.12	0.03	−0.53	0.91	<0.001	0.74
	SAS3	1.77	1.04	1.26	0.81	0.93	2.48	1.10	0.33	−0.51	0.84	<0.001	0.67
	MPAI	1.57	0.76	1.72	3.16	0.93	2.20	0.96	0.66	−0.21	0.91	<0.001	0.76
	MPAI2	1.40	0.72	2.37	6.47	0.89	2.03	1.07	1.02	0.25	0.88	<0.001	0.74
	MPAI3	1.53	0.83	1.89	3.64	0.86	2.43	1.13	0.63	−0.44	0.85	<0.001	0.95
	MPAI4	1.52	0.81	1.85	3.43	0.90	2.29	1.05	0.63	−0.32	0.84	<0.001	0.86

Note. FoMO, Fear of Missing Out Scale. SAS, Social Anxiety Scale. MPAI, Mobile Phone Addiction Index. T1, wave 1. T2, wave 2. *SD*, standard deviation.

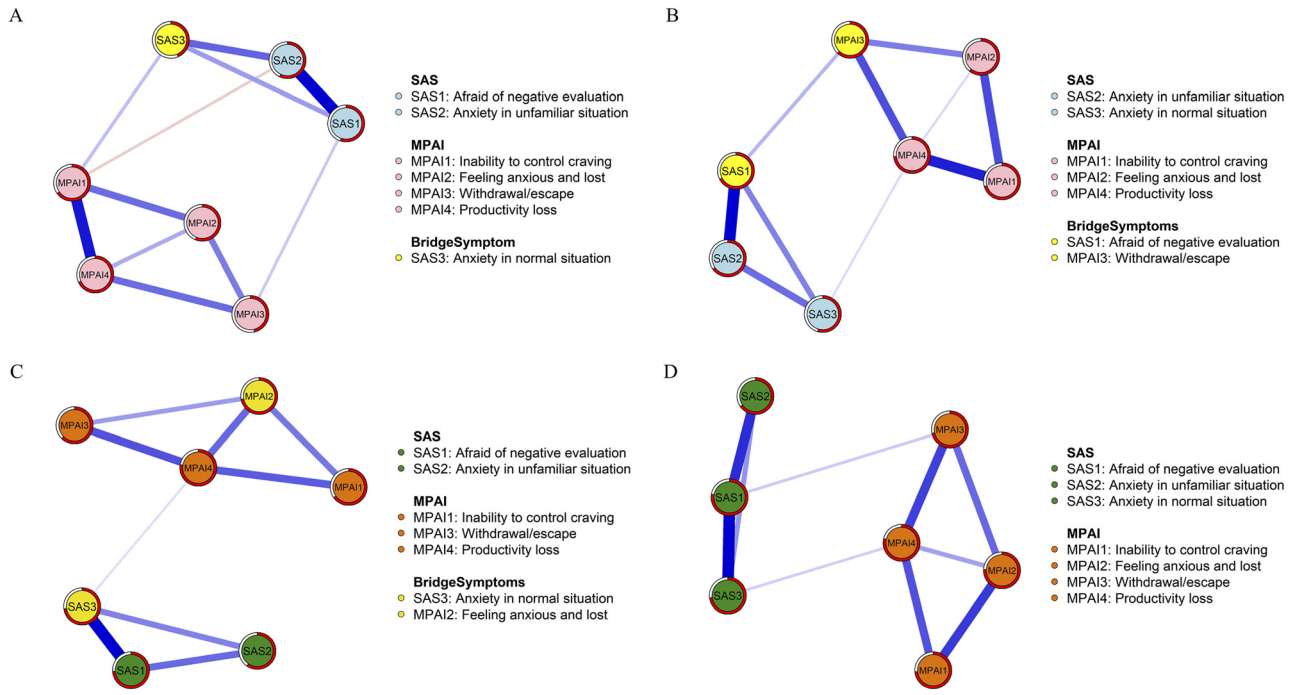

Fig. 1. Network structures. A, High-FoMO group at the first time point. B, High-FoMO group at the second time point. C, Low-FoMO group at the first time point. D, Low-FoMO group at the second time point

For the high-FoMO group, the edge of "afraid of negative evaluation"–"anxiety in unfamiliar situation" (SAS1–SAS2) showed the strongest association (see Parts A and B of Fig. 1) and was significantly stronger than the other edges in both waves 1 and 2 (see Parts A and B of Fig. S2). For the low-FoMO group, the edge of "afraid of negative evaluation"–"anxiety in normal situation" (SAS1–SAS3) showed the strongest association (see Parts C and D of Fig. 1) and was significantly stronger than other edges in both waves 1 and 2 (see Parts C and D of Fig. S2).

In terms of symptom centrality, in wave 1, "productivity loss" (MPAI4) had the strongest node EI among both the high-FoMO and low-FoMO groups (see Part A of Fig. 2) and was significantly stronger than other nodes (see Parts A and B of Fig. S3). In wave 2, with the exception of "productivity loss" (MPAI4), it had the strongest node EI in both the high-FoMO and low-FoMO groups, while "afraid of negative evaluation" (SAS1) was also the strongest node EI in the low-FoMO group (see Part B of Fig. 2) and was significantly stronger than the other nodes (see Parts C and D of Fig. S3).

The bridge symptom in wave 1 was "anxiety in normal situation" (SAS3) among both the low-FoMO and high-FoMO groups (see Part C of Fig. 2), while "feeling anxious and lost" (MPAI2) was the only distinct bridge EI node in the low-FoMO group. In wave 2, "afraid of negative evaluation" (SAS1) and "withdrawal/escape" (MPAI3) were the strongest bridge EIs in the high-FoMO group, whereas no bridge symptoms were present in the low-FoMO group (the cut-off was a *Z* score equal to 1; see Part D of Fig. 2).

Cross-lagged panel networks

The CLPN structures are shown in Fig. 3. All edge weights are shown in the LASSO cross-lagged regression matrices in Tables S7 and S8. Autoregression paths at two waves are shown in Fig. S4.

For the high-FoMO group (see Part A of Fig. 3), except for autoregression paths, the edge of "withdrawal/escape"–"productivity loss" (MPAI3-MPAI4) showed the strongest cross-lagged association and was significantly stronger than 6 edges within the network (see Part A of Fig. S5), followed by the edge of "afraid of negative evaluation"–"inability to control craving" (SAS1-MPAI1), the edge of "afraid of negative evaluation"–"withdrawal/escape" (SAS1-MPAI3) and the edge of "afraid of negative evaluation"–"productivity loss" (SAS1-MPAI4). Part B in Fig. 3 shows the *OEI* and *IEI* values: "afraid of negative evaluation" (SAS1) had the highest node *OEI* and was significantly stronger than 5 nodes (see Part A of Fig. S6), followed by "withdrawal/escape" (MPAI3). "Productivity loss" (MPAI4) had the highest node *IEI* and was significantly stronger than 2 nodes (see Part B of Fig. S6).

For the low-FoMO group (see Part C of Fig. 3), the edge of "inability to control craving"–"productivity loss" (MPAI1-MPAI4) showed the strongest cross-lagged association but no significant difference from the other edges within the network (see Part B of Fig. S5), followed by the edge of "productivity loss"–"withdrawal/escape" (MPAI4-MPAI3) and the edge of "productivity loss"–"afraid of negative evaluation" (MPAI4- SAS1). In Fig. 3 Part D, "productivity loss" (MPAI4) has the highest node *OEI,* and "withdrawal/escape" (MPAI3) and "productivity loss"

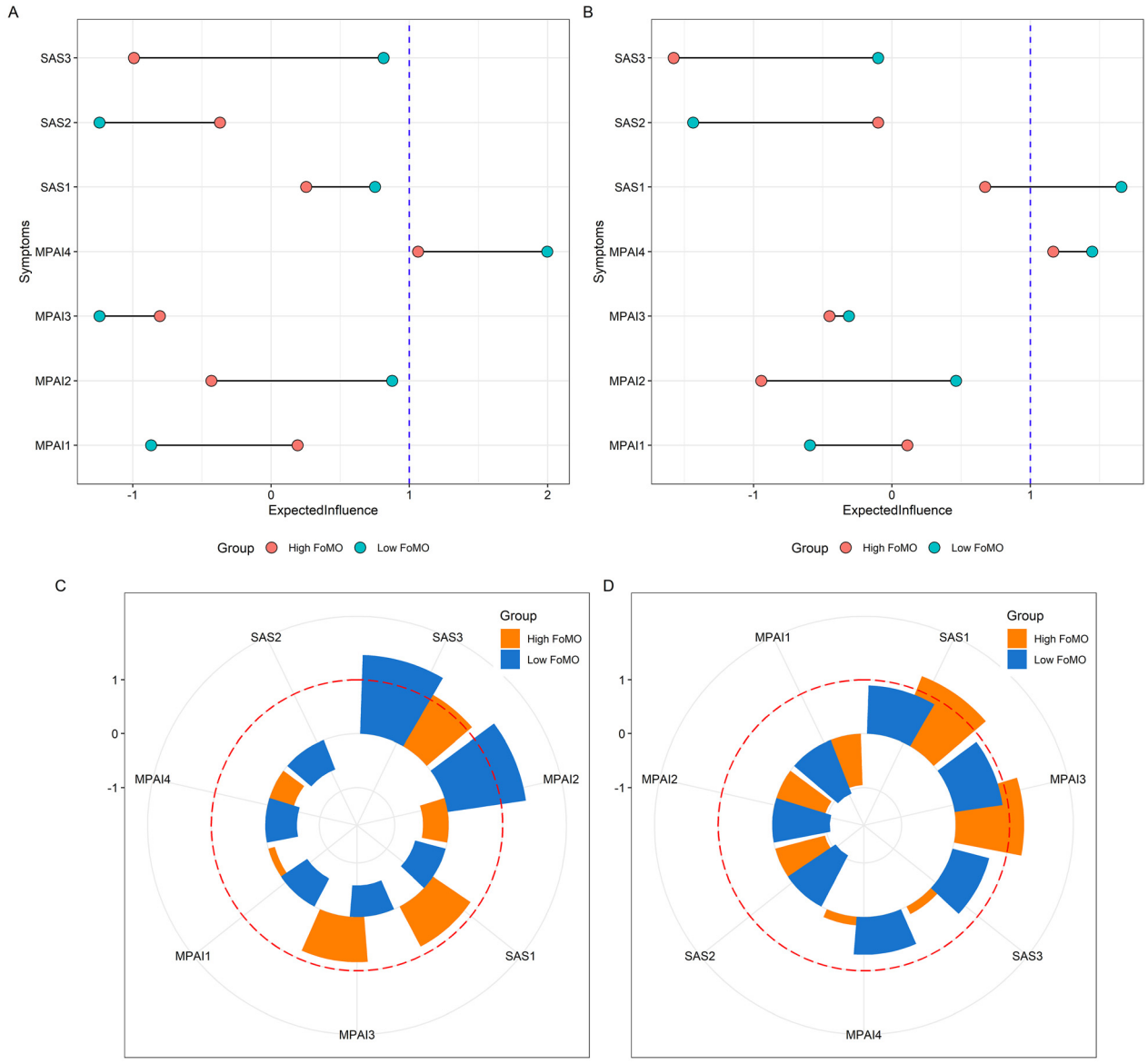

Fig. 2. Centrality and bridge index. A, *EI* values of high-FoMO and low-FoMO groups at the first time point. B, *EI* values of high-FoMO and low-FoMO groups at the second time point. C, bridge EI values of high-FoMO and low-FoMO groups at the first time point. D, bridge EI values of high-FoMO and low-FoMO groups at the second time point

(MPAI4) has the highest *IEI*, but not all are significantly different from the other nodes (see Parts C and D of Fig. S6).

Network comparison test

The results of the four symptom network comparison tests are shown in Table 2 and Figs S7 and S8. Only the test for invariance of network structure between the high-FoMO and low-FoMO groups in both waves 1 and 2 was significant ($M = 0.40$, $p < 0.001$; $M = 0.28$, $p = 0.01$). Specifically, the association between "afraid of negative evaluation" (SAS1) and "anxiety in normal situation" (SAS3) was significantly lower in the high-FoMO group than in the low-FoMO group in both waves 1 and 2, whereas the association between "afraid of negative evaluation" (SAS1) and "anxiety in unfamiliar situation" (SAS2) was significantly higher in the high-FoMO group than in the low-FoMO group in wave 1 (see Fig. S9).

In wave 1, the EI scores of the low-FoMO group were significantly higher than those of the high-FoMO group for "anxiety in normal situation" (SAS3) (p <0.001). However, other than SAS3, there were no significant differences in EI scores across the low-FoMO and high-FoMO groups at other nodes in wave 1 or across all nodes in wave 2. The longitudinal NCT results also indicate no significant differences in EI scores between the low-FoMO and high-FoMO groups in both waves 1 and 2. In addition, the bridge EI scores show no significant differences across the cross-sectional symptom network and the longitudinal network.

The results of the Mann–Whitney U test for the average edge weight from the SAS to the MPAI and the average edge

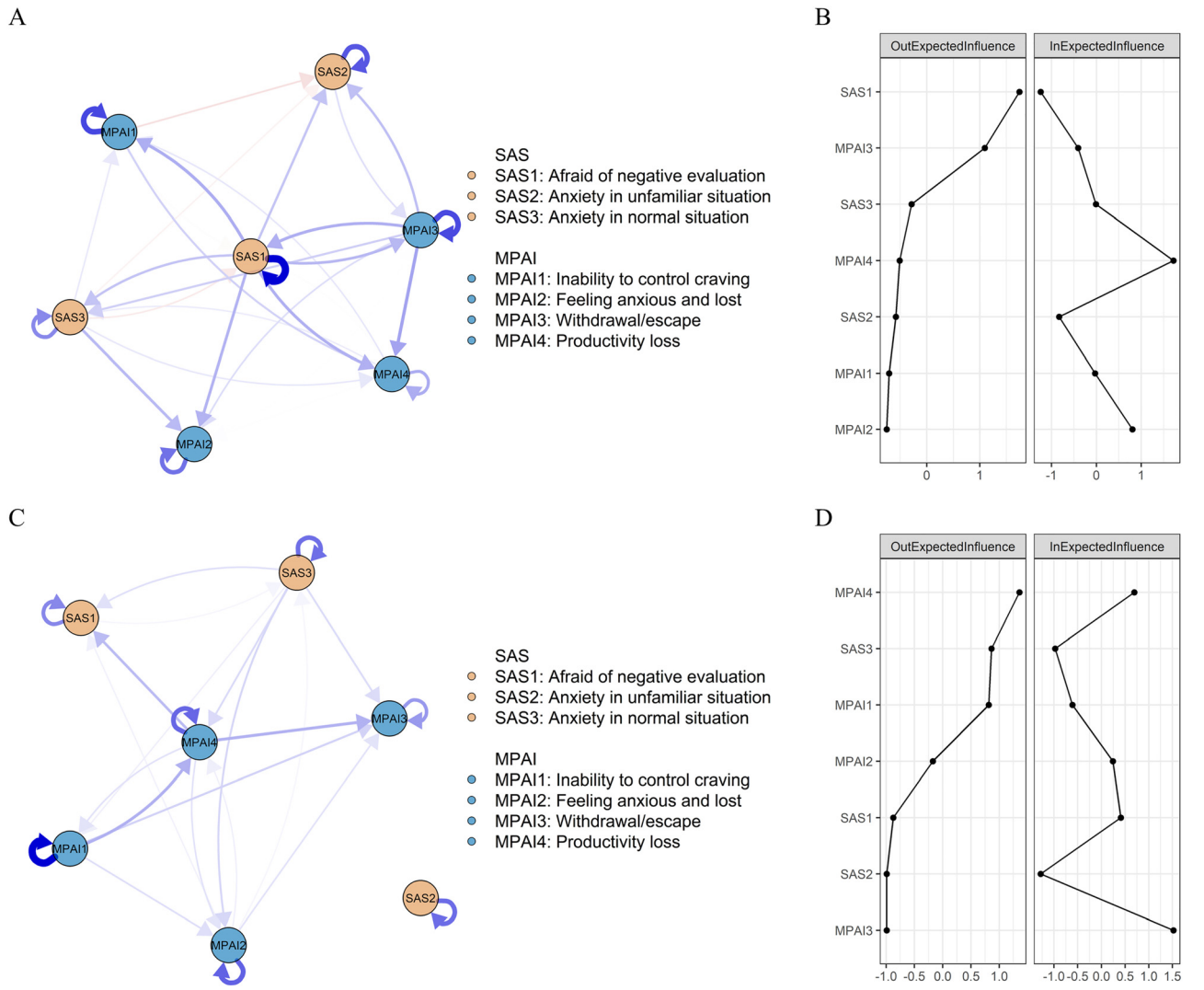

Fig. 3. Cross-lagged panel network (CLPN) structure and centrality indices. A, CLPN structure of the high-FoMO group. B, *OEI*, and *IEI* values of the high-FoMO group. C, CLPN structure of the low-FoMO group. D, *OEI*, and *IEI* values of the low-FoMO group

Table 2. Network comparison results (1,000 permutations)

	Network structure invariance	Global strength invariance
High FoMO - low FoMO (wave 1)	$M = 0.40$ $p < 0.001$	$S = 0.12$ $p = 0.46$
High FoMO - low FoMO (wave 2)	$M = 0.28$ $p = 0.01$	$S = 0.13$ $p = 0.43$
High FoMO (wave 1–wave 2)	$M = 0.09$ $p = 0.90$	$S = 0.08$ $p = 0.74$
Low FoMO (wave 1–wave 2)	$M = 0.17$ $p = 0.17$	$S = 0.09$ $p = 0.26$

Note. M: The value of the maximum difference in edge weights *S*: The value of the difference in the sum of all edge weights.

weight from the MPAI to the SAS, IEI, and OEI in the two CLPNs are also shown in Table 3. In particular, the edges from SAS to MPAI and IEI are significantly stronger for the high-FoMO group, while the edges from MPAI to SAS and OEI are insignificant between the low-FoMO and high-FoMO groups.

Network stability

The case-dropping results are shown in Fig. S10, and the *CS-Cs* are shown in Table 4. The case-dropping test results indicated good stability for all centrality indicators. The 95% bootstrapped *CI*s of the edges were narrow (see Figs S11 and S12), suggesting that the edges were trustworthy.

Sensitivity analysis

Sensitivity analysis between the new small-sized sample and the original sample of the low-FoMO group. 389 data points were randomly selected from the low-FoMO group, and the new small-sized sample symptom and CLPN network structures were generated. The weighted adjacency matrixes and cross-lagged regression matrix of the new network are shown in Tables S9–S11. The main centrality

Table 3. The Mann–Whitney U test for average edge weight between edges from the SAS to MPAI community and edges from the MPAI to SAS community and IEI/OEI of each community in cross-lagged panel networks

	High FoMO	Low FoMO	*Z*	*p*	Effect sizes
IEI	0.25[a] (0.18, 0.31)	0.13 (0.04, 0.15)	2.00	0.03	0.86
OEI	0.08 (0.04, 0.39)	0.09 (0.01, 0.20)	0.60	0.60	0.59
Edges from SAS to MPAI	0.05 (0.00, 0.14)	0.00 (0.00, 0.03)	2.00	0.03	0.75
Edges from MPAI to SAS	0.00 (0.00, 0.05)	0.00 (0.00, 0.00)	−0.20	0.90	0.48

Note. [a] 0.25 (0.18, 0.31), where 0.25 is the median, 0.18 is the 25th percentile, and 0.31 is the 75th percentile.

Table 4. The *CS-Cs* of all *EI* values

	EI (baseline)	*EI* (follow-up)	*OEI*	*IEI*
High FoMO group	0.21	0.44	0.44	0.36
Low FoMO group	0.75	0.67	0.05	0.13

indexes of the new networks and the original networks are shown in Figs S13 and S14. The most influential nodes and bridge nodes were basically the same between the new sample and the original sample in both waves 1 and 2. Similarly, the NCT results between the new networks and the original low-FoMO networks are shown in Table S12 and Fig. S15. The network distribution and global strength were not significantly different between the new network and the original network. The bootstrapped difference test results of edges and centralities are shown in Figs S16 and S17, indicating that the variation between the two groups was small. These results indicated that there was no significant difference between the new small-sized network structures and the original low-FoMO network structures.

According to the Mann-Whitney U test results in Table S13, the differences between the new CLPN and the original low-FoMO CLPN are also not significant.

Sensitivity analysis between the new small-sized sample of the low-FoMO group and the original sample of the high-FoMO group. We then compared the small-sized sample networks of the low-FoMO and the high-FoMO network structure (see Table S14). The NCT results showed that the edge difference test between the high-FoMO and low-FoMO groups in wave 1 was significant, while the global strength difference test in waves 1 and 2 was not significant. These results were consistent with those of the original low-FoMO network (see Table 2). The only inconsistency was the edge difference test in wave 2, but this variation was minor.

Table S15 shows the U test results for the differences between the small group of CLPN from the low-FoMO group and the CLPN from the high-FoMO group. These results were mostly the same as those from the original low-FoMO group (see Table 3). The above analysis supported the assumption that current conclusions do not have significant bias due to sample size.

DISCUSSION

This study has explored the correlation and cross-lagged effects among each specific symptom of PSU and social anxiety while examining the moderating effect of FoMO in this process. Certain results merit further discussion.

Differences in the mean levels of social anxiety and PSU before and after the four-month online learning period

The most obvious finding is that the mean levels of all dimensions of PSU and social anxiety were significantly more severe in the high-FoMO group than in the low-FoMO group, consistent with previous findings (Dempsey et al., 2019; Oberst et al., 2017; Wegmann, Oberst, Stodt, & Brand, 2017). This high correlation between FoMO and PSU is natural. The compulsive thoughts and behaviours of continually staying connected to others on social networks is a fundamental dimension of FoMO (Przybylski et al., 2013). Mobile phones, meanwhile, are the primary means for people to access social networks. Therefore, the concern about missing life events or losing contact with others caused by FoMO may compel individuals to use their mobile phone to refresh their social media platforms (Duan, He, & Tang, 2020). This anxiety component, inherent in the concept of FoMO, has also led to FoMO being conceptualized as a construct primarily involving anxiety-related psychopathology (Oberst et al., 2017; Wegmann et al., 2017). However, when we generalize this particular anxiety to social anxiety, a paradox seems to emerge. FoMO is often driven by a fear of social exclusion or a desire to fit in with a particular group or community (Przybylski et al., 2013) among individuals with a tendency towards social anxiety fear who often avoid others (Kirk, Meyer, Whisman, Deacon, & Arch, 2019). The above evidence therefore suggests a paradox for people struggling with social anxiety: they seem to cognitively desire connection with others yet behaviourally reject them. This phenomenon is similar to individuals with a disorganized attachment style, who are both fascinated by and afraid of others and both desire to have and seek detachment from interpersonal relationships (Van Ijzendoorn & Bakermans-Kranenburg, 2003). Future researchers can further investigate the relationship between disorganized attachment and social anxiety.

Second, we have found that after four months of online courses, the severity of social anxiety and PSU in the high-FoMO group was alleviated. As discussed in the previous paragraph, students with higher FoMO also had higher levels of social anxiety. However, during traditional face-to-face learning, students experience greater social presence and more peer interactions (Yen, Lo, Lee, & Enriquez, 2018).

For those with severe social anxiety and difficulty in face-to-face interactions, offline school activities such as giving oral presentations, answering questions in front of others, or participating in cliques are potentially stressful for them and may harm their academic and social function (de Lijster et al., 2018). In contrast, online instruction allows students to interact with their peers and instructors in a less intimidating and more secure environment where they can control how they interact with others and the length of their conversations (Annoni et al., 2021). In this way, students with social anxiety have ample time and interpersonal distance to consider how best to articulate themselves (Pierce, 2009). The results of a previous meta-analysis also indicate that higher social anxiety is associated with more feelings of comfort online (Prizant-Passal, Shechner, & Aderka, 2016).

One interesting finding regarding the low-FoMO group is that their scores on SAS2 ("anxiety in unfamiliar situation") and all MPAI symptoms increased significantly after the long period of online learning. Long-term online learning and social distancing during the pandemic may have decreased the social skills of individuals (Branquinho, Kelly, Arevalo, Santos, & Gaspar de Matos, 2020; Chaturvedi, 2020), compelling low-FoMO individuals to feel awkward or anxious when facing unfamiliar situations when they returned to school, contributing to the exacerbation of their SAS2 symptoms. Regarding the worsening of PSU, one possible explanation for it is that during the pandemic, long-term online learning gave students more access to smartphones, heightening the levels of PSU among the low-FoMO group (Duan et al., 2021; Serra et al., 2021). Notably, while in the low-FoMO group, the scores of symptoms SAS2 and PSU increased after long-term online learning, their mean levels of social anxiety and PSU were actually lower than those in the high-FoMO group, highlighting the significance of concern about high-FoMO students.

Symptom network structures between the high- and low-FoMO groups at two time points

Importantly, however, the relief from social anxiety and PSU symptoms among the high-FoMO group offered by online education is not a natural cure for these disorders. In fact, it has actually worsened the comorbidity of these two disorders. The number of bridge nodes in the symptom networks increased (from 1 to 2) in the high-FoMO group after long-term online learning. Bridge symptoms reflect how different symptom clusters generate comorbidities (Jones et al., 2021). More bridge symptoms mean that the connection between two mental disorders is closer (i.e., the triggering of symptoms of one mental disorder is more likely to activate other symptoms of another mental disorder) (Cramer, Waldorp, Maas, & Borsboom, 2010; Jones et al., 2021).

As our findings show, the level of social anxiety decreased in the high-FoMO group after the long period of online learning; thus, online communication may alleviate social anxiety to some extent because people may have positive interactions and more support online (O'Day & Heimberg, 2021; Seabrook, Kern, & Rickard, 2016). However, high-FoMO individuals may not consistently receive support online (O'Day & Heimberg, 2021), and this kind of online emotional support seeking cannot change the nature of social anxiety. Indeed, social anxiety shares an association with factors such as negative social beliefs and fears of negative evaluation (Leigh & Clark, 2018; Teale Sapach, Carleton, Mulvogue, Weeks, & Heimberg, 2015). Meanwhile, most variations of cognitive–behavioural therapy for social anxiety include social exposure as a central component (Heimberg, 2002), underscoring the significance of interpersonal interaction practices in the real world for intervening in social anxiety. Without changing these significant factors, it may be difficult to sever the link between social anxiety and PSU; long-term excessive smartphone use undermines the enjoyment and benefits of face-to-face interaction (Dwyer et al., 2018).

In our study, we also found that in wave two, two bridge symptoms in the high-FoMO group were "afraid of negative evaluation" (SAS1) and "withdrawal/escape" (MPAI3), consistent with previous evidence showing that socially anxious and lonely individuals use smartphones to compensate for their unfulfilled need for in-person relationships (O'Day & Heimberg, 2021). Therefore, although the mean levels of PSU and social anxiety decreased after the long-term online learning, the tendency of high-FoMO individuals to use their smartphones to avoid their fear of negative evaluation and alleviate their social anxiety may have actually been exacerbated, which may have ultimately exacerbated the comorbidity between social anxiety and PSU.

Cross-lagged panel networks between high- and low-FoMO groups

Regarding symptoms with high OEI and IEI and the strongest cross-lagged edges, discrepancies were found between the two groups. For the high-FoMO group, "Productivity loss" (MPAI4) had the highest node IEI (i.e., the symptom that is most affected by symptoms of wave 1), and it was significantly stronger than 2 nodes. The negative effect of PSU on academic and work performance has been demonstrated in several studies. A meta-analysis has revealed that students' overall academic performance and cognitive abilities for academic success and learning are negatively impacted by PSU. Furthermore, the more a smartphone is used for learning, the greater the negative impact (Sunday et al., 2021). Zhang and Wu (2020) have also found that PSU leads to bedtime procrastination and poor sleep quality, which in turn reduces daytime productivity and threatens physical health.

Our research also indicates that "afraid of negative evaluation" (SAS1) had the highest node OEI in the high-FoMO group (i.e., the symptom of wave 1 that most affected other symptoms in wave 2), significantly stronger than the other symptoms in the network. Together with the results regarding the strong edges in the high-FoMO CLPN network, showing that "afraid of negative evaluation" (SAS1)

has a high association with several symptoms of PSU, the important role of "afraid of negative evaluation" in the high-FoMO group is outstanding. "Afraid of negative evaluation" may therefore be the motivation that drives high-FoMO students to abuse their smartphone use. We refer to this type as "compensatory smartphone addiction". Fear of negative evaluation is the core belief of social anxiety (Kirk et al., 2019). According to compensatory internet use theory, to some extent, social anxiety activates individuals' desire to use their smartphone because socially anxious individuals may use the internet to regulate and compensate for their social anxiety (Kardefelt-Winther, 2014; Wei et al., 2023). Meanwhile, people with higher FoMO have stronger expectations of internet use because they believe there are interesting and rewarding experiences on the internet (Wegmann et al., 2017). Therefore, people with high FoMO are more likely to develop a pathway from social anxiety to PSU. For these individuals, PSU is no longer a mere impulsive-compulsive behaviour but becomes a compensatory behaviour driven by social fears and aimed at alleviating social anxiety and meeting psychological needs. Psychotherapy that begins by rectifying inaccurate beliefs, such as cognitive–behavioural therapy, may be effective for this kind of PSU (Yang, Hu, et al., 2022).

In terms of the results for the low-FoMO group, the edge of "inability to control craving"–"productivity loss" (MPAI1-MPAI4) showed the strongest cross-lagged association. Additionally, "productivity loss" (MPAI4) had the highest node OEI, and "withdrawal/escape" (MPAI3) had the highest IEI; both are symptoms of PSU. First, this result for the low-FoMO group may be a reflection of the impulsive pathway to PSU (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). This pathway is promoted by poor impulse control, which results in uncontrolled urges and the dysregulated use of a smartphone (Billieux et al., 2015; Canale et al., 2021). Impulsivity is a traditional and predictive dimension of smartphone abuse and other behavioural addictions (De-Sola Gutiérrez, Rodríguez de Fonseca, & Rubio, 2016). Billieux, Van der Linden, and Rochat (2008) suggest that higher impulsivity means lower self-control, which leads to more severe smartphone abuse. Consistently, several studies have also identified the link between impulsivity and PSU (Jo, Na, & Kim, 2018; Mitchell & Hussain, 2018), providing supportive evidence for the impulsive pathway to PSU. In addition, sensation seeking may explain the results of the low-FoMO group, reflecting the extraversion pathway to PSU (Billieux et al., 2015). Sensation seeking is a personality trait regarding the individual's pursuit of multiple novel stimulations and sensitivity to boredom (Wang et al., 2019; Zuckerman, Kolin, Price, & Zoob, 1964). Individuals who exhibit higher sensation seeking have higher requirements for the stimulation needed for their appropriate arousal levels; thus, they are more likely to experience leisure as boredom (Zhang et al., 2022). Sensation seeking is thus associated with various risky behaviours, including smoking, alcohol abuse (Lydon-Staley, Falk, & Bassett, 2020), and PSU (Wang et al., 2019).

In general, for the low-FoMO group, our results indicate a strong association among several symptoms of PSU; this may be explained by the effect of impulsivity or sensation seeking but not the effect of social anxiety. However, one critical point is that since the bootstrapped results for the CLPN network for the low-FoMO group were not satisfactory, this finding may be difficult to generalize to other studies. That is, any interpretation of our results must be prudent.

IMPLICATIONS

The study emphasizes the importance of targeted interventions and addresses the complex interplay among social anxiety, problematic smartphone use (PSU), and the fear of missing out (FoMO) among secondary school students. It identifies distinct mechanisms of PSU between high- and low-FoMO students, necessitating tailored interventions that specifically target FoMO and negative evaluation. Specifically, high-FoMO students exhibit a greater interconnectedness among these issues, as evidenced by their increased bridge symptoms. Particularly, for high-FoMO students who are the most affected by the fear of poor evaluation, managing smartphone use and reducing dependency are crucial strategies. Maintaining focus and productivity, fostering a healthy balance between online learning and other activities, promoting self-regulation, and providing support mechanisms are of the utmost importance. Furthermore, this study highlights the significance of the "inability to control craving" as a significant predictor of symptoms, underscoring the need for self-regulation strategies and the development of healthy technology use habits. To address social anxiety, manage PSU, and promote balanced and healthy technology use, comprehensive approaches are warranted.

LIMITATIONS

Some limitations of this study should be mentioned. First, in our longitudinal study, we collected the first wave of data before the start of the four-month online course and the second wave of data after its end. However, the current study did not collect specific online course-related data regarding, e.g., daily learning time, learning effectiveness, or satisfaction with online learning. Future research could incorporate these variables into their models. Second, we used a nonclinical sample of secondary school students, which is unlikely to be representative of clinical individuals. Whether the current results can be generalized to people who have been diagnosed with social anxiety or PSU remains to be tested. Third, this study employed self-reported measures to examine PSU. However, extant findings, as indicated by Parry et al. (2021), have raised concerns about the validity of research relying solely on self-reported measures of digital media use. Therefore, more objective indicators are needed to measure PSU and its associated

psychological health problems. Fourth, despite our use of longitudinal data, relationships among symptoms, especially causality, should be treated with caution. The current conclusions need to be validated by further experimental studies. Finally, caution should be exercised when generalizing these findings to non-Chinese schoolchildren due to potential cultural, educational, and technological variation. Conducting comparative research involving non-Chinese schoolchildren would provide a broader understanding of the effects of online learning on social anxiety and PSU while considering specific cultural factors and educational systems.

CONCLUSIONS

This study investigates the relationship between social anxiety, PSU, and the moderating role of FoMO. To the best of our knowledge, this is the first study to use the CLPN method to analyse these relationships. The results show that individuals with high FoMO tend to experience more severe social anxiety and PSU. However, after four months of online learning, while they experienced a temporary relief of symptoms, they still had a deeper underlying problem of comorbidity. The CLPN analysis has also revealed differences in the root cause of PSU between those with low FoMO and those with high FoMO: for the former, it is primarily an impulsive-compulsive behaviour problem; for the latter, it primarily concerns coping with negative emotions related to social fear. This study therefore contributes to the understanding of FoMO's impact on social anxiety and PSU. It can thus facilitate the development of targeted psychotherapeutic approaches for different populations, thereby leading to improved treatment outcomes.

Funding sources: This study was supported by the key subject of the Ministry of Education in the 2023 National Education Science Program: "Empowering College Students' Mental Health Monitoring and Applications with Artificial Intelligence Technology" DIA230433).

Authors' contribution: Study design: GL and XL. Data collection: LZ. Analysis and interpretation: SW. Drafting of the manuscript: YT. Critical revision of the manuscript: SW, QT, XZ, and ZM.

Conflict of interest: The authors have no conflicts of interest regarding this research study.

Code and data availability: The data and codes are available as follows: https://osf.io/vy7kw/?view_only=72b9b2d142304e00b5f7a330a2f5f030.

Acknowledgments: This study was supported by the college students' mental health education center, Northeast Agricultural University.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1556/2006.2023.00081.

REFERENCES

Akhtar, F., Patel, P. K., Bin Heyat, M. B., Yousaf, S., Baig, A. A., Mohona, R. A., … Wu, K. (2023). Smartphone addiction among students and its harmful effects on mental health, oxidative stress, and neurodegeneration towards future modulation of anti-addiction therapies: A comprehensive survey based on SLR, research questions, and network visualization techniques. *CNS & Neurological Disorders-Drug Targets*, *22*(7), 1070–1089. https://doi.org/10.2174/1871527321666220614121439.

Annoni, A. M., Petrocchi, S., Camerini, A.-L., & Marciano, L. (2021). The relationship between social anxiety, smartphone use, dispositional trust, and problematic smartphone use: A moderated mediation model. *International Journal of Environmental Research and Public Health*, *18*(5), 2452. https://www.mdpi.com/1660-4601/18/5/2452.

Billieux, J. (2012). Problematic use of the mobile phone: A literature review and a pathways model. *Current Psychiatry Reviews*, *8*(4), 299–307. https://doi.org/http://dx.doi.org/10.2174/157340012803520522.

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

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

Blakemore (2019). Adolescence and mental health. *The Lancet (British Edition)*, *393*(10185), 2030–2031. https://doi.org/10.1016/S0140-6736(19)31013-X.

Bonetti, L., Campbell, M. A., & Gilmore, L. (2010). The relationship of loneliness and social anxiety with children's and adolescents' online communication. *Cyberpsychology, Behavior, and Social Networking*, *13*(3), 279–285. https://doi.org/10.1089/cyber.2009.0215.

Borsboom, & Cramer, A. O. (2013). Network analysis: An integrative approach to the structure of psychopathology. *Annual Review of Clinical Psychology*, *9*(1), 91–121. https://doi.org/10.1146/annurev-clinpsy-050212-185608.

Brand, Young, K. S., Laier, C., Wölfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific Internet-use disorders: An Interaction of Person-Affect-Cognition-Execution (I-PACE) model. *Neuroscience and Biobehavioral Reviews*, *71*, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033.

Branquinho, C., Kelly, C., Arevalo, L. C., Santos, A., & Gaspar de Matos, M. (2020). "Hey, we also have something to say": A qualitative study of Portuguese adolescents' and young people's experiences under COVID-19. *Journal of Community Psychology*, *48*(8), 2740–2752. https://doi.org/10.1002/jcop.22453.

Brunborg, G. S., Skogen, J. C., & Burdzovic Andreas, J. (2022). Fear of missing out and binge-drinking among adolescents. *Drug and Alcohol Review*, *41*(1), 230–237. https://doi.org/10.1111/dar.13356.

Canale, N., Moretta, T., Pancani, L., Buodo, G., Vieno, A., Dalmaso, M., & Billieux, J. (2021). A test of the pathway model of problematic smartphone use. *Journal of Behavioral Addictions*, *10*(1), 181–193. https://doi.org/10.1556/2006.2020.00103.

Caskey, M. M., & Anfara, V. A., Jr (2007). *Research summary: Young adolescents' developmental characteristics*. Westerville, OH: National Middle School Association.

Chaturvedi, S. K. (2020). Covid-19, coronavirus and mental health rehabilitation at times of crisis. *Journal of Psychosocial Rehabilitation and Mental Health*, *7*(1), 1–2. https://doi.org/10.1007/s40737-020-00162-z.

Compas, B. E., & Wagner, B. M. (2017). Psychosocial stress during adolescence: Intrapersonal and interpersonal processes. In *Adolescent stress* (1st ed., pp. 67–86). Routledge.

Coskun, S., & Karayagız Muslu, G. (2019). Investigation of problematic mobile phones use and fear of missing out (FoMO) level in adolescents. *Community Mental Health Journal*, *55*(6), 1004–1014. https://doi.org/10.1007/s10597-019-00422-8.

Coyne, S. M., Stockdale, L., & Summers, K. (2019). Problematic cell phone use, depression, anxiety, and self-regulation: Evidence from a three year longitudinal study from adolescence to emerging adulthood. *Computers in Human Behavior*, *96*, 78–84. https://doi.org/10.1016/j.chb.2019.02.014.

Cramer, A. O. J., Waldorp, L. J., Maas, H. L. J. van der, & Borsboom, D. (2010). Complex realities require complex theories: Refining and extending the network approach to mental disorders. *Behavioral and Brain Sciences*, *33*(2–3), 178–193. https://doi.org/10.1017/S0140525X10000920.

Dahl, Allen, N. B., Wilbrecht, L., & Suleiman, A. B. (2018). Importance of investing in adolescence from a developmental science perspective. *Nature (London)*, *554*(7693), 441–450. https://doi.org/10.1038/nature25770.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008.

de Lijster, J. M., Dieleman, G. C., Utens, E. M. W. J., Dierckx, B., Wierenga, M., Verhulst, F. C., & Legerstee, J. S. (2018). Social and academic functioning in adolescents with anxiety disorders: A systematic review. *Journal of Affective Disorders*, *230*, 108–117. https://doi.org/10.1016/j.jad.2018.01.008.

De-Sola Gutiérrez, J., Rodríguez de Fonseca, F., & Rubio, G. (2016). Cell-phone addiction: A review. *Frontiers in Psychiatry*, *7*, 175. https://www.frontiersin.org/articles/10.3389/fpsyt.2016.00175.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum Press. https://doi.org/10.16309/j.cnki.issn.1007-1776.2003.03.0.

Dempsey, A. E., O'Brien, K. D., Tiamiyu, M. F., & Elhai, J. D. (2019). Fear of missing out (FoMO) and rumination mediate relations between social anxiety and problematic Facebook use. *Addictive Behaviors Reports*, *9*, 100150. https://doi.org/10.1016/j.abrep.2018.100150.

Dogan, V. (2019). Why do people experience the fear of missing out (FoMO)? Exposing the link between the self and the FoMO through self-construal. *Journal of Cross-Cultural Psychology*, *50*(4), 524–538. https://doi.org/10.1177/0022022119839145.

Dong, H., Yang, F., Lu, X., & Hao, W. (2020). Internet addiction and related psychological factors among children and adolescents in China during the coronavirus disease 2019 (COVID-19) epidemic. *Frontiers in Psychiatry*, *11*, 751. https://doi.org/10.3389/fpsyt.2020.00751.

Duan, L., He, J., Li, M., Dai, J., Zhou, Y., Lai, F., & Zhu, G. (2021). Based on a decision tree model for exploring the risk factors of smartphone addiction among children and adolescents in China during the COVID-19 pandemic. *Frontiers in Psychiatry*, *12*, 652356. https://doi.org/10.3389/fpsyt.2021.652356.

Duan, W., He, C., & Tang, X. (2020). Why do people browse and post on WeChat moments? Relationships among fear of missing out, strategic self-presentation, and online social anxiety. *Cyberpsychology, Behavior, and Social Networking*, *23*(10), 708–714. https://doi.org/10.1089/cyber.2019.0654.

Dumford, A. D., & Miller, A. L. (2018). Online learning in higher education: Exploring advantages and disadvantages for engagement. *Journal of Computing in Higher Education*, *30*(3), 452–465. https://doi.org/10.1007/s12528-018-9179-z.

Dwyer, R. J., Kushlev, K., & Dunn, E. W. (2018). Smartphone use undermines enjoyment of face-to-face social interactions. *Journal of Experimental Social Psychology*, *78*, 233–239. https://doi.org/10.1016/j.jesp.2017.10.007.

Elhai, J. D., Dvorak, R. D., Levine, J. C., & Hall, B. J. (2016). Problematic smartphone use: A conceptual overview and systematic review of relations with anxiety and depression psychopathology. *Journal of Affective Disorders*, *207*, 251–259. https://doi.org/10.1016/j.jad.2016.08.030.

Elhai, J. D., McKay, D., Yang, H., Minaya, C., Montag, C., & Asmundson, G. J. G. (2021). Health anxiety related to problematic smartphone use and gaming disorder severity during COVID-19: Fear of missing out as a mediator. *Human Behavior and Emerging Technologies*, *3*(1), 137–146. https://doi.org/10.1002/hbe2.227.

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

Elhai, J. D., Yang, H., & Montag, C. (2021). Fear of missing out (FOMO): Overview, theoretical underpinnings, and literature review on relations with severity of negative affectivity and problematic technology use. *Brazilian Journal of Psychiatry*, *43*(2), 203–209. https://doi.org/10.1590/1516-4446-2020-0870.

Enez Darcin, A., Kose, S., Noyan, C. O., Nurmedov, S., Yılmaz, O., & Dilbaz, N. (2016). Smartphone addiction and its relationship with social anxiety and loneliness. *Behaviour & Information Technology*, *35*(7), 520–525. https://doi.org/10.1080/0144929x.2016.1158319.

Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A tutorial paper.

Behavior Research Methods, *50*(1), 195–212. https://doi.org/10.3758/s13428-017-0862-1.

Epskamp, S., & Fried, E. I. (2018). A tutorial on regularized partial correlation networks. *Psychological Methods*, *23*, 617–634. https://doi.org/10.1037/met0000167.

Feng, Y., Ma, Y., & Zhong, Q. (2019). The relationship between adolescents' stress and internet addiction: A mediated-moderation model. *Frontiers in Psychology*, *10*, 2248. https://doi.org/10.3389/fpsyg.2019.02248.

Franchina, V., Vanden Abeele, M., van Rooij, A. J., Lo Coco, G., & De Marez, L. (2018). Fear of missing out as a predictor of problematic social media use and phubbing behavior among Flemish adolescents. *International Journal of Environmental Research and Public Health*, *15*(10). https://doi.org/10.3390/ijerph15102319.

Friedman, J. H., Hastie, T., & Tibshirani, R. (2010). Regularization paths for generalized linear models via coordinate descent. *Journal of Statistical Software*, *33*, 1–22. https://doi.org/10.18637/jss.v033.i01.

Göker, H., & Tekedere, H. (2022). Phubbing, alienation, digital game addiction, independent self-construal, and interdependent self-construal among high school students: A path analysis. *Behavioral Psychology/Psicología Conductual*, *30*(1), 157–181. https://doi.org/10.51668/bp.8322108n.

Harbin Municipal People 's Government (2022). *Notice of conversion of offline teaching to online teaching in some of the city's primary and secondary schools*. from https://mp.weixin.qq.com/s?__biz=MjM5NTIzMzUyOA==&mid=2650834948&idx=3&sn=1530b50635f0c8c28ff4cb682ffa32e9&scene=0 [Retrieved 20 August 2023].

Harbort, J., Witthöft, M., Spiegel, J., Nick, K., & Hecht, H. (2013). The widening of the gaze cone in patients with social anxiety disorder and its normalization after CBT. *Behaviour Research and Therapy*, *51*(7), 359–367. https://doi.org/https://doi.org/10.1016/j.brat.2013.03.009.

Hawes, M. T., Szenczy, A. K., Klein, D. N., Hajcak, G., & Nelson, B. D. (2022). Increases in depression and anxiety symptoms in adolescents and young adults during the COVID-19 pandemic. *Psychological Medicine*, *52*(14), 3222–3230. https://doi.org/10.1017/S0033291720005358.

Hawi, N., & Samaha, M. (2018). Identifying commonalities and differences in personality characteristics of internet and social media addiction profiles: Traits, self-esteem, and self-construal. *Behaviour & Information Technology*, *38*(2), 110–119. https://doi.org/10.1080/0144929x.2018.1515984.

Heimberg, R. G. (2002). Cognitive-behavioral therapy for social anxiety disorder: Current status and future directions. *Biological Psychiatry*, *51*(1), 101–108. https://doi.org/10.1016/S0006-3223(01)01183-0.

Jaccard, J., Turrisi, R., & Wan, C. K. (1990). *Interaction effects in multiple regression*. Newbury Park, CA: Sage.

Jo, H.-s., Na, E., & Kim, D.-J. (2018). The relationship between smartphone addiction predisposition and impulsivity among Korean smartphone users. *Addiction Research & Theory*, *26*(1), 77–84. https://doi.org/10.1080/16066359.2017.1312356.

Jones, P. J., Ma, R., & McNally, R. J. (2021). Bridge centrality: A network approach to understanding comorbidity. *Multivariate Behavioral Research*, *56*(2), 353–367. https://doi.org/10.1080/00273171.2019.1614898.

Kang, Y., Liu, S., Yang, L., Xu, B., Lin, L., Xie, L., … Zhang, B. (2020). Testing the bidirectional associations of mobile phone addiction behaviors with mental distress, sleep disturbances, and sleep patterns: A one-year prospective study among Chinese college students. *Frontiers in Psychiatry*, *11*, 634. https://doi.org/10.3389/fpsyt.2020.00634.

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

Kardefelt-Winther, D., Heeren, A., Schimmenti, A., van Rooij, A., Maurage, P., Carras, M., … Billieux, J. (2017). How can we conceptualize behavioural addiction without pathologizing common behaviours? *Addiction*, *112*(10), 1709–1715. https://doi.org/10.1111/add.13763.

Khesht-Masjedi, M. F., Shokrgozar, S., Abdollahi, E., Habibi, B., Asghari, T., Ofoghi, R. S., & Pazhooman, S. (2019). The relationship between gender, age, anxiety, depression, and academic achievement among teenagers. *Journal of Family Medicine and Primary Care*, *8*(3), 799–804. https://doi.org/10.4103/jfmpc.jfmpc_103_18.

Kim, J. H., Kim, M.-S., & Nam, Y. (2010). An analysis of self-construals, motivations, Facebook use, and user satisfaction. *International Journal of Human–Computer Interaction*, *26*(11–12), 1077–1099. https://doi.org/10.1080/10447318.2010.516726.

Kim, K., Ryu, E., Chon, M.-Y., Yeun, E.-J., Choi, S.-Y., Seo, J.-S., & Nam, B.-W. (2006). Internet addiction in Korean adolescents and its relation to depression and suicidal ideation: A questionnaire survey. *International Journal of Nursing Studies*, *43*(2), 185–192. https://doi.org/https://doi.org/10.1016/j.ijnurstu.2005.02.005.

Kirk, A., Meyer, J. M., Whisman, M. A., Deacon, B. J., & Arch, J. J. (2019). Safety behaviors, experiential avoidance, and anxiety: A path analysis approach. *Journal of Anxiety Disorders*, *64*, 9–15. https://doi.org/10.1016/j.janxdis.2019.03.002.

Kong, F., Qin, J., Huang, B., Zhang, H., & Lei, L. (2020). The effect of social anxiety on mobile phone dependence among Chinese adolescents: A moderated mediation model. *Children and Youth Services Review*, *108*. https://doi.org/10.1016/j.childyouth.2019.104517.

La Greca, A. M., & Lopez, N. (1998). Social anxiety among adolescents: Linkages with peer relations and friendships. *Journal of Abnormal Child Psychology*, *26*(2), 83–94. https://doi.org/10.1023/A:1022684520514.

Lee, E. W. J., Ho, S. S., & Lwin, M. O. (2016). Explicating problematic social network sites use: A review of concepts, theoretical frameworks, and future directions for communication theorizing. *New Media & Society*, *19*(2), 308–326. https://doi.org/10.1177/1461444816671891.

Leigh, E., & Clark, D. M. (2018). Understanding social anxiety disorder in adolescents and improving treatment outcomes: Applying the cognitive model of Clark and wells (1995). *Clinical Child and Family Psychology Review*, *21*(3), 388–414. https://doi.org/10.1007/s10567-018-0258-5.

Lepp, A., Barkley, J. E., & Karpinski, A. C. (2014). The relationship between cell phone use, academic performance, anxiety, and

Satisfaction with Life in college students. *Computers in Human Behavior*, *31*, 343–350. https://doi.org/https://doi.org/10.1016/j.chb.2013.10.049.

Leung, L. (2008). Linking psychological attributes to addiction and improper use of the mobile phone among adolescents in Hong Kong. *Journal of Children and Media*, *2*(2), 93–113. https://doi.org/10.1080/17482790802078565.

Li, Q., Wang, J., Zhao, S., & Jia, Y. (2019). Validity and reliability of the Chinese version of the Fear of Missing Out scale in college students. *Chinese Mental Health Journal*, *33*(04), 312–317. https://doi.org/11.1873/R.20190226.0906.028.

Li, J., Xue, W., Zhao, J., & Tan, L. (2022). Cognitive bias and fear of missing out (FoMO) among Chinese college students: The mediating effects of attentional control, need to belong and self-construal. *Current Psychology*, 1–10. https://doi.org/10.1007/s12144-022-03435-x.

Li, J., Zhan, D., Zhou, Y., & Gao, X. (2021). Loneliness and problematic mobile phone use among adolescents during the COVID-19 pandemic: The roles of escape motivation and self-control. *Addictive Behaviors*, *118*, 106857. https://doi.org/10.1016/j.addbeh.2021.106857.

Lin, L., Wang, X., Li, Q., Xia, B., Chen, P., & Wang, W. (2021). The influence of interpersonal sensitivity on smartphone addiction: A moderated mediation model. *Frontiers in Psychology*, *12*, 670223. https://doi.org/10.3389/fpsyg.2021.670223.

Liu, J., Liu, M., & Liang, W. (2022). The dynamic COVID-zero strategy in China. *China CDC Wkly*, *4*(4), 74–75. https://doi.org/10.46234/ccdcw2022.015.

Lydon-Staley, D. M., Falk, E. B., & Bassett, D. S. (2020). Within-person variability in sensation-seeking during daily life: Positive associations with alcohol use and self-defined risky behaviors. *Psychology of Addictive Behaviors*, *34*(2), 257–268. https://doi.org/10.1037/adb0000535.

Mandasari, B. (2020). The impact of online learning toward students' academic performance on business correspondence course. *EDUTEC: Journal of Education and Technology*, *4*(1), 98–110. https://doi.org/10.29062/edu.v4i1.74.

Masaeli, N., & Farhadi, H. (2021). Prevalence of internet-based addictive behaviors during COVID-19 pandemic: A systematic review. *Journal of Addictive Diseases*, *39*(4), 468–488. https://doi.org/10.1080/10550887.2021.1895962.

Meng, S. Q., Cheng, J. L., Li, Y. Y., Yang, X. Q., Zheng, J. W., Chang, X. W., … Shi, J. (2022). Global prevalence of digital addiction in general population: A systematic review and meta-analysis. *Clinical Psychology Review*, *92*, 102128. https://doi.org/10.1016/j.cpr.2022.102128.

Mitchell, L., & Hussain, Z. (2018). Predictors of problematic smartphone use: An examination of the integrative pathways model and the role of age, gender, impulsiveness, excessive reassurance seeking, extraversion, and depression. *Behavioral Sciences*, *8*(8), 74. https://doi.org/10.3390/bs8080074.

Morfaki, C., & Skotis, A. (2022). Academic online learning experience during COVID-19-a systematic literature review based on personality traits. *Higher Education, Skills and Work-Based Learning* (ahead-of-print) https://doi.org/10.1108/HESWBL-03-2022-0062.

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

O'Day, E. B., & Heimberg, R. G. (2021). Social media use, social anxiety, and loneliness: A systematic review. *Computers in Human Behavior Reports*, *3*, 100070. https://doi.org/10.1016/j.chbr.2021.100070.

Omar, H. A., Ali, E. M., & Belbase, S. (2021). Graduate students' experience and academic achievements with online learning during COVID-19 pandemic. *Sustainability*, *13*(23), 13055. https://doi.org/10.3390/su132313055.

Panova, T., & Carbonell, X. (2018). Is smartphone addiction really an addiction? *Journal of Behavioral Addictions*, *7*(2), 252–259. https://doi.org/10.1556/2006.7.2018.49.

Parry, Davidson, B. I., Sewall, C. J. R., Fisher, J. T., Mieczkowski, H., & Quintana, D. S. (2021). A systematic review and meta-analysis of discrepancies between logged and self-reported digital media use. *Nature Human Behaviour*, *5*(11), 1535–1547. https://doi.org/10.1038/s41562-021-01117-5.

Patton, G. C., Sawyer, S. M., Santelli, J. S., Ross, D. A., Afifi, R., Allen, N. B., … Viner, R. M. (2016). Our future: A lancet commission on adolescent health and wellbeing. *Lancet (London, England)*, *387*(10036), 2423–2478. https://doi.org/10.1016/S0140-6736(16)00579-1.

Pera, A. (2020). The psychology of addictive smartphone behavior in young adults: Problematic use, social anxiety, and depressive stress. *Frontiers in Psychiatry*, *11*, 573473. https://doi.org/10.3389/fpsyt.2020.573473.

Pierce, T. (2009). Social anxiety and technology: Face-to-face communication versus technological communication among teens. *Computers in Human Behavior*, *25*(6), 1367–1372. https://doi.org/10.1016/j.chb.2009.06.003.

Prizant-Passal, S., Shechner, T., & Aderka, I. M. (2016). Social anxiety and internet use – A meta-analysis: What do we know? What are we missing? *Computers in Human Behavior*, *62*, 221–229. https://doi.org/10.1016/j.chb.2016.04.003.

Przybylski, A. K., Murayama, K., DeHaan, C. R., & Gladwell, V. (2013). Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior*, *29*(4), 1841–1848. https://doi.org/10.1016/j.chb.2013.02.014.

R Core Team (2022). *R: A language and environment for statistical computing*. https://www.R-project.org/.

Ran, G., Li, J., Zhang, Q., & Niu, X. (2022). The association between social anxiety and mobile phone addiction: A three-level meta-analysis. *Computers in Human Behavior*, *130*, 107198. https://doi.org/10.1016/j.chb.2022.107198.

Rhemtulla, M., van Bork, R., & Cramer, A. (2022). Cross-lagged network models. Multivariate *Behavioral Research*. Retrieved from https://osf.io/r24q6/.

Rizvi, S., Rienties, B., & Khoja, S. A. (2019). The role of demographics in online learning; A decision tree based approach. *Computers & Education*, *137*, 32–47. https://doi.org/10.1016/j.compedu.2019.04.001.

Robinson, T. (2019). Using the technology acceptance model to examine technology acceptance of online learning technologies by non-traditional students. *I-Manager's Journal of Educational Technology*, *16*(1), 21. https://doi.org/10.26634/jet.16.1.15826.

Rogers, A. P., & Barber, L. K. (2019). Addressing FoMO and telepressure among university students: Could a technology intervention help with social media use and sleep disruption? *Computers in Human Behavior*, *93*, 192–199. https://doi.org/10.1016/j.chb.2018.12.016.

Salloum, S. A., Alhamad, A. Q. M., Al-Emran, M., Monem, A. A., & Shaalan, K. (2019). Exploring students' acceptance of E-learning through the development of a comprehensive technology acceptance model. *IEEE Access*, *7*, 128445–128462. https://doi.org/10.1109/ACCESS.2019.2939467.

Samaha, M., & Hawi, N. S. (2016). Relationships among smartphone addiction, stress, academic performance, and satisfaction with life. *Computers in Human Behavior*, *57*, 321–325. https://doi.org/https://doi.org/10.1016/j.chb.2015.12.045.

Sánchez Hernández, M. O., Carrasco, M. A., & Holgado-Tello, F. P. (2021). Anxiety and depression symptoms in Spanish children and adolescents: An exploration of comorbidity from the network perspective. *Child Psychiatry and Human Development*, *54*(3), 736–749. https://doi.org/10.1007/s10578-021-01286-4.

Seabrook, E. M., Kern, M. L., & Rickard, N. S. (2016). Social networking sites, depression, and anxiety: A systematic review. *JMIR Mental Health*, *3*(4), e50. https://doi.org/10.2196/mental.5842.

Serra, G., Lo Scalzo, L., Giuffre, M., Ferrara, P., & Corsello, G. (2021). Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: Cohort study on 184 Italian children and adolescents. *Italian Journal of Pediatrics*, *47*(1), 150. https://doi.org/10.1186/s13052-021-01102-8.

Servidio, R. (2021). Self-control and problematic smartphone use among Italian University students: The mediating role of the fear of missing out and of smartphone use patterns. *Current Psychology*, *40*(8), 4101–4111. https://doi.org/10.1007/s12144-019-00373-z.

Servidio, R., Koronczai, B., Griffiths, M. D., & Demetrovics, Z. (2022). Problematic smartphone use and problematic social media use: The predictive role of self-construal and the mediating effect of fear missing out. *Frontiers in Public Health*, *10*, 814468. https://doi.org/10.3389/fpubh.2022.814468.

Sunday, O. J., Adesope, O. O., & Maarhuis, P. L. (2021). The effects of smartphone addiction on learning: A meta-analysis. *Computers in Human Behavior Reports*, *4*, 100114. https://doi.org/10.1016/j.chbr.2021.100114.

Tang, X., Liu, Q., Cai, F., Tian, H., Shi, X., & Tang, S. (2022). Prevalence of social anxiety disorder and symptoms among Chinese children, adolescents and young adults: A systematic review and meta-analysis. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.792356.

Tao, Y., Tang, Q., Zou, X., Wang, S., Ma, Z., Liu, X., & Zhang, L. (2023). The impact of long-term online learning on internet addiction symptoms among depressed secondary school students: Insights from a cross-panel network analysis. *Behavioral Sciences*, *13*(7), 520. https://doi.org/10.3390/bs13070520.

Teale Sapach, M. J. N., Carleton, R. N., Mulvogue, M. K., Weeks, J. W., & Heimberg, R. G. (2015). Cognitive constructs and social anxiety disorder: Beyond fearing negative evaluation. *Cognitive Behaviour Therapy*, *44*(1), 63–73. https://doi.org/10.1080/16506073.2014.961539.

The Paper (2022). *Harbin resumed offline teaching in an orderly manner*. from https://m.thepaper.cn/baijiahao_18055225 [Retrieved 20 August 2023].

UNESCO (2023). *Education: From school closure to recovery*. from https://www.unesco.org/en/covid-19/education-response [Retrieved 29 July 2023].

Van Ijzendoorn, M. H., Van Ijzendoorn, & Bakermans-Kranenburg, M. J. (2003). Attachment disorders and disorganized attachment: Similar and different1. *Attachment & Human Development*, *5*(3), 313–320. https://doi.org/10.1080/14616730310001593938.

Vassilopoulos, S. P., Brouzos, A., Moberly, N. J., Tsorbatzoudis, H., & Tziouma, O. (2017). Generalisation of the Clark and Wells cognitive model of social anxiety to children's athletic and sporting situations. *British Journal of Guidance & Counselling*, *45*(1), 1–15. https://doi.org/10.1080/03069885.2015.1057474.

Wang, J., Wang, P., Yang, X., Zhang, G., Wang, X., Zhao, F., … Lei, L. (2019). Fear of missing out and procrastination as mediators between sensation seeking and adolescent smartphone addiction. *International Journal of Mental Health and Addiction*, *17*(4), 1049–1062. https://doi.org/10.1007/s11469-019-00106-0.

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

Wei, X.-Y., Ren, L., Jiang, H.-B., Liu, C., Wang, H.-X., Geng, J.-Y., … Lei, L. (2023). Does adolescents' social anxiety trigger problematic smartphone use, or vice versa? A comparison between problematic and unproblematic smartphone users. *Computers in Human Behavior*, *140*, 107602. https://doi.org/10.1016/j.chb.2022.107602.

Xiao, Z., & Huang, J. (2022). The relation between college students' social anxiety and mobile phone addiction: The mediating role of regulatory emotional self-efficacy and subjective well-being. *Frontiers in Psychology*, *13*, 861527. https://doi.org/10.3389/fpsyg.2022.861527.

Xin, S., Peng, H., & Sheng, L. (2022). Changes of social anxiety in Chinese adolescents during 2002 ~ 2020: An increasing trend and its relationship with social change. *Children and Youth Services Review*, *142*, 106614. https://doi.org/10.1016/j.childyouth.2022.106614.

Yang, W., Hu, W., Morita, N., Ogai, Y., Saito, T., & Wei, Y. (2022). Impact of short-term intensive-type cognitive behavioral therapy intervention on internet addiction among Chinese college students: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, *19*(9), 5212. https://doi.org/10.3390/ijerph19095212.

Yang, H., Wang, Z., Elhai, J. D., & Montag, C. (2022). The relationship between adolescent emotion dysregulation and problematic technology use: Systematic review of the empirical literature. *Journal of Behavioral Addictions*, *11*(2), 290–304. https://doi.org/10.1556/2006.2022.00038.

Yen, S.-C., Lo, Y., Lee, A., & Enriquez, J. (2018). Learning online, offline, and in-between: Comparing student academic outcomes and course satisfaction in face-to-face, online, and blended

teaching modalities. *Education and Information Technologies*, *23*(5), 2141–2153. https://doi.org/10.1007/s10639-018-9707-5.

Young, K. S., Sandman, C. F., & Craske, M. G. (2019). Positive and negative emotion regulation in adolescence: Links to anxiety and depression. *Brain Sciences*, *9*(4), 76. https://www.mdpi.com/2076-3425/9/4/76.

Zhang, H. (2022). The influence of the ongoing COVID-19 pandemic on family violence in China. *Journal of Family Violence*, *37*(5), 733–743. https://doi.org/10.1007/s10896-020-00196-8.

Zhang, X.-C., Chu, X.-W., Fan, C.-Y., Andrasik, F., Shi, H.-F., & Hu, X.-E. (2022). Sensation seeking and cyberbullying among Chinese adolescents: Examining the mediating roles of boredom experience and antisocial media exposure. *Computers in Human Behavior*, *130*, 107185. https://doi.org/10.1016/j.chb.2022.107185.

Zhang, M. X., & Wu, A. M. S. (2020). Effects of smartphone addiction on sleep quality among Chinese university students: The mediating role of self-regulation and bedtime procrastination. *Addictive Behaviors*, *111*, 106552. https://doi.org/10.1016/j.addbeh.2020.106552.

Zhu, H. (2008). *A Study on the Relationship of Attachment to social Anxiety among adolescents*. [Master, Southwest University]. https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD2008&filename=2008092512.nh.

Zuckerman, M., Kolin, E. A., Price, L., & Zoob, I. (1964). Development of a sensation-seeking scale. *Journal of Consulting Psychology*, *28*, 477–482. https://doi.org/10.1037/h0040995.