# The relationship between adolescent stress and problematic smartphone use: The serial mediating effects of anxiety and frequency of smartphone use

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## Abstract
Adolescents' increased use of smartphones associates with stress and anxiety. Recently studies have examined mediating psychological constructs accounting for relations between stress and problematic smartphone use severity. The current cross-sectional study aimed to analyze anxiety and smartphone use frequency as possible mediators between stress and problematic smartphone use. We recruited 7681 Chinese adolescents (54.58% female) by cluster sampling via a web-based survey that measured stress, anxiety (Depression Anxiety Stress Scale-21, DASS-21), problematic smartphone use (Smartphone addiction scale-short version, SAS-SV), and smartphone use frequency (Smartphone use frequency scale, SUF). For adolescents, stress was significantly associated with problematic smartphone use severity ($r=0.52$, $p<0.01$). Anxiety and the smartphone use frequency mediated relations between stress and problematic smartphone use severity. In the final model, anxiety and smartphone use frequency played a serial mediating role between stress and problematic smartphone use severity. Adolescent stress has a positively related to problematic smartphone use severity, both directly and indirectly, through their anxiety and smartphone use frequency. Thus, future research should focus on adolescents' anxiety and its association with smartphone use frequency.

**Keywords** Stress · Problematic smartphone use · Anxiety · Smartphone use frequency · Adolescent

## Highlights
● Adolescent stress is a positive correlate of problematic smartphone use (PSU) severity.
● Anxiety and the smartphone use frequency play a serial mediating role between adolescent stress and PSU severity.
● This is a large-scale questionnaire survey of Chinese adolescents.

**Implications and Contribution** Adolescents perceiving more stress reported more problematic smartphone use severity. Their anxiety and smartphone use frequency play a serial mediating role in this relationship. Findings raise concerns about adolescent problematic smartphone use and their behavior habits.

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Literature shows that excessive smartphone use has become a worldwide phenomenon (Liu et al., 2017a), and its negative consequences have attracted a wide body of scholarly research. As people continue to overuse their smartphones, they use it more and more uncontrollably (Durak, 2019). This has a series of negative consequences. Therefore, excessive smartphone use can turn into a problematic smartphone use as a result. Problematic smartphone use (PSU) is defined by maladaptive smartphone use with functional impairment, involving symptoms observed in substance use disorders (Elhai et al., 2020). PSU has a negative impact on academic performance (Çağan et al., 2014) and interpersonal relationships (Chen et al., 2016), and is associated with psychological and behavioral problems such as anxiety (Elhai et al., 2017a), depression (Seo et al., 2016; Coyne et al., 2019), sleep disorders (Liu et al., 2017b) and suicidal ideation (Wang et al., 2014). However, many studies only explore the relationship between PSU, stress and anxiety (Elhai et al., 2017a; Xu et al., 2018), but no studies have explored the role of the frequency of smartphone use in them. That is, the effect of smartphone use frequency on the relationship between stress, anxiety and PSU. The current

study constructs a model that incorporates smartphone use frequency and three other variables into a model that could explain why individuals are more prone to PSU when they feel stressed or anxious, as they may use smartphone more frequently. Based on those the empirical evidence, the purpose of this paper is to investigate PSU severity in relation to several psychological constructs, exploring mechanisms for PSU's development in a Chinese sample of adolescents.

Research Report on Internet use of Chinese Minors in 2019 points out that there are 175 million underage Internet users in China, of which 93.9% use a smartphone to access the Internet (CNNIC, 2019). Some people are more likely to engage in smartphone overuse because of the functionality and convenience of the smartphone (Liu et al., 2017a). Adolescents are at high risk of PSU due to their high impulsivity in psychology and behavior (Jun, 2016). Numerous studies in many countries have shown that rates of PSU among adolescents are over 30% and it is accompanied by problems such as insomnia, anxiety, and substance addiction (He et al., 2012; Yen et al., 2008). Such behavior can predict addictive behavior in adulthood (Englund et al., 2008). Therefore, research on the influencing factors of adolescent PSU can elucidate this phenomenon to help reduce smartphone overuse in adulthood.

## Adolescent Stress and PSU

From Davis's view (Davis, 2001), stress may be a necessary factor for Internet overuse. In the same vein, Compensatory Internet Use Theory (CIUT) (Kardefelt-Winther, 2014) also indicates that some people overuse their smartphones to deal with negative emotions and life stressors. The I-PACE (Interaction of Person-Affect-Cognition-Execution) model (Brand et al., 2016) indicates that stress is a potential factor leading to the overuse of Internet-related technologies, and can cause cognitive and emotional reactions (the A- and C-components). Individuals' perceived stress affects their cognitive processes, and they may use the Internet to cope with the effects of stress on cognitive processing (Brand et al., 2016). These cognitive and emotional reactions (including attentional bias to Internet-related stimuli) lead to individual decisions to use a certain Internet-related technology, possibly resulting in problematic use. Adolescent stress is associated with problematic levels of Internet use (Li et al., 2009), social network site use (Zhao & Zhou, 2021), online gaming (Zhang et al., 2019a), and smartphone use (Qin et al., 2020). The heightened risk of impulsivity during adolescence may also make adolescents more likely to engage in PSU during stressful situations, and therefore, adolescent stress may be positively related to the severity of PSU.

## Anxiety as a Mediator of Stress and PSU

Adolescent stress also is associated with anxiety (Al-Gelban, 2007). CIUT (Kardefelt-Winther, 2014) emphasizes that people overuse the Internet and other related technologies because they want to alleviate negative emotions, subsequently leading to overuse. The theory has been supported by research on PSU (Elhai et al., 2018; Long et al., 2016; Zhitomirsky-Geffet & Blau, 2016). The I-PACE model (Brand et al., 2016) also indicates that anxiety is a predisposing variable representing core characteristics of the person related to internet overuse (the P- components), and it is also one of the emotional responses induced by stress, which drives the individual to engage in internet overuse. Such theories have informed models of the association between these variables, it is speculated that stress makes adolescent anxiety, and anxiety may play an important role in stress and adolescent PSU.

## The Mediating Role of Smartphone Use Frequency in the Relationship Between Stress and PSU

According to CIUT (Kardefelt-Winther, 2014), adolescent stress may also closely relate to the frequency of using smartphones. Specifically, adolescents may use a smartphone to relieve academic stress and resulting negative emotions (Wang et al., 2020). The relationship between adolescents' smartphone use frequency and their PSU severity has been confirmed by previous research (Elhai et al., 2020), and the higher smartphone use frequency, the greater possibility of overuse (van Deursen et al., 2015). In summary, it is speculated that stress faced by adolescents increases their smartphone use frequency, which makes they more prone to PSU.

## Aims

Several studies reviewed above revealed associations between adolescent stress, anxiety, smartphone use frequency, and PSU. Furthermore, adolescent anxiety and smartphone use frequency may mediate relations between stress and PSU severity. This topic is essential in understanding why many adolescents with stress or anxiety may engage in problematic Internet technology use. Based on this, the current study used self-reported scales to investigate the relationship between the four variables.

## Hypotheses

The hypotheses of the current study are in part guided by CIUT's conceptualization (Kardefelt-Winther, 2014) that stress drives internet overuse (e.g., PSU) to alleviate negative emotion. And hypotheses are especially guided by I-PACE's conceptualization (Brand et al., 2016) of the subjectively perceived situation (e.g., stress), as risk factors for increased levels of internet use (e.g., smartphone use frequency) which in turn can develop into problematic use such as PSU. In the adolescent sample, more importantly, they have high impulsive psychological characteristics, and they are more likely to engage in PSU due to stress (Jun, 2016). Therefore, we propose:

> H1: Adolescent stress should be positively related to PSU severity

Stress is closely related to PSU, and both are all related to anxiety. In the I-PACE model, anxiety is a predisposing variable of Internet-related overuse (Brand et al., 2016). Based on these previous research results, anxiety should be a mechanism mediating the relationship between stress and PSU severity. Therefore, we propose:

> H2: Adolescent anxiety should mediate relations between their stress and PSU severity

Stress makes adolescents use smartphones more frequently, and smartphone use frequency is also closely related to PSU (Shen & Wang, 2019). Similar to anxiety, the smartphone use frequency may be a mechanism mediating the relationship between stress and PSU. Therefore, we propose:

> H3: Adolescent smartphone use frequency should mediate relations between their stress and PSU severity

Although anxiety and smartphone use frequency may be mediating variables between adolescent stress and PSU severity, there is also a prominent correlation between them (Elhai et al., 2017b). A meta-analysis showed that smartphone use frequency was higher in anxious individuals, and there was a moderate positive correlation between use frequency and anxiety (Zhang et al., 2019b). Mobile Internet has the function of satisfying communication and venting emotions, which can let individuals obtain satisfaction (Zhang et al., 2019c), to effectively deal with stress and negative emotion. Therefore, according to the previous research and CIUT (Kardefelt-Winther, 2014), the smartphone use frequency may be to deal with anxiety caused by stress,

but it may increase the probability of PSU. The I-PACE model (Brand et al., 2016) also indicates that the negative emotional state caused by stress makes individuals decide to use a certain network-related technology, resulting in overuse such as PSU. Therefore, we propose:

> H4: Adolescent anxiety should be positively related to smartphone use frequency. That is, anxiety and smartphone use frequency should play a serial mediating role in the relationship between adolescent stress and PSU severity

The hypothesis model is shown in Fig. 1.

## Method

### Participants and Procedure

In 2020, we conducted a web survey in Tianjin, China. Student participants were recruited at their schools by university psychology faculty. Those enrolling were routed online to an informed consent statement, and (for those consenting) a web survey, hosted by the Chinese web survey platform: wjx.cn. All measures were administered in simplified Chinese characters.

A total of 8346 questionnaires were collected from students of several junior and senior middle schools in Tianjin. After removing participants whose response time was substantially short or long, resulted in an effective sample of 7681 participants (92.03%). There were 3489 boys (45.42%) and 4192 girls (54.58%); there were 4704 junior high school students (61.24%), and 2977 senior high school students (38.76%). Mean age was 15.21 years (SD = 1.63).

### Instruments

#### Depression Anxiety Stress Scale-21 (DASS-21)

The DASS-21 (Wang et al., 2016) consists of 21 items measuring depression, anxiety, and stress symptoms. Each sub-scale is measured by seven items rated over the past week, with options from "0 = Did not apply to me" to "3 = Applied
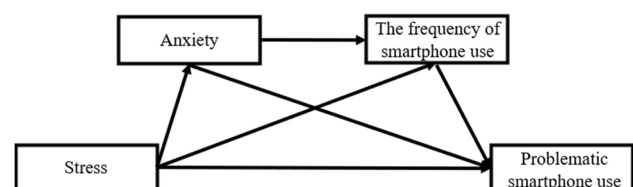


**Fig. 1** Hypothetical serial mediation model

to me very much or most of the time"; we only analyzed the anxiety and stress subscales. The validity of the Chinese version of the scale has been verified in Chinese samples (Gong et al., 2010; Lu et al., 2020). Coefficient alphas for our sample were 0.881 for stress, and 0.856 for anxiety.

### Smartphone Addiction Scale-Short Version (SAS-SV)

SAS-SV (Kwon et al., 2013) was used to measure problematic smartphone use severity via self-report. The SAS-SV contains 10 items with response options from "1 = Strongly disagree" to "6 = Strongly agree". The validity of the Chinese version of the scale has been verified in Chinese samples (Elhai et al., 2020). Coefficient alpha for our sample was 0.924.

### Smartphone Use Frequency Scale (SUF)

The smartphone use frequency scale (Elhai et al., 2020) measures the individual smartphone use frequency. It contains 12 items with response options from "1 = never" to "6 = very often". The higher the score, the higher frequency of smartphone use. Coefficient alpha for our sample was 0.792.

### Data Analysis

SPSS 21 software was used for descriptive statistics. R software's (version 4.0.3) *corrplot* package was used for data analysis (variable intercorrelations). The PROCESS macro for SPSS 21 software was used for serial mediation effect analysis.

## Results

### Descriptive Statistics and Correlation Analysis of Variables

The descriptive statistical results of the scales are shown in Table 1, and correlations are shown in Fig. 2. The
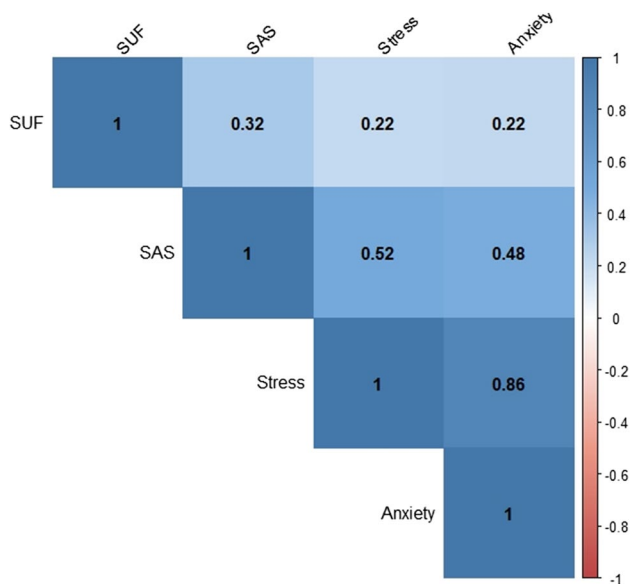


**Fig. 2** Correlation matrix among variables Notes: SUF = Smartphone use frequency scale; SAS = Smartphone addiction scale-short version (SAS-SV). All correlations were significant at p < 0.01, Correlations with a darker shade indicate stronger correlations

relationships between the four variables in this study support the subsequent hypothesis tests.

### Results of the Model

According to the above hypothesis model, the independent variable is stress, mediating variable 1 is anxiety, mediating variable 2 is smartphone use frequency, and the dependent variable is PSU. The serial mediating model of the PROCESS macro was selected to test the mediating effect, with 1000 bootstrapped replications. According to the hypothesis model, it can be seen that stress is associated with PSU severity through four paths. Direct path: stress → PSU; Indirect path 1: stress → anxiety → PSU; Indirect path 2: stress → anxiety →smartphone use frequency → PSU; Indirect path 3: stress → smartphone use frequency → PSU. If any of the three indirect paths are significant, this suggests mediation.

As results in Table 2; Fig. 3, the direct path effect value was 0.383 (95% CI: 0.346–0.419), the indirect path 1 effect value was 0.092 (95% CI: 0.057–0.124), the indirect path 2 effect value was 0.018 (95% CI: 0.009–0.029), and the indirect path 3 effect value was 0.028 (95% CI: 0.019–0.037). None of the confidence intervals included 0, and the mediating effect ratio was 26.35%. The hypothesis model of this study was supported after data analysis. Adolescent stress not only has a direct relationship with their PSU severity but also has an indirect association with PSU through the

**Table 1** Descriptive statistical results of variables

| Variables | M | SD |
|---|---|---|
| 1 Stress | 11.06 | 4.58 |
| 2 Anxiety | 10.39 | 4.07 |
| 3 SUF | 39.60 | 9.89 |
| 4 SAS-SV | 27.64 | 12.63 |

**Table 2** The serial mediating effect of anxiety and frequency of smartphone use between stress and PSU in adolescents, with standardized estimates displayed

| Effect | Path | Effect value | SE | Confidence interval | |
|---|---|---|---|---|---|
| | | | | LLCI | ULCI |
| Mediating effect | stress → anxiety → PSU (indirect1) | 0.092 | 0.017 | 0.057 | 0.124 |
| | stress → anxiety → frequency of smartphone use → PSU (indirect2) | 0.018 | 0.005 | 0.009 | 0.029 |
| | stress → frequency of smartphone use → PSU(indirect3) | 0.028 | 0.004 | 0.019 | 0.037 |
| Total mediating effect | indirect1 + indirect2 + indirect3 | 0.137 | 0.018 | 0.103 | 0.172 |
| Direct effect | stress → PSU (direct) | 0.383 | 0.188 | 0.346 | 0.419 |
| Total effect | direct effect + indirect effect | 0.520 | 0.010 | 0.501 | 0.539 |
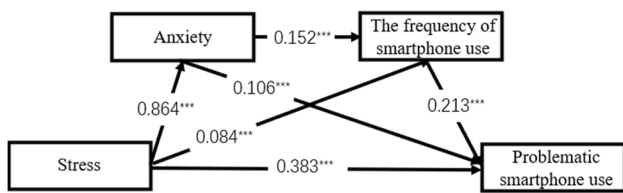


**Fig. 3** Model of serial mediating effect, with standardized estimates displayed. Notes: ** p < 0.01

serial mediating effect of anxiety and smartphone use frequency.

## Discussion

### The Serial Mediating Effect of Anxiety and Smartphone Use Frequency

We found that anxiety and the smartphone use frequency played a serial mediating role between adolescent stress and PSU severity, which verified H4. The result indicated that adolescents can use smartphones and mobile Internet to cope with stress and alleviate their negative emotions. The result also revealed that anxiety is closely related to the smartphone use frequency. Consistent with the orientation of CIUT (Kardefelt-Winther, 2014), in the investigation of Internet-related overuse, we should combine the motivation for smartphone use and mental health to better explain why individuals use the Internet and addiction. This potential explanation seems to support the I-PACE model (Brand et al., 2016) and the finding that adolescents' stress is associated with the experience of anxiety which leads to higher frequency of smartphone use and, subsequently, more experiences of problematic smartphone use, is interesting in and of itself and suggests that turning to the smartphone to relieve anxiety may be a maladaptive coping mechanism - since it leads them to experiencing more problematic use (which can be harmful).

The current study revealed the serial mediating effect of anxiety and smartphone use frequency between stress and adolescent PSU. This result provides a way of thinking for the prevention and intervention of adolescent PSU. First of all, there was a positive correlation between stress and adolescent PSU severity. Adolescents will encounter a variety of stressors in their lives. It is recommended that parents and teachers provide them with more social support to reduce their stress and reduce their maladaptive behaviors. Secondly, anxiety and smartphone use frequency played a mediating role between stress and PSU severity. Psychological education practitioners in primary and secondary schools are advised to pay attention to the negative emotions of adolescents when they see an increase in the frequency of smartphone use among adolescents to reduce the severity of their PSU.

Of course, although in the model constructed in the current study, the frequency of smartphone use bears a negative effect. But it also seems inappropriate to directly prevent adolescents from using smartphone or blindly reduce their smartphone usage. After all, using a smartphone is one of the ways they deal with negative emotions.

### Adolescent Stress is Positively Related to PSU Severity

The current study explored the relationship between adolescent stress and PSU severity. There was a significant positive correlation between adolescent stress and PSU severity, which verified H1. The result was consistent with previous work finding relations between stress and addictive behavior (Zhang et al., 2019a), and stress was also an important factor for individuals with PSU (Gao et al., 2018; Samaha & Hawi, 2016; Qin et al., 2020).

This study expanded the related research on the influencing factors of adolescent PSU and explored the relationship between adolescent stress and PSU and its mechanism based on CIUT (Kardefelt-Winther, 2014) and I-PACE model (Brand et al., 2016). When adolescents experience stress,

they may be more likely to form PSU. This may be because adolescents need smartphones to relieve their stress and maintain the internal and external balance of the organism (Kardefelt-Winther, 2014). Therefore, it's also important to note that adolescents can also use smartphones normally to relieve stress. The results enrich the field of adolescent addictive behaviors and provide an empirical basis for PSU's relations with psychological constructs.

## The Mediating Effect of Anxiety and the Smartphone Use Frequency

The results indicated that anxiety is positively correlated with adolescent stress and PSU severity, and anxiety plays a mediating role between adolescent stress and PSU, which verified H2. At the same time, the results support CIUT (Kardefelt-Winther, 2014) and I-PACE model (Brand et al., 2016): adolescent stress and anxiety are closely related to PSU. Adolescents' anxiety may be greater when they feel stressed, which is inextricably linked to the severity of their PSU. The current study investigated these three variables simultaneously and revealed that adolescent stress is associated with PSU severity through anxiety. Anxiety in adolescents can sometimes be the result of their need to cope with stress. In order to alleviate this negative emotion, they resort to increased smartphone use as a coping mechanism. Drawing inspiration from the I-PACE model (Brand et al., 2016), anxiety is a predisposing variable for individuals to become PSU. Therefore, anxiety can be used as an entry point in the intervention strategies of adolescent PSU, and reduce their PSU by alleviating their anxiety. From this point of view, adolescents can use smartphones appropriately to relieve their anxiety.

The results also indicated that the smartphone use frequency is positively correlated with adolescents' stress and PSU severity, and the smartphone use frequency plays a mediating role between adolescents' stress and PSU, which verified H3. Adolescent stress positively predicts the smartphone use frequency, while the smartphone use frequency also positively predicts PSU severity. The results are consistent with the view of CIUT (Kardefelt-Winther, 2014) and the I-PACE model (Brand et al., 2016): stress is one of the factors that encourage individuals to keep using a smartphone. With the increase of people's smartphone use frequency, people may rely more on smartphones, resulting in PSU. Adolescents' use of smartphones to relieve anxiety may be a maladaptive coping mechanism. If their smartphone use frequency cannot be controlled, their problematic use will increase when adolescents are under great stress, which may lead to the formation of PSU.

## Strengths and Limitations

This study has several strengths, as well as some limitations. A strength of our study has a large number of samples, which shows that the results are more representative. However, this investigation was a cross-sectional study and the participants were all from Tianjin, which contributes to the persuasiveness of this study. Although some psychological theories and previous empirical evidence provide the basis for this study, it is difficult to prove a causal relationship between variables. In the future, we need to use experimental research methods to further verify the relationship between variables. Secondly, this study verified the previous hypotheses, but the four variables of stress, anxiety, smartphone use frequency, and PSU can be subdivided and further explored. In addition, as a daily tool, individual PSU is due to some content, such as problematic social media use. This study is limited by measurement tools and has not carried out a detailed analysis on this aspect. It should also be noted that Internet and smartphone-related technologies are developing rapidly, and the results of this study need to be verified continuously.

## Conclusions

Adolescent stress was a positive correlate of PSU severity. Anxiety and smartphone use frequency played a serial mediating role between adolescent stress and PSU. Our findings have implications for the prevention of adolescent PSU: pubertal PSU risk is an important area that can help identify at-risk adolescents who would benefit from prevention efforts.

**Declarations**

Informed consent was obtained from all participants, while parents' permission was also obtained for those less than 18 years of age. The procedures were carried out in accordance with the Declaration of Helsinki. The ethical approval for this study was also obtained from the ethics committee of Tianjin Normal University (No. XL2020-21).

**Conflict of Interest** All authors declare that they have no conflicts of interest with this study. However, outside the scope of the present paper, the authors report the following…

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