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Abstract

Internet addiction has been found to be prevalent worldwide, including Asian countries, and related to several negative outcomes and other behavioral addictions. The Bergen Social Media Addiction Scale (BSMAS), Smartphone Application-Based Addiction Scale (SABAS), and 9-item Internet Gaming Disorder Scale-Short Form (IGDS-SF9) have been extensively used to assess internet-related addictions. However, the three aforementioned instruments have rarely been used in Asian countries. The aim of the present study was to investigate whether the BSMAS, SABAS, and IGDS-SF9 were appropriate for use in heterogeneous subsamples from Hong Kong and Taiwan. University students from Hong Kong (n=306) and Taiwan (n=336) were recruited via an online survey. Multigroup confirmatory factor analysis (MGCFA) was used to assess measurement invariance of the BSMAS, SABAS, and IGDS-SF9 across the two subcultures. The original unidimensional structures of BSMAS, SABAS and IGDS-SF9 were confirmed through confirmatory factorial analysis in both subcultures. The MGCFA results showed that the unidimensional structures of the BSMAS and IGDS-SF9 were invariant across the two Chinese cultural areas (Hong Kong and Taiwan). However, the measurement invariance of the SABAS was established after some model modifications. In conclusion, the present study found that the Chinese BSMAS, SABAS, and IGDS-SF9 were all adequate instruments to validly assess internet-related addictions among university students. The three brief instruments used for assessing addictions to social media, smartphone applications, and online gaming are valid and psychometrically robust across two Chinese subcultures and can be used by healthcare professionals in these regions.

Keywords: Internet gaming disorder; smartphone addiction; measurement invariance; Chinese; social media addiction

1. Introduction

Due to the rapid growth of technology, the use of the internet has become widespread in many individual's daily routines. Research by the Pew Research Center (2016) indicated that 54% of individuals (median percentage) across 21 emerging and developing countries (e.g., Malaysia, mainland China) had used the internet. Among 11 countries with advanced economies, this was even higher at 87% (e.g., United States, Canada) in 2015 (Pew Research Center, 2016). In addition, given the development of Wi-Fi and the wide variety of smartphone applications ('apps'), increasingly more people own a smartphone with an estimated 60% to 95% of young adults having a smartphone across developing and developed countries (Yang, Chen, Huang, Lin, & Chang, 2017). Among those who own a smartphone, the Pew Research Center (2016) reported nearly three-quarters of adult users accessed the internet at least once per day and 76% of them accessed social networking sites (e.g., *Facebook*, *Twitter*) whenever they surfed online. In addition to social media use, another common internet activity is online gaming (Kuss & Griffiths, 2012; Kuss, Griffiths, Karila, & Billieux, 2014).

Research has consistently shown that various online activities such as online gaming and social media use may be potentially addictive to a small minority of individuals particularly adolescents and emerging adults (Cheng & Li, 2014; Kuss & Griffiths, 2012; Kuss et al. 2014; Ryan, Chester, Reece, & Xenos, 2014). The latest (fifth) version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) identified the potential negative effects of problematic online gaming on the wellbeing of an individual. Consequently, the DSM-5 has recognized Internet Gaming Disorder (IGD) as a tentative disorder (American Psychiatric Association, 2013). Similarly, the World Health Organization (Van den Brink, 2017) has also proposed to include online and offline gaming disorders in the eleventh revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-11)

although the formal decision of inclusion is still pending at the time of writing. In addition to IGD, social media addiction appears to be another growing issue (e.g., Kuss & Griffiths, 2017; Pantic, 2014; Ryan et al., 2014). One of the main contributory factors in the growth of internet-related addictions is the increasing ubiquity of smartphone use. Smartphones now provide individuals with a convenient and mobile way to access many different types of content that can be potentially addictive to a small minority (e.g., gambling, gaming, shopping, social media; Billieux, Maurage, Lopez-Fernandez et al. 2015; Kuss & Griffiths, 2017).

However, in the literature concerning internet addiction and related topics, there is no consensus on the use of terminology to describe problematic internet use because it has variously been described as internet dependence, internet addiction, pathological internet use, problematic internet use, internet use disorder, and internet addiction disorder (among others) (Kuss et al., 2014). There are also debates about whether problems with specific internet applications (e.g., social media use, gaming) or problematic behavior via other types of Wi-Fi enabled hardware (e.g., 'smartphone addiction') should be classed as problematic behaviors in their own right or subsumed within the umbrella term of 'internet addiction' (Brand, Young, Laier, Wölfling, & Potenza, 2016; Pontes, Szabo & Griffiths, 2015). Despite these different terminologies used, internet-related disorders have received growing research interest and require further investigation. Indeed, many studies have explored internet-related addiction from different aspects, such as epidemiological studies, comorbidity studies, neuroimaging studies, intervention and treatment studies (e.g., Kuss et al., 2014; Kuss, Pontes & Griffiths, 2018; Shek & Leung, 2013; Shek & Yu, 2016).

The phenomenon of problematic internet use is similar between two westernized Asian areas, which share similar traditional Chinese cultures (i.e., Hong Kong and Taiwan, where the present study was carried out). Shek and Yu (2016) reported that the prevalence of

internet addiction ranges between 17% and 26% among Hong Kong adolescents. In their longitudinal study, general positive youth development qualities were negatively associated with the internet addiction. In Taiwan, Lin, Wu, You, Hu, and Yen (2018) reported that nearly one-fifth of high school students experienced internet addiction. They also reported that the internet addiction was correlated with high impulsivity, depressive symptoms, and low subjective wellbeing.

Given that Hong Kong and Taiwan share a similar culture and written language system (Chang, Lin, Gronholm, & Wu, 2018), studies on Chinese culture usually compare the similarities and differences between these two areas (e.g., Hsu & Wang, 2018; Ip et al., 2018). In order to make meaningful comparisons, there is a need to test the linguistic equivalence among instruments across those living in Hong Kong and Taiwan. Unfortunately, the literature gap shows that the lack of such instruments that can be simultaneously used in both areas. Additionally, to the best of the present authors' knowledge, no brief instruments have been developed to assess social media addiction or smartphone addiction in these two areas. Although the Smartphone Addiction Inventory (SPAI) was developed in Taiwan (Lin et al., 2014), it contains relatively large number of items (n=26). In terms of an instrument to assess IGD, Sigerson et al. (2017) used the IGD criteria from DSM-5 to develop a Chinese Internet Gaming Disorder Scale (C-IGDS), which comprises nine items. However, the C-IGDS adopts a dichotomous rating scale across the nine items, which arguably restricts the score distribution. More specifically, the score range of the C-IGDS is 0-9 and is hard to achieve a normal distribution for statistical testing. As a result, there is a need for an ultra-brief instrument (i.e., less than 10 items) with a more widespread rating option (e.g., 5-point Likert-type response) for researchers to efficiently and effectively assess social media addiction, smartphone addiction, and IGD. However, healthcare providers may have alternative options to assess these different types of addiction related to internet but can

utilize such instruments as an addition to their other assessment criteria.

Although several measures have been developed to assess internet addiction, including the addictive use of social media, these measures may not be comparable in terms of the theoretical basis and the characteristics of the scales. Consequently, there is still a lack of general consensus on definition of generalized internet addiction and several grounding theoretical frameworks have been used in developing internet addiction scales (Beard, 2005; Starcevic & Aboujaoude, 2017; Weinstein & Lejoyeux, 2010). (Beard, 2005; Starcevic & Aboujaoude, 2017; Weinstein & Lejoyeux, 2010). In addition, many of these instruments lack rigorous and systematic psychometric investigations (Laconi, Rodgers, & Chabrol, 2014). Because of heterogeneity of these measures across studies, a literature review was undertaken to identify potential important measures to assess internet addiction.

After reviewing the contemporary literature, the research team proposed to translate and validate three psychometric scales: Bergen Social Media Addiction Scale (BSMAS; Andreassen et al., 2016); Smartphone Application-Based Addiction Scale (SABAS; Csibi et al., 2018); and the nine-item Internet Gaming Disorder Scales- Short Form (IGDS-SF9; Pontes & Griffiths, 2015). The main reasons of using these instruments include their brevity (IGDS-SF9 has nine items; BSMAS and SABAS both have six items) and robust psychometric properties based on previous studies (see 'Measures' section below for detailed information). More importantly, the three instruments assess different aspects of internet addiction. The aims of the present study were to (i) investigate the factorial structures and basic psychometric properties of the three instruments; and (ii) examine the measurement invariance of the three instruments across university students in Hong Kong and Taiwan.

2. Methods

The study was approved by the ethics committee of the Hong Kong Polytechnic

University before the commencement.

2.1. Translation procedure

The three instruments (i.e., BSMAS, SABAS, and IGDS-SF9) followed a standardized back-translation process (Beaton, Bombardier, Guillemin & Ferraz, 2000) with consideration in Chinese systems in written language (Chang et al., 2018; Wu et al., 2015). Detailed information is in Appendix A.

2.2. Participants and procedure

All the scales (BSMAS, SABAS, and IGDS-SF9), and questions concerning demographic information and informed consent were incorporated in an online questionnaire survey via *Google Forms*. The details of the study's purpose and requirements were provided on the first page of the online survey, and only those who provided their informed consent to participate could continue answering the survey questions. The online survey was accessed via a hyperlink and a QR code for students to log onto *Google Forms*. Several research assistants disseminated the survey link and QR code in the university lectures with the permission of the teaching faculties. The inclusion criteria for being a participant were (i) being aged 18 years or older; (2) having the ability to understand written Chinese in traditional characters; (3) possessing a smartphone; and (4) having access to the internet. Those with a diagnosed mental health problem (e.g., mood disorders) were excluded. Individuals with a diagnosed mental health problem were excluded to ensure the homogeneity of our studied population. The prevalence of having a diagnosed mental health problem is relatively low among university students. Therefore, such students could be potential outlier in the sample recruited.

The inclusion and exclusion criteria were assessed by the respondents' self-reports from the demographic information in the survey. In order to ensure that no respondents completed the survey more than once, each participant was asked to provide their cellphone number and

an email account. Although the participants were requested to provide personal information in the present study, anonymity and confidentiality was ensured through the following methods. First, all participants did not need not to provide their real names in the study. Therefore, the research team did not know who the cellphone number or email account of any participant. Second, only the research team had the access to retrieve the data. Third, all personal information will be destroyed after the study completed. Following this process, a total of 308 students from Hong Kong and 337 students from Taiwan agreed to participate. Two Hong Kong students and one Taiwanese student were excluded due to having diagnosed mental health problems. This left 306 Hong Kong students and 336 Taiwanese students remaining in the present study for further analysis.

After collecting the baseline data, all of the 306 Hong Kong students and 336 Taiwanese students were contacted again using the cellphone number or email account they left to complete a follow-up. In the present study, only baseline data were used, while baseline and follow-up data were used in another study with detailed information described elsewhere (Chen et al., 2019). Additionally, from the response of time on gaming, 458 were classified as a non-gamer (i.e., they did not play online game regularly) and 184 were a gamer (i.e., they paled online game regularly; at least an hour per week).

2.3. Measures

The Bergen Social Media Addiction Scale (BSMAS) developed by Andreassen et al. (2016) comprises six items based on the six core components (salience, mood, modification, tolerance, withdrawal conflict and relapse) proposed by Griffiths (2000; 2005) to assess social media addiction. More specifically, the six items examine the experience of using social media over the past year and are responded to using a five-point Likert type scale ranging between 1 (*very rarely*) and 5 (*very often*). A higher score in the BSMAS indicates a greater likelihood of being at risk of developing a social media addiction. More recently, a

cutoff score of 19 (out of 30) for problematic use of social media on the BSMAS was proposed by Bányai et al., (2017) following a large nationally representative study of nearly 6000 Hungarian adolescents. The psychometric properties of the BSMAS have been supported in different language versions, including English (Andreassen et al., 2016), Italian (Monacis et al., 2017), Persian (Lin et al., 2017), and Portuguese (Pontes, Andreassen & Griffiths, 2016).

The Smartphone Application-Based Addiction Scale (SABAS) developed by Csibi et al., (2018) comprises six items assessing the single construct of smartphone use addiction. The six items are also based on the six core criteria of the addiction components model (Griffiths, 2005). Using a six-point Likert type scale ranging between 1 (*strongly disagree*) and 6 (*strongly agree*), a higher score in the SABAS indicates a greater likelihood of being at risk of developing an addiction to smartphone use. The psychometric properties of the SABAS have been supported in different language versions including English (Csibi et al., 2018) and Hungarian (Csibi, Demetrovics & Szabo, 2016).

The Internet Gaming Disorder Scale-Short Form (IGDS-SF9) developed by Pontes and Griffiths (2015) comprises the nine IGD criteria described in the latest (fifth) edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) (American Psychiatric Association, 2013). Using a five-point Likert type scale ranging between 1 (*never*) and 5 (*very often*), a higher score in the IGDS-SF9 indicates a greater likelihood of being at risk of developing IGD. The IGDS-SF9 has been validated with promising psychometric properties in several studies and different languages, including English (Pontes & Griffiths, 2015; Pontes et al., 2017), Portuguese (Pontes & Griffiths, 2016), Italian (Monacis et al., 2016), Persian (Wu et al., 2017), Polish (Schivinski et al., 2018), Albanian (de Palo et al., 2018), and Turkish (Arıcak et al, 2018; Evren et al., 2018).

2.4. Data analysis

Because the three instruments adopt a Likert-type scale, analyses were used that tackled categorical data and did not assume normal distribution. Therefore, the ordinal α and confirmatory factor analysis (CFA) with the diagonally weighted least square (DWLS) estimator was used. Item properties of the three scales were examined using factor loadings derived from CFA and the corrected item-total correlation. In addition, psychometric properties in the scale level were examined using ordinal α and CFA. Ordinal α was used to tackle the ordinal nature in the Likert-type scales used in the three scales. In terms of the CFA, the Likert-type response options used in the three scales were tackled by the DWLS estimator (Lin, Updegraff, & Pakpour, 2016). Given that the three scales assess different types of addictive behaviors in a one-factor structure, six first-order CFAs in a one-factor structure were conducted (three CFAs using the Hong Kong sample; three using the Taiwan sample). Also, the IGDS-SF9 structure was tested using the multiple indicators multiple causes (MIMIC) model because gamers/non-gamers were considered to be a potential confounder in its factorial structure. Therefore, the gamers/non-gamers were treated as a controlled variable in the MIMIC model for IGDS-SF9. Fit indices, including a nonsignificant χ^2 test, a comparative fit index (CFI) > 0.9, a Tucker-Lewis index (TLI) > 0.9, a root mean square error of approximation (RMSEA) < 0.08, a standardized root mean square residual (SRMR) < 0.08, and a weighted root mean square residual (WRMR) < 1 (Cook, Kallen, & Amtmann, 2009; Wu et al., 2015), were adopted to examine whether the one-factor structure was supported in a specific scale for Hong Kong or Taiwan participants.

Measurement invariance across Hong Kong and Taiwan participants was then examined for those scale scores which had satisfactory fit indices in the CFAs for both Hong Kong and Taiwan participants. Three nested models in the multigroup CFA (MGCFA) were constructed and compared to determine whether measurement invariance was supported: a configural model, a model with factor loadings constrained equal across Hong Kong and Taiwan

participants, and a model with factor loadings and item thresholds constrained equal across Hong Kong and Taiwan participants (van de Schoot, Lugtig, & Hox, 2012; Jafari, Nozari, Ahrari, & Bagheri, 2017). Measurement invariance is supported if the comparison between every two models (i.e., configural model vs. model with factor loadings constrained equal and model with factor loadings constrained equal *vs.* model with factor loadings and item thresholds constrained equal) show the following indices: ΔCFI>-0.01 (Lin et al., 2013), ΔRMSEA<0.02 (Lin et al., 2012), and ΔSRMR<0.03 (for invariant loadings) or 0.01 (for invariant thresholds) (Chen, 2007). After ensuring the measurement invariance across Hong Kong and Taiwan participants, Pearson correlation coefficients were used to examine the associations between time spent on social media, time spent on smartphones, time on gaming, and scores on the BSMAS, SABAS, and IGDS-SF9. Moreover, given that both non-gamers and gamers were recruited (i.e., whether the participants played online games regularly, and a gamer was defined as playing an online game at least one hour per week), the BSMAS, SABAS, and IGDS-SF9 was compared between gamers and non-gamers. Independent *t*-tests with Cohen's *d* were used for the comparisons. All the analyses were performed using R software. More specifically, ordinal α and corrected item-total correlations were computed using Psych package (https://cran.r-project.org/web/packages/psych/psych.pdf); CFA and MGCFA using lavaan package (http://lavaan.ugent.be/).

3. Results

The Hong Kong participants were significantly older than the Taiwan participants (24.08 years ±5.06 vs. 20.51 years ±1.22; $p<0.001$), and the Hong Kong participants had significantly fewer males than the Taiwan participants (n=99 [32.4%] vs. 167 [49.7%]; $p<0.001$). No significant differences were found between Hong Kong and Taiwan participants in the percentage of being a current smoker, the average hours per week spent on smartphone, and the average hours per week spent on social media. However, Hong Kong participants

engaged less in the gaming (0.99±1.70 hours/week) compared with the Taiwan participants (1.32±2.06; p=0.03), although no significant differences were found when the participants were separated into gamer and non-gamer subgroups. Also, approximately 60% of the Hong Kong participants had a monthly income less than 10000 Hong Kong dollars whereas almost all Taiwan participants had a monthly income less than 10000 New Taiwanese dollars (Table 1), where the exchange rate between Hong Kong and New Taiwanese dollars is about 1:4. However, the monthly incomes between Hong Kong and Taiwan participants were not compared using inferential statistics due to unmatched living expenses and currency rates.

(Insert Table 1 here)

Table 2 shows the satisfactory item properties of the BSMAS, SABAS, and IGDS-SF9 for Hong Kong and Taiwan participants, respectively. In terms of the scale properties, ordinal α was satisfactory in all three scales. For BSMAS, α=0.85 for Hong Kong participants; 0.82 for Taiwan participants. For SABAS, α=0.78 for Hong Kong participants; 0.79 for Taiwan participants. For IGDS-SF9, α=0.93 for Hong Kong participants; 0.94 for Taiwan participants. Excellent fit indices were also observed for the three scales (Table 3), except for a slightly high WRMR (1.131) for BSMAS among Taiwan participants.

(Insert Tables 2 and 3 here)

After ensuring that the factorial structures were supported for the three scales separately in Hong Kong and Taiwan participants, the MGCFAs were applied to detect whether Hong Kong and Taiwan participants interpret the scales differently. Both BSMAS and IGDS-SF9 had their measurement invariance supported at factor loadings (except for a slightly high ΔRMSEA of 0.024 in the IGDS-SF9) and item thresholds without relaxing any parameters. However, the SABAS had its measurement invariance supported after relaxing one factor loading (item S1: *My smartphone is the most important thing in my life*) and two item thresholds (items S1 and S3: *Preoccupying myself with my smartphone is a way of changing*

my mood) (Table 4). Also, Table 5 shows the correlation matrix among time spent on social media, time spent on smartphones, time spent on gaming, and scores on the BSMAS, SABAS, and IGDS-SF9. More specifically, the correlation matrix was conducted for the entire sample, including gamer and non-gamer subgroups. Additionally, the addictive behaviors were significantly different between gamers and non-gamers. BSMAS scores were 2.31±0.74 for gamers and 2.57±0.69 for gamers (Cohen's d=0.35; p<0.001); SABAS scores were 3.63±0.96 for gamers and 3.43±0.19 for non-gamers (Cohen's d=0.21; p=0.014); and IGDS-SF9 scores were 2.41±0.67 for gamers and 1.66±0.62 for non-gamers (Cohen's d=1.17; p<0.001).

(Insert Tables 4 and 5 here)

4. Discussion

To the best of the present authors' knowledge, this is the first study that examines the measurement invariance across two Chinese cultural areas (Hong Kong and Taiwan) in three internet addiction-related scales. In addition, the measurement invariance of the English IGDS-SF9 has only recently been studied (de Palo et al., 2018; Pontes et al., 2017; Stavropoulos et al., 2018), and no measurement invariance studies have ever been conducted for either the BSMAS or SABAS. In the study conducted by Pontes et al. (2017), the unidimensional structure of the English IGDS-SF9 was confirmed among gamers in the United States, United Kingdom, and India. However, the measurement invariance was only partially supported: loadings in Items 1, 3, 7, 8, and 9; intercepts in Items 2, 3, 4, 8, and 9 were relaxed to achieve the satisfactory indices. Another measurement invariance study on English IGDS-SF9 (Stavropoulos et al., 2018) showed similar findings to those of Pontes et al. (2017) among gamers in the United States, United Kingdom, and Australia: unidimensional structure was supported and measurement invariance was partially supported

(loadings in Items 1, 2, and 5; intercepts in Items 1, 5, 7, and 9 were relaxed to achieve the satisfactory indices). Unlike the findings from Pontes et al. (2017) and those from Stavropoulos et al. (2018), the results of the present study demonstrated a fully supported invariance across Hong Kong and Taiwan university students in the Chinese IGDS-SF9.

Two possible reasons are proposed here to explain the different measurement invariance findings between the English IGDS-SF9 and Chinese IGDS-SF9. First, the cultural differences could be larger in the two previous studies (Pontes et al., 2017; Stavropoulos et al., 2018) than in the present study. The subsamples in the study of Pontes et al. (2017) were recruited from the United States, United Kingdom, and the India, which are located in three continents (i.e., North America, Europe, and South Asia). Similarly, the subsamples in the study of Stavropoulos et al. (2018) were recruited from three continents: North America (the United States), Europe (United Kingdom), and Oceania (Australia). In contrast, the subsamples in the present study were both from South East Asia. Given that the geographical difference is larger among the subsamples in the two studies on English IGDS-SF9, their subsamples were arguably more likely to have different lifestyles and cultures, which subsequently contribute to the different interpretations of items in the IGDS-SF9. On the other hand, Hong Kong and Taiwan are viewed to have the subcultures within traditional Chinese culture (Cheung & Chow, 1999). Additionally, Hong Kong and Taiwan are both located in South East Asia and have close relationship. Therefore, it is anticipated that Hong Kong and Taiwan people are likely to have similar lifestyles when interpreting the IGDS-SF9.

Second, the sample characteristics were not comparable between the sample in the present study and the samples from previous studies. In the present study university students were recruited with a narrow age range (SD=4.02 years); Pontes et al. (2017) and Stavropoulos et al. (2018) recruited gamers with a wider age range (SD=12.27 years and 6.38

years, respectively). Therefore, the sample here compared with the other two samples is less likely to have the issue of *generation gap*. More specifically, in Pontes et al.'s study, the youngest participant was aged 16 years and the oldest was aged 70 years. The interpretation of IGDS-SF9 items is therefore likely to be very different because of the different growing experiences among their participants. In contrast, in the present study, the sample had similar ages between Hong Kong and Taiwan participants. Additionally, their educational levels were comparable. Therefore, the subsamples in the present study were likely to interpret the IGDS-SF9 items more similarly than the subsamples in previous studies (Pontes et al., 2017; Stavropoulos et al., 2018).

Although the WRMR was slightly higher than the recommended cutoff in the BSMAS for Taiwan participants (1.131 vs. 1), the present authors believe that the unidimensional structure of the BSMAS is supported for Taiwan participants. DiStefano, Liu, Jiang and Shi (2018) recently conducted a simulation study and found that WRMR "might provide misleading results under situations where extremely large sample sizes are used" (p.1). They further suggested that "[r]esearchers might want to increase the cutoff (of WRMR) slightly (p12)." Given that other fit indices (i.e., CFI, TLI, RMSEA, and SRMR) had satisfactory performance, it is tentatively concluded that the unidimensional structure of the BSMAS is supported for Taiwan participants.

In addition, the measurement invariance was also fully supported for the Chinese BSMAS but not for the Chinese SABAS. Some implications from the present findings can therefore be made; most notably that healthcare providers and researchers can compare social media addiction between Hong Kong and Taiwan people using BSMAS because of the supported measurement invariance. Comparisons on social media addiction between Hong Kong and Taiwan people can also be carried out using the SABAS. However, some adjustments may be needed for Items 1 and 3 in the SABAS. More specifically, using CFA to

calculate latent scores in the SABAS rather than the summated item scores is more preferable for comparisons (Lin et al., 2013). Additionally, given that this is the first study to examine the measurement invariance of the BSMAS and SABAS across different cultures, it was not possible to compare the present study's findings to other studies. Future studies are therefore needed to corroborate and compare the findings here.

Nevertheless, the findings of the present study support the notions made by prior research that distinguish specific internet addictions from generalized internet addiction, and that they are essential and meaningful (Montag et al., 2015; Griffiths & Pontes, 2014). More specifically, the findings here suggest that BSMAS, SABAS, and IGDS-SF9 were differently correlated between each other (i.e., more specifically, addiction to social media is different from addiction to smartphone and addiction to gaming). Additionally, Sha, Sariyska, Riedl, Lachmann, and Montag (2018) recently found that different types of social media have various levels of overlap with each other. Strong overlaps were found between *WhatsApp* and Smartphone Use Disorder, while other social media applications (such as *Facebook*) have less overlap. Future studies are therefore warranted to further delineate specific forms of internet addiction from generalized internet addiction.

There are some limitations in the present study. First, only university students were recruited, therefore the results cannot be generalized to children, adolescents, and non-student adults (both young and old). Also, participants from other Asian countries (e.g., mainland China, Malaysia and Singapore which also have Chinese speaking citizens) were not included. Therefore the generalizability of the three instruments across these Asian countries is unknown. Future studies recruiting a large sample with different ages and from different Asian countries are recommended. Second, the present study did not identify whether any participants were at risk of developing IGD, or whether any participants were at risk of developing of addictions to social media or smartphone use. Therefore, the present study was

unable to define the cutoff scores for the three instruments for healthcare providers to screen for those at high-risk of developing an addiction to these behaviors. Third, all the instruments were assessed using self-report. Consequently, the findings of the study may have been affected by biases due to memory recall or social desirability. Finally, the Hong Kong participants had significantly fewer males than the Taiwanese participants in the study. Therefore, the comparisons between Hong Kong and Taiwan participants might not necessarily be representative.

5. Conclusion

The present study found that the Chinese BSMAS, SABAS, and IGDS-SF9 were all adequate instruments to validly assess internet-related addictions among university students. Additionally, the measurement invariance across the two Chinese cultural areas (Hong Kong and Taiwan) was supported for all the instruments, except for one factor loading and two item thresholds in the SABAS. Researchers examining the comparison between Hong Kong and Taiwanese individuals in their risk of developing social media addiction, smartphone application addiction, and IGD will benefit from using the Chinese BSMAS, SABAS, and IGDS-SF9.

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Table 1. Participant characteristics of samples in Hong Kong and Taiwan and differences between the samples

	Hong Kong (*n*=306)	Taiwan (*n*=336)	*t* or χ^2 (*p*-value)	Effect size[a]
Age (years); *M*±*SD*	24.08±5.06	20.51±1.22	11.50 (<0.001)	0.97
Gender (male); *n* (%)	99 (32.4)	167 (49.7)	19.87 (<0.001)	0.18
Current smoker (no); *n* (%)	300 (98.0)	332 (98.8)	0.22 (0.64)	0.03
Time on social media (hours/week); *M*±*SD*	3.11±3.38	3.26±2.47	0.65 (0.52)	0.05
Time on smartphone (hours/week); *M*±*SD*	5.29±3.79	5.07±2.75	0.84 (0.40)	0.07
Time on gaming (hours/week); *M*±*SD*	0.99±1.70	1.32±2.06	2.21 (0.03)	0.17
Time on gaming for gamers[b] (hours/week); *M*±*SD*	0.34±0.43 (*n*=232)	0.36±0.44 (*n*=226)	0.31 (0.76)	0.06
Time on gaming for non-gamers[b] (hours/week); *M*±*SD*	3.03±2.45 (*n*=74)	3.30±2.59 (*n*=110)	0.73 (0.47)	0.22
Monthly income (<10000 dollars[c]); *n* (%)	175 (57.2)	308 (91.7)	--[d]	--[d]

[a] Cohen's *d* (0.2=small; 0.5=medium; 0.8=large) is used to assess the effect sizes of Age, Time on smartphone, Time on social media, and Time on gaming; Cramer's *V* (0.1=small; 0.3=medium; 0.5=large) is used to assess the effect sizes of Gender and Current smoker.

[b] Whether the participants played online games regularly, and a gamer was defined as playing an online game at least one hour per week

[c] Hong Kong participants reported in Hong Kong Dollars (HKD) with 1 USD≈7.8 HKD; Taiwan participants reported in New Taiwanese Dollars (NTW) with 1 USD≈30 NTD

[d] Monthly income was not compared between Hong Kong and Taiwan participants because the unmatched living expenses and the unmatched currency rates.

Table 2. Item properties in the three scales across Hong Kong and Taiwan participants

	Hong Kong			Taiwan		
	M (*SD*)	Loading	Item-total correlation	*M* (*SD*)	Loading	Item-total correlation
Bergen Social Media Addiction Scale (BSMAS)						
B1: Use a lot of time thinking about or planning using social media	3.12 (1.05)	0.72	0.76	3.18 (1.10)	0.68	0.72
B2: Felt an urge to use social media more and more	2.76 (0.96)	0.68	0.72	2.90 (1.05)	0.77	0.78
B3: Used social media to forget about personal problems	2.11 (0.97)	0.63	0.68	2.19 (0.96)	0.60	0.64
B4: Tried to cut down on the use of social media without success	2.34 (1.00)	0.67	0.71	2.43 (0.93)	0.59	0.63
B5: Got troubled by being prohibited from social media use	2.00 (0.90)	0.62	0.66	2.17 (0.93)	0.54	0.61
B6: Used social media too much to negatively impact on your job	2.25 (0.99)	0.61	0.65	2.40 (0.99)	0.54	0.59
Smartphone Application-Based Addiction Scale (SABAS)						
S1: My smartphone is the most important thing in my life	4.04 (1.32)	0.32	0.34	4.72 (1.38)	0.49	0.55
S2: My smartphone use results in conflicts	2.47 (1.20)	0.44	0.46	2.90 (1.54)	0.48	0.52
S3: Preoccupying myself with my smartphone is a way of	3.45 (1.34)	0.59	0.60	4.18 (1.44)	0.58	0.61

changing my mood						
S4: I fiddle around more and more with my smartphone.	3.59 (1.31)	0.71	0.73	4.14 (1.39)	0.61	0.65
S5: If I cannot use my smartphone when I feel like, I feel sad	2.91 (1.30)	0.66	0.68	3.06 (1.36)	0.64	0.68
S6: If I try to cut the time I use my smartphone, I end up using it as much or more than before.	2.95 (1.31)	0.78	0.79	3.20 (1.25)	0.68	0.69
Internet Gaming Disorder Scale-Short Form (IGDS-SF9)						
I1: Do you feel preoccupied with your gaming behavior?	2.10 (1.05)	0.83	0.82	2.41 (1.18)	0.84	0.81
I2: Do you feel more irritability, anxiety or even sadness when you try to either reduce or stop your gaming activity?	1.79 (0.82)	0.84	0.85	1.93 (0.87)	0.83	0.86
I3: Do you feel the need to spend increasing amount of time engaged gaming in order to achieve satisfaction or pleasure?	1.99 (0.97)	0.75	0.76	2.10 (1.01)	0.80	0.81
I4: Do you systematically fail when trying to control or cease your gaming activity?	1.89 (0.90)	0.82	0.84	2.04 (0.97)	0.79	0.82
I5: Have you lost interests in previous hobbies because of your engagement with gaming?	1.72 (0.83)	0.72	0.78	1.84 (0.90)	0.67	0.74
I6: Have you continued your gaming activity despite knowing it	1.72 (0.87)	0.73	0.80	1.79 (0.96)	0.79	0.85

was causing problems between you and other people?						
I7: Have you deceived any of your important others because the amount of your gaming activity?	1.44 (0.71)	0.54	0.68	1.62 (0.85)	0.65	0.74
I8: Do you play to temporarily escape or relieve a negative mood?	2.21 (1.05)	0.64	0.69	2.46 (1.14)	0.77	0.79
I9: Have you jeopardized an important relationship, job or an educational or career opportunity because of your gaming activity?	1.38 (0.75)	0.54	0.72	1.55 (0.81)	0.66	0.77

Note: Factor loadings were reported as standardized coefficients using configural model in the confirmatory factor analysis. The IGDS-SF9 was analyzed using multiple indicators and multiple causes (MIMIC) model with gamer/non-gamer as a controlled variable.

Table 3. Fit indices for confirmatory factor analysis stratified by Hong Kong and Taiwan

	Hong Kong (*N*=306)	Taiwan (*N*=336)	Suggested cutoff
BSMAS			
χ^2 (*df*)/ *p*-value	11.24 (9)/ 0.26	26.86 (9)/ 0.001	n.s.
CFI	0.996	0.967	>0.9
TLI	0.994	0.945	>0.9
RMSEA (90% CI)	0.031 (0.000, 0.080)	0.081 (0.047, 0.117)	<0.08
SRMR	0.052	0.074	<0.08
WRMR	0.732	1.131	<1
SABAS			
χ^2 (*df*)/ *p*-value	5.13 (9)/ 0.82	11.02 (9)/ 0.28	n.s.
CFI	1.000	0.996	>0.9
TLI	1.013	0.993	>0.9
RMSEA (90% CI)	0.000 (0.000, 0.040)	0.026 (0.000, 0.071)	<0.08
SRMR	0.030	0.044	<0.08
WRMR	0.494	0.724	<1
IGDS-SF9[a]			
χ^2 (*df*)/ *p*-value	27.79 (35)/ 0.80	37.35 (35)/ 0.36	n.s.
CFI	1.000	0.999	>0.9
TLI	1.005	0.999	>0.9
RMSEA (90% CI)	0.000 (0.000, 0.030)	0.016 (0.000, 0.047)	<0.08
SRMR	0.052	0.056	<0.08
WRMR	0.711	0.824	<1

BSMAS=Bergen Social Media Addiction Scale; SABAS=Smartphone Application-Based Addiction Scale; IGDS-SF9=Internet Gaming Disorder Scale-Short Form; CFI=comparative

fit index; TLI=Tucker-Lewis index; RMSEA=root mean square error of approximation; SRMR=standardized root mean square residual; WRMR=weighted root mean square residual; n.s.=nonsignificant; [a] Using multiple indicators and multiple causes (MIMIC) model with gamer/non-gamer as a controlled variable.

Table 4. Measurement invariance across Hong Kong and Taiwan participants

	Configural model[a]	Ladings constrained equal[a]	Ladings and thresholds constrained equal[a]
BSMAS			
χ^2 (*df*) or $\Delta\chi^2$ (Δdf)	38.04 (18)	7.18 (5)	1.58 (5)
p-value	0.004	0.21	0.90
CFI or ΔCFI	0.982	-0.002	0.003
RMSEA or ΔRMSEA	0.063	-0.004	-0.010
SRMR or ΔSRMR	0.056	0.005	0.001
SABAS[b]			
χ^2 (*df*) or $\Delta\chi^2$ (Δdf)	16.14 (18)	8.53 (4)	9.97 (3)
p-value	0.58	0.07	0.02
CFI or ΔCFI	1.000	-0.003	-0.007
RMSEA or ΔRMSEA	0.000	0.020	0.016
SRMR or ΔSRMR	0.033	0.008	0.007
IGDS-SF9[c]			
χ^2 (*df*) or $\Delta\chi^2$ (Δdf)	65.04 (70)	24.86 (8)	7.95 (8)

p-value	0.65	0.002	0.44
CFI or ΔCFI	1.000	0.002	0.000
RMSEA or ΔRMSEA	0.000	0.024	-0.001
SRMR or ΔSRMR	0.050	0.009	0.002

BSMAS=Bergen Social Media Addiction Scale; SABAS=Smartphone Application-Based Addiction Scale; IGDS-SF9=Internet Gaming Disorder Scale-Short Form; CFI=comparative fit index; RMSEA=root mean square error of approximation; SRMR=standardized root mean square residual; [a] Configural models are reported using χ^2 (*df*), CFI, RMSEA, and SRMR; other models are reported using $\Delta\chi^2$ (Δdf), ΔCFI, ΔRMSEA, and ΔSRMR; [b]One factor loading (item S1) and two item thresholds (items S1 and S3) were relaxed in the constrained models; [c] Using multiple indicators and multiple causes (MIMIC) model with gamer/non-gamer as a controlled variable.

Table 5. Correlations among time on social media, time on smartphone, time on gaming, Bergen Social Media Addiction Scale (BSMAS), Smartphone Application-Based Addiction Scale (SABAS), and Internet Gaming Disorder Scale-Short Form (IGDS-SF9)

	r (*p*-value)				
	Time on smartphone	Time on gaming	BSMAS	SABAS	IGDS-SF9
Entire sample					
Time on social media	0.549 (<0.001)***	0.146 (<0.001)***	0.268 (<0.001)***	0.098 (0.014)*	-0.111 (0.008)***
Time on smartphone	--	0.202 (<0.001)***	0.164 (<0.001)***	0.188 (<0.001)***	-0.038 (0.37)
Time on gaming	--	--	-0.151 (<0.001)***	0.111 (0.006)**	0.430 (<0.001)***
BSMAS	--	--	--	0.472 (<0.001)***	0.101 (0.018)*
SABAS	--	--	--	--	0.356 (<0.001)***
Gamer[a]					
Time on social media	0.456 (<0.001)***	0.316 (<0.001)***	0.305 (<0.001)***	-0.026 (0.73)	-0.229 (0.002)**
Time on smartphone	--	0.190 (0.01)*	0.154 (0.042)*	0.191 (0.01)*	-0.195 (0.009)**
Time on gaming	--	--	-0.080 (0.29)	0.100 (0.18)	0.149 (0.048)*
BSMAS	--	--	--	0.354 (<0.001)***	0.271 (0.001)**
SABAS	--	--	--	--	0.459 (<0.001)***

Non-gamer[a]					
Time on social media	0.608 (<0.001)***	-0.057 (0.23)	0.267 (<0.001)***	0.155 (0.001)**	-0.109 (0.03)*
Time on smartphone	--	-0.030 (0.53)	0.237 (<0.001)***	0.166 (<0.001)***	-0.129 (0.01)*
Time on gaming	--	--	-0.066 (0.17)	0.032 (0.50)	0.418 (<0.001)***
BSMAS	--	--	--	0.561 (<0.001)***	0.165 (0.001)**
SABAS	--	--	--	--	0.300 (<0.001)***

[a] Whether the participants played online games regularly, and a gamer was defined as playing an online game at least one hour per week

* $p<0.05$; ** $p<0.01$; *** $p<0.001$.

- Chinese Bergen Social Media Addiction Scale has unidimensional structure.
- Chinese Smartphone Application-Based Addiction Scale has unidimensional structure.
- Chinese Internet Gaming Disorder Scale-Short Form has unidimensional structure.