Technostress from Smartphone Use and Its Impact on University Students' Sleep Quality and Academic Performance

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Accepted: 17 February 2022 / Published online: 2 March 2022
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Abstract Smartphone has been widely used by the younger generation. However, research exploring the *technostress* triggered by smartphone use lacks. Based upon the stressor-strain-outcome model, this study examined how smartphone use, especially *compulsive use*, *life invasion*, and *information overload*, cause university students' *technostress* and, furthermore, how *technostress* impact their *sleep quality* and *academic performance*. Data were collected from 540 undergraduates studying at a Chinese public university and analyzed using structural equation modeling. Results revealed that *compulsive smartphone use* and *information overload* are both positively associated with *technostress*, which in turn have a positive effect on poor *sleep quality* and *academic self-perception*. Furthermore, *compulsive smartphone use* indirectly predicts sleep and academic problems through the mediating effect of *technostress*. The findings contribute to extend the existing *technostress* literature and provide valuable practical implications for smartphone-related designers, university teachers, and students.

Keywords Technostress · Smartphone use · Information overload · Life invasion · Academic performance · Sleep quality

Introduction

Smartphone was widely used by university students around the world. On one hand, the benefits of smartphone use are undeniable. It brings students with grateful convenience, such as efficient and quick social interactions, mobile learning, and language learning (Zhang, 2021). On the other hand, overuse of mobile devices may also lead to negative reactions, such as *technostress*, which refers to individuals' stressful experiences due to the usage of information technologies (Ayyagari et al., 2011; Salo et al., 2019).

Technostress was considered to be negatively associated with individuals' well-being and performance (Brod, 1984; Nimrod & Galit, 2017; Upadhyaya & Acharya, 2020). However, the existing research on *technostress* mainly focused on employees (Tarafdar et al., 2007, 2011), teachers (Dong et al., 2019; Jena, 2015; Li & Wang, 2020), librarians (Ahmad & Amin, 2012), and older adults (Nimrod & Galit, 2017). Only a few researchers concerned the *technostress* of university students. Although the younger generation is digital natives, researchers have demonstrated that they also experience *technostress*. For example, Zhao et al. (2021) examined the relationships among university students' *technostress*, university support, and learning burnout in the context of technology-enhanced learning. They found that university students' *technostress* is at the upper-middle level. With the wide use of smartphones, the new generation may at a risk of experience increasing *technostress*. However, the *technostress* triggered by smartphone use of university students remains scarce.

In this background, this study aims to fulfill the research gaps by employing stressor-strain-outcome (SSO) model to estimate how smartphone use, especially *compulsive use*,

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life invasion, and *information overload*, cause university students' *technostress*, furthermore, how *technostress* influences their *sleep quality* and *academic performance*. Specifically, this study aims to address these two specific issues:

Research question 1: How *smartphone compulsive use*, *life invasion*, and *information overload* influence university students' *technostress*?

Research question 2: How *technostress* experienced by university students influences their *sleep quality* and *academic performance*?

Literature Review and Hypotheses Development

Technostress

Technostress was initially proposed by Brod (1984), who defined it as “a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner.” Then Arnetz and Wiholm (1997) viewed *technostress* as an arousal state experienced by individuals who need to use computers extensively to complete their work. In recent times, researchers defined it as users' any stress triggered by the usage of information and communications technologies (Ayyagari et al., 2011; Li & Wang, 2020; Ragu-Nathan et al., 2008), the present study adopt this definition.

The impacts of *technostress* on individuals may be manifested in physical, psychological, and behavioral aspects. The negative physical reactions include restlessness, headache, and fatigue (Arnetz & Wiholm, 1997); while the induced psychological effects include burnout, reduced satisfaction with the technology being used, and job (Ayyagari et al., 2011; Maier et al., 2019). Reduced productivity, decreased performance, and innovation are common negative behavioral effects (Ragu-Nathan et al., 2008; Upadhyaya & Acharya, 2020).

Several researchers have examined the *technostress* in the context of mobile devices usage. They found that the *compulsive use* predicts users' *technostress* positively (Boonjing & Chanvarasuth, 2017; Hsiao, 2017; Lee et al., 2014). For instance, with a sample of 546 Taiwanese users, Hsiao (2017) confirmed that *compulsive use* of both mobile social communication and game applications could lead to *technostress*. However, few studies have explored the specific related stressors that lead to users' *technostress* when using mobile devices. One exception is Lee et al. (2016). They examined the stressors of mobile communication use in the after-work hours of business workers. They found that social insecurity, *life invasion*, and work-

home conflict are the significant stressors of workers' *technostress*, which in turn predict their life satisfaction negatively. As far as we known, there is no study examined the antecedents and outcomes of *technostress* due to smartphone use of university students, who are a special population using smartphones widely. Examination of these associations would provide evidence for a better understanding of students' smartphone usage and intervention.

Research Model

The stressor-strain-outcome model (SSO) is an influential theoretical paradigm to understand the antecedents and consequences of stress related to technology use. A number of researchers have applied the SSO framework to study stress-related situations (Ayyagari et al., 2011; Dhir et al., 2018; Pang, 2021). The framework includes three main parts, stimulators (stressor), psychological response to stimulators (strain), and physical or mental consequences (outcome). Since SSO framework is completely consistent with the main purposes of the study, we employed it to get a deeper understanding of the determinants and outcomes of university students' *technostress* resulting from smartphone use.

According to the *technostress* frame of Tarafdar et al. (2011) and the findings of Hsiao (2017) and Lee et al. (2014), this study identified *compulsive smartphone use*, *information overload*, and *life invasion* as stressors related to smartphone use, while identified the *poor sleep quality* and *academic performance* as the related outcomes.

Compulsive Smartphone Use and Technostress

Compulsive smartphone use was regarded as a problematic use of smartphones, instead of rational use behavior (Panda & Jain, 2018). It usually manifests itself in the following characteristics: (1) unable to control the impulse to use smartphones; (2) falling into distressed when smartphones are inaccessible; (3) feeling excited when using smartphones even when one is fatigue; and (4) feeling restless when stop using smartphones.

Smartphones' characteristics of powerful engagement, such as computing function, entertainment capabilities, and constant Internet connectivity, may lead to users' uncontrolled use urge (Panda & Jain, 2018). On average, users touch their smartphones more than 2000 times per day (Dscout, 2016). In the recent times, people are using mobile phones more extensively due to the lockdown during the COVID-19 break (Sebire, 2020). Student is a

population at a higher risk, up to 61% of parents considered their children as smart devices addict (Robb, 2019). In China, up to 31.5% of college students have the problem of excessive mobile phone use (Fu & Peng, 2020).

In recent years, because of the wide popularity and disturbing consequences, *compulsive smartphone use* has attracted researchers' increasing attention (Panda & Jain, 2018; Wang et al., 2014). Researchers have confirmed that smartphones *compulsive use* would bring negative effects on users (Panda & Jain, 2018; Samaha & Hawi, 2016; Wang et al., 2015). In addition, several researchers found that *compulsive use* of mobile phones probably leads to *technostress* (Boonjing & Chanvarasuth, 2017; Panda & Jain, 2018). In this regard, this study formulated the hypothesis that university students' *compulsive smartphone use* is positively associated with their *technostress* (H1).

Life Invasion and Technostress

Previous researchers have studied *life invasion* in different contexts of technology usage. In organizational context, *life invasion* describes the situations where employee's personal life is being invaded by work related matters due to the extensive connectivity of ICT (Gaudio et al., 2017; Ragu-Nathan et al., 2008). In this context, employee may have to handle work issues at after-work hours. As a result, the boundaries between work and family may blur. In the nonorganizational context, *life invasion* refers to users' perception of their daily life being invaded due to the excessive centrality of the diverse ICT tools being used, such as social networks sites (Cao & Sun, 2018; Maier et al., 2015). As a result, the time and efforts spent on other worthwhile things would be reduced.

In this study, *life invasion* refers to university students' negative perception that smartphone plays a too central role and has invaded their personal life. Students may experience *life invasion* due to the ubiquitous Internet connectivity and various applications of smartphone use. For instance, WeChat, a widely used social software in China, which has been installed on almost every university student's smartphone and enables them to be online 24 h a day. Students may continuously check their WeChat with smartphones when dealing with other worthwhile activities that need to be focused, such as learning, attending meetings, playing sports, and face-to-face conversation.

In the *technostress* literature, *life invasion* was considered to be positively associated with *technostress* (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). Similarly, Xiao and Mou (2019) also confirmed that *life invasion* due to Wechat use leads to users' social media fatigue. Therefore, this study formulated the hypothesis that *life invasion* due to smartphone use is positively associated with university students' *technostress* (H2).

Information Overload and Technostress

Users can obtain a huge amount of information quickly and conveniently using smartphone. However, *information overload*, which refers to the situation in which individuals are exposed to more information than they can effectively handle, has become a pervasive issue (Fu et al., 2020). *Information overload* is identified as a key factor leading to the negative consequences of digital technology use (Lee et al., 2016).

In this study, *information overload* describes the situation where students are exposed to excessive information via smartphone, which beyond their capability to process. The smartphone may increase the risk of *information overload* at least in these two aspects. First, universities tend to release information about learning and management through social class groups, such as WeChat group. However, these social groups are often filled with a lot of irrelevant information such as chatting, advertising, and rumors. Second, other diverse apps on smartphones usually push messages and notifications to students constantly and automatically. Since students' cognitive ability is limited, they may not be able to handle the constant flow of information through their smartphones effectively.

Previous studies have confirmed that different types of overload, inclusive of *information overload*, could lead to users' social media exhaustion, and then consequently, result in the discontinuous usage of social media (Fu et al., 2020). Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) also proposed that continuous *information overload* will lead to *technostress*. Similarly, Arla et al. (2012) identified *information overload* as a formative indicator of technostress. Hence, we formulated the hypothesis that *information overload* due to smartphone use is positively associated with students' *technostress* (H3).

Technostress and Sleep Quality

It is found that up to 60% university students suffer from sleep difficulties, such as decreased sleep duration and difficult in falling asleep (Foulkes et al., 2019). *Poor sleep quality* may lead to diverse and serious consequences, such as physical ill-being, mental problems, and mortality (Freeman et al., 2017). For students, another common negative outcome of insufficient sleep is poor *academic performance*. Researchers have confirmed that *sleep quality* is negatively associated with students' academic achievements (Gomes et al., 2011). University students with longer sleep duration are more likely to get higher grade point averages (Kelly et al., 2001).

Researchers studied that the negative effects of smartphone use have proved that the overuse of smartphone is positively associated with individuals' poor quality of sleep

(The Guardian, 2017). Since stress is an important contributor to individuals' sleep problems (Greubel & Kecklund, 2011; Lazarus & Folkman, 1984), excepting that smartphone use would take up some sleep time, resulting in insufficient sleep (Salo et al., 2019), another possible explanation is the *technostress* resulting from smartphone use leads to users' sleep difficulties or challenges. Therefore, we formulated the hypothesis that *technostress* is positively associated with university students' poor *sleep quality* (H4).

Technostress and Academic Performance

Some prior studies have examined the impact of *technostress* on students' *academic performance*. For instance, Cao and Sun (2018) examined the association between students' *academic performance* and their usage of mobile social-networking sites. They found that the strain triggered by the overuse of mobile social-networking sites predicts students' poor academic significantly. Similarly, Upadhyaya and Acharya (2020) also confirmed that *technostress* is negatively associated with university students' academic productivity. However, Qi (2019) investigated the effect of *technostress* in the context of university students' mobile devices usage for academic purposes. The findings indicated that *technostress* has no significant effect on *academic performance*. Therefore, the existing findings about the influence of *technostress* on students' *academic performance* are inconsistent. In the recent times, smartphones are being extensively used by the university students as valuable learning, communication, and entertainment tools (Zhang, 2021). Therefore, it is necessary to understand how *technostress* impacts the *academic performance* of this population.

In this study, we measured students' *academic self-perception*, which refers to the extent to which students are confident in their abilities to succeed in school and to evaluate students' *academic performance*. We temporarily proposed that *technostress* is positively associated with students' poor academic self-perception (H5).

Method

Participants

For Chinese university students, smartphones are available to everyone and have been widely used for various purposes. Thus, we adopted a convenient sampling method and selected a public university in southern China for data collection. Data collection lasted for two weeks (May 15 to

May 29, 2021). Since the senior students were practicing or looking for jobs during this period, they were not included in our study. The research team sent the online questionnaire via WeChat to about 600 potential respondents in various majors, including science of law, English, political economy, mechanical automation, and electrical automation, and invited them to participate anonymously and voluntarily. A total of 549 responses were received, of which nine incomplete responses were excluded. Therefore, the valid data for empirical analysis were 540. The demographic information of the respondents is summarized in Table 1.

Measurements

The questionnaire used in this study included two parts. First, items were designed to collect the respondents' demographic information. Second, a scale was developed to test the six constructs of this study. All the 19 items in this part were presented in form of Five-point Likert scale and were adopted from relevant literature with ideal reliability and validity.

Specifically, the subscale of *compulsive smartphone use* was revised from Panda & Jain (2018) to test the extent to which university students use smartphone frequently and unable to control the eager to use. The subscale of *life invasion* was adopted from the study of Cao and Sun (2018). The *information overload* subscale was revised from Fu et al. (2020) to test the extent to which students feel overwhelmed by the amount of information exposed to them through smartphone. The *poor sleep quality* subscale was revised from Panda & Jain (2018). The *poor academic self-perception* subscale was adopted from Hsiao et al. (2017). Items were inversely encoded ranging from 1 (totally agree) to 5 (totally disagree).

A preliminary test was conducted with 10 university students after the completion of the questionnaire development. According to their feedback, language expression was adjusted to eliminate possible ambiguity and misunderstanding.

Data Analysis

SPSS 20.0 and AMOS 24.0 were used for data analysis. First, to test the measurement model, we performed confirmatory factor analysis and calculated the Cronbach's alpha coefficients. Second, structural equation modeling was conducted to verify the research model and test the research hypotheses. Last, the mediating effect of *technostress* was calculated.

Table 1 The demographic information of participants

	Number	Percentage	Age	Number	Percentage
<i>Gender</i>					
Female	161	29.81	< 18	29	5.37
Male	379	70.19	18–20	510	94.44
<i>Smartphone use per day</i>					
< 3 h	50	9.26	> 20	1	0.19
3–5 h	185	34.26	<i>Grade</i>		
6–8 h	217	40.19	Freshman	246	45.56
> 8 h	88	16.30	Sophomore	262	48.52
			Junior	32	5.93

Results

Descriptive Statistics

The means of the six latent variables are shown in Table 2. The results suggested that the students' *compulsive use* behaviors and their perception of *life invasion*, *technostress*, *poor sleep quality*, and *academic self-perception* are at relatively low levels with means less than 3, while their perception of *information overload* is relatively high (mean = 3.15).

The Measurement Model

The measurement model was examined with the following indicators: item and construct reliability, convergent

validity, discriminant validity, and the fitness of the measurement model.

Calculation results (shown in Table 2) revealed that the standardized factor loadings of the 19 items are all above 0.50 (ranging from 0.524 to 0.941). In addition, the Cronbach's alpha coefficients of the six latent variables are all above 0.80 (ranging from 0.826 to 0.927). All these values meet the criteria recommended by Schumacker and Lomax (2004), suggesting a satisfactory item reliability and construct reliability.

The convergent validity was examined by composite reliability (CR) and average variance extracted (AVE). Fornell and Larcker (1981) recommended that the coefficients of CR should not be lower than 0.70, while AVE should not be lower than 0.50. In this study, the calculation results revealed that the six constructs' CR coefficients

Table 2 Results of construct validity and reliability analysis

Construct	Item	Loading	α	CR	AVE	Mean	SD
Compulsive smartphone use	CSU1	0.927	0.922	0.927	0.809	2.93	0.87
	CSU2	0.922					
	CSU3	0.847					
Life invasion	LI1	0.941	0.900	0.931	0.818	2.38	0.83
	LI2	0.849					
	LI3	0.921					
Information overload	IO1	0.768	0.865	0.868	0.687	3.15	0.84
	IO2	0.892					
	IO3	0.822					
Technostress	TS1	0.845	0.826	0.837	0.569	2.14	0.89
	TS2	0.798					
	TS3	0.806					
	TS4	0.524					
Poor sleep quality	PSQ1	0.841	0.927	0.929	0.814	2.66	0.87
	PSQ2	0.932					
	PSQ3	0.931					
Poor academic self-perception	PAS1	0.821	0.881	0.882	0.715	2.21	0.81
	PAS2	0.93					
	PAS3	0.778					

Fig. 1 The research model. This model was adopted from Ayyagari et al. (2011) and adjusted according to the characteristics of smartphone use of university students

Table 3 Discriminate validity

Constructs	1	2	3	4	5	6
CSU	0.899					
LI	0.561	0.904				
IO	0.029	0.010	0.829			
TS	0.175	0.136	0.072	0.754		
PSQ	0.077	0.050	0.180	0.404	0.902	
PAS	0.012	0.010	0.206	0.326	0.602	0.846

CSU compulsive smartphone use, LI Life invasion, IO information overload, TS technostress, PSQ poor sleep quality, PAS poor academic self-perception

were all above 0.80, ranging from 0.882 to 0.931; AVE coefficients were between 0.569 and 0.818. Therefore, the convergent validity of this study is acceptable (Fig. 1).

Furthermore, the AVE coefficient of each latent variable is higher than the correlation coefficients between that and other latent variables (Table 3), suggesting an acceptable discriminant validity (Chin, 1998).

As for the fitness of the measurement model, the values of the key indicators ($\chi^2/df = 2.807$, GFI = 0.931, TLI = 0.959, CFI = 0.968, RMR = 0.068, RMSEA = 0.058) all meet the criteria proposed by Hu and Bentler (1999).

The Hypotheses Testing

The results of hypotheses testing revealed that compulsive smartphone use ($\beta = 0.178$, $P < 0.05$) and information overload ($\beta = 0.180$, $P < 0.05$) are both positively associated with technostress, supporting H1 and H2. However, the association between life invasion and technostress is not significant ($\beta = 0.011$, $P > 0.05$), rejecting H3. In

addition, the squared multiple correlation coefficient of technostress was 0.252, suggesting that compulsive use, life invasion, and information overload have a certain explanatory power to technostress. Technostress is positively associated with both poor sleep quality ($\beta = 0.450$, $P < 0.001$) and poor academic self-perception ($\beta = 0.348$, $P < 0.001$), supporting H4 and H5. Figure 2 shows the results of hypotheses testing with standardized coefficients. In addition, we also tested whether technostress mediates the relationships between compulsive smartphone use, information overload, and the consequences. The calculation results indicated that the impacts of compulsive smartphone use on both poor sleep quality and academic self-perception are not significant when technostress is added. However, technostress-mediating effect in the association between information overload and consequences is not significant. These calculation results confirmed that technostress plays a mediating role in the influence of compulsive smartphone use on students' poor sleep quality and academic self-perception (Table 4).

Fig. 2 The research model with its standardized coefficients **Table 4** The results of hypotheses testing

Hypotheses	Hypothesized path	<i>B</i>	β	S.E	<i>t</i>	Supported?
H1	CSU → TS	0.221	0.178	0.102	2.168*	Yes
H2	LI → TS	0.015	0.011	0.107	0.137	No
H3	IO → TS	0.180	0.127	0.069	2.607*	Yes
H4	TS → PSQ	0.376	0.450	0.040	9.509***	Yes
H5	TS → PAS	0.328	0.348	0.046	7.145***	Yes

CSU compulsive smartphone use, LI Life invasion, IO information overload, TS technostress, PSQ poor sleep quality, PAS poor academic self-perception

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$

Discussion

Building upon the existing literature of *technostress* and SSO model, this study aims to unfold the mechanism of the influences of *compulsive smartphone use*, *life invasion*, and *information overload* on university students' life. Specifically, this study employed a theoretical model and highlighted the mediating role of *technostress* in the relationship between students' *smartphone use* and their poor *sleep quality* and *academic performance*. The empirical results indicated that the research model has valuable explanatory power to understand university students' *technostress*.

The Antecedents of Technostress When Using Smartphone

The results indicated that *compulsive smartphone use* is positively associated with students' *technostress*. Maier et al. (2015) also confirmed that SNS overuse would lead to pressure. Similarly, both Lee et al. (2014) and Hsiao et al.

(2017) demonstrated that compulsive mobile phone apps use has a positive impact on *technostress*. The compulsive users may be eager to use their smartphones frequently, regardless of the time, space, and the matters at hand (Lapointe et al., 2013), which may result in their pressure.

As for the *information overload*, the result indicated that it is also positively associated with students' *technostress*. This finding is in line with previous studies which confirmed that *information overload* would lead to negative impacts on users (Fu et al., 2020; Lee et al., 2016). Our finding furthers the previous research by examining the influence of *information overload* in the context of students' smartphone use. The endless stream of information from smartphone probably exceeds the student's ability to handle it effectively.

Different from the research hypothesis, the results indicated that *life invasion* has no significant association with *technostress*. This finding is inconsistent with prior studies (Tarafdar et al., 2007; Xiao & Mou, 2019). We provide two possible explanations for this finding. First, previous researchers such as Xiao and Mou (2019) and

Tarafdar et al. (2007) mainly concerned the ICT use demanded by job, users may have to process work-related information or even handle work issues because the connectivity of ICT at after-work hours, consequently, the boundary between work and family may be blurred and their perceptions of *technostress* may be increased. However, to college students, smartphone use is usually not because of the requirements of work or learning, but their own choice. Second, participants of the two aforementioned studies are adults over 26 years old, while the respondents of this study are students under the age of 20. The younger generation is more accustomed to communicating with mobile phones and Internet (Cao & Sun, 2018), *life invasion* may not trigger their perception of *technostress*.

The Effects of Technostress

The results indicated that *technostress* is positively associated with university students' *poor sleep quality*. This finding is in line with the previous studies which confirmed the negative influences of *technostress* (Ragu-Nathan et al., 2008; Zhao et al., 2021). Since excessive *technostress* is likely to trigger individuals' negative physical and psychological reactions (Arnetz & Wiholm, 1997; Ayyagari et al., 2011), this study further confirms that *technostress* may also lead to sleep problems.

The results also indicated that *technostress* probably leads to students' *poor academic self-perception*. This finding is in line with Upadhyaya and Acharya (2020), which argued significant negative association between *technostress* and *academic performance*; while is inconsistent with Hsiao et al. (2017) and Qi (2019) which confirmed no significant effect. The inconsistent conclusions may result from the different methods used to measure participants' academic achievement and the characteristics of participants themselves.

In addition, according to the mediation analysis, *technostress* may exert a mediating effect on the associations between *compulsive smartphone use* and negative outcomes (i.e., *poor sleep quality* and *academic self-perception*). These findings again strengthen the mediating effect of psychological strain between stressors and adverse outcomes (Pang, 2021; Whelan et al., 2020).

Implications

Theoretically, this study contributes to extend the current *technostress* literature by investigating *technostress* of university students. Although the previous researchers have realized that the younger generation may at a risk of experience increasing *technostress* (Upadhyaya & Acharya, 2020), the associations between *compulsive*

smartphone use, *life invasion*, *information overload*, *technostress*, and negative influences remain unclear. The present research is probably the initial study to empirically investigate these associations of this special population. Second, this research confirms the mediating effect of *technostress* in the influence of *compulsive smartphone use* on *sleep quality* and *academic performance*. Although existing studies have found that smartphone overuse would lead to adverse impacts on well-being and *academic performance* (Hsiao et al., 2017; Panda & Jain, 2018; Pang, 2021), the underlying mechanisms have not been fully investigated. Third, although previous researchers have studied university students' well-being and *academic performance* from various aspects, such as remote learning, university life, social support, and voice behavior (Foulkes et al., 2019; Horita et al., 2020), few studies have concerned the influence of *technostress* due to smartphone use. This study developed a research model unpacking how three types of stressors related to smartphone use influence sleep and academic performance of university students, which provide a new research perspective to understand the life of this population.

The findings also provide some practical implications for *technostress* researchers, smartphone-related designers, university teachers, and students. First, the research model of this study may provide a guide for further researchers to investigate diverse dimensions of *technostress* by employing additional exploratory variables. Second, the predictive effect of *compulsive smartphone use* and *information overload* on *technostress* suggests that control these two stressors can mitigate students' *technostress*. Therefore, prevention mechanisms against the students' eagerness of *compulsive smartphone use* need to be explored. It may be advisable for students to develop a variety of interests and hobbies after enrolled to university, such as joining student clubs and making new friends. Teachers can require students to keep smartphones out of reach or turn them off during class. Physical activity also can reduce smartphone overuse significantly (Abbasi et al., 2021). In addition, practical measures should be taken to minimize *information overload* to allow students concentrate and pay attention to the things they are doing. Smartphone app providers should take measures to reduce *information overload* at its source, such as using infographics instead of text. Given the negative effects of *technostress*, stress coping training, which instructs students to adopt appropriate strategies to cope with *technostress*, is necessary.

Limitations and Further Research

This research has certain limitations. First, this study only examined the *technostress* of smartphone use in the general sense. However, university students usually use smartphones

for various purposes, such as entertainment, communication, learning, and games. Since the experiences of using smartphones may vary with different purposes, further research may explore the *technostress* of mobile phone use for specific purpose. Second, data of this study was collected from online survey with nonrandom sampling, and the sample size is relatively small. Future researchers could replicate this study with more systematic sampling methods and larger samples.

Conclusion

Employing the paradigm of SSO, this study examined the antecedents and consequences of university students' *technostress* when using smartphone. This study may be the first to concern the *technostress* of university students from the perspective of smartphone use. The findings provide evidences that *technostress* associated with smartphone use could lead to *technostress*, which in turn impacts students' *sleep* and *academic performance*. Hence, it is necessary for universities to guide students use smartphone rationally.

Acknowledgements This study was partially funded by the Hunan Social Science Achievement Evaluation Committee (Project Number: XSP22YBC437 and XSP22YBZ009). The authors would like to thank all the university students who participated in the study.

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