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ORIGINAL ARTICLE

Development of short-form and screening cutoff point of the Smartphone Addiction Inventory (SPAI-SF)

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Abstract

Smartphone addiction is considered a form of technological addiction that has attracted increasing attention. The present study developed and validated the short-form Smartphone Addiction Inventory (SPAI-SF) and established cutoff point for screening smartphone addiction based on diagnostic criteria established by psychiatric interview. A total of 268 participants completed an online survey that collected demographic data, smartphone use behaviours, and responses to the 26-item SPAI. Each participant also completed a psychiatric interview. Confirmatory factor analysis (CFA) revealed that the 10-item SPAI-SF replicated the structure of original 26-item SPAI accurately, yielding a four-factor model consisting of compulsive behaviour, functional impairment, withdrawal, and tolerance. For maximal diagnostic accuracy, a cutoff point of 24/25 best discriminated cases of smartphone addiction from diagnostic negatives. The present findings suggest that both the 26-item SPAI and SPAI-SF manifest the four constructs of behavioural addiction and the characteristics of smartphone addiction. The cutoff point determined by psychiatrists' diagnostic interview will be useful for clinical screening and epidemiologic research.

KEYWORDS

cutoff point, short-form SPAI, smartphone addiction

1 | INTRODUCTION

Due to increasing popularity of smartphones, excessive uses of smartphone and even smartphone addiction have become substantial worldwide social issues. Smartphone addiction is a form of technological addiction. Griffiths (1996) operationally defined technological addiction as one type of behavioural addiction that involves human-machine interaction and is non-chemical in nature. The most well-known behaviour addiction, gambling disorder, has been categorized within "substance-related and addictive disorders" in the current version of Diagnostic and Statistical Manual of Mental Disorders [DSM-5; American Psychiatric Association (APA), 2013] on the basis of symptomatology, attendant biological dysfunction (Potenza et al., 2003), genetic liability (Slutske et al., 2000), and treatment approach (Hodgins, Currie, & el-Guebaly, 2001; Petry et al., 2006; Petry, Weinstock, Ledgerwood, & Morasco, 2008). Another similar behaviour pattern, Internet gaming disorder, has also been listed in the research criteria of the DSM-5 (APA, 2013). The work group focused on gaming because it was the most well studied and arguably problematic form of Internet use at the time (Petry & O'Brien, 2013). Given that more people are exposed to smartphones in daily life, considering a broader range of Internet-related activities as potentially addictive is important for addiction researchers. Nowadays, the smartphone has become one of the predominant devices to access the Internet. Smartphone addiction and computer-based Internet addiction are different in problem manifestations (Lin et al., in press-b), among which only about 25% overlap (Kwon, Kim, Cho, & Yang, 2013a; Kwon et al., 2013b). Therefore, it is important to develop a valid instrument for smartphone addiction that is with unestablished diagnosis, but yet worthy to obtain clinical and research attention.

Generally, smartphone addiction consists of four main components: compulsive behaviours, tolerance, withdrawal, and functional impairment (Lin et al., 2014), which are identical to that of Internet addiction (Block, 2008). Several self-report questionnaires have been developed to assess smartphone addiction in recent years (Davey & Davey, 2014; Demirci, Orhan, Demirdas, Akpinar, & Sert, 2014; Lin et al., 2014). In general, these questionnaires were developed based on commonalities between smartphone addiction and other behavioural addictions (Bian & Leung, 2015; Demirci et al., 2014; Kim, Lee, Lee, Nam, & Chung, 2014; Kwon et al., 2013a; Kwon et al.,

2013b). With four-factor structure, Smartphone Addiction Inventory (SPAI) yields four-factors that are common across most variants of self-report measure for Internet addiction (Lin et al., 2014). Among these scales, only the short version Smartphone Addiction Scale (SAS-SV) has a cutoff value that was determined by clinical judgement on tolerance, withdrawal, and daily-life disturbance, rather than a structured interview with proposed diagnostic criteria. The concept of behavioural addiction continues to be questioned (Billieux, Schimmenti, Khazaal, Maurage, & Heeren, 2015), perhaps because the aberrant, impulsive, and compulsive behaviours that are characteristic of such addictions have not been clearly documented to tie to neurobiology. In particular, the physiological dependence, tolerance, and withdrawal symptoms, are highly debated in the context of behavioural addiction. From the perspective of neurobiology, the onset of withdrawal symptoms depends on the half-life of the substance (Petursson, 1994). However, unlike substances, most behaviours vulnerable to addiction have no direct biological effect on the brain. Similarly, tolerance is based on the dosage of the substance, but dose in the context of behavioural addiction is ill-defined (Ko & Yen, 2015). Therefore, it is necessary to develop a short form of smartphone addiction measure based on the state-of-the-art theoretical framework of behavioural addiction as well as intensive clinical observation among heavy smartphone users.

To the best of our knowledge, we propose the first diagnostic criteria of smartphone addiction for clinical interview. The preliminary diagnostic criteria demonstrate that smartphone addiction is similar to generalized Internet addiction rather than a specific Internet gaming disorder because smartphone use is characterized by the use of multiple apps (Lin et al., in press-a). However, it is not feasible to conduct diagnostic interviews for smartphone addiction in a large-scale epidemiology study. It would be optimal to conduct a one-stage investigation using a brief self-report instrument with high diagnostic accuracy. However, no research has evaluated the screening cutoff point based on psychiatrists' diagnostic interview. The specific aim of this study was to validate the short-form SPAI (SPAI-SF) and establish a cutoff value for the SPAI-SF for the assessment of smartphone addiction based on diagnostic criteria obtained by psychiatric interview.

2 | METHOD

2.1 | Participants and procedure

Participants were 268 undergraduate and graduate students (205 male, 63 female) recruited from the Department of Electrical Engineering and Department of Computer and Communication Engineering of two universities in Northern Taiwan during December 2012 to June 2015. Their ages ranged from 18 to 31 [mean (M) = 20.89, standard deviation (SD) = 1.58]. All participants were smartphone users. After giving informed consent, all 268 participants completed an online survey that collected demographic data, characteristics of smartphone use, and smartphone addiction symptoms. Furthermore, participants were interviewed individually by a psychiatrist. The study was approved by the Institutional Review Board of National Taiwan University Hospital and carried out in accordance with the latest version of the Declaration of Helsinki.

2.2 | Measures

2.2.1 | The SPAI-SF

The SPAI is a 26-item self-report inventory which for assessing smartphone addiction symptoms (Lin et al., 2014), is a modified version of the Chen Internet Addiction Scale (CIAS; Chen, Weng, Su, Wu, & Yang, 2003). Five of the 26 items of the original scale were revised greatly due to the uniqueness of smartphone use behaviour. Participants were asked to rate items on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The total score of the SPAI ranges from 26 to 104. The SPAI demonstrated very good internal consistency (Cronbach's α = 0.94) and two-week test–retest reliability of the four subscales ranged from 0.80 to 0.91 (Lin et al., 2014).

Considering the definition of smartphone addiction is still a controversial concept in the field of behavioural addiction, we decided to re-examine the original 26-item version of the SPAI, using experts' clinical judgement. To form candidate items for the SAPI-SF, a content validity index (CVI) (Polit & Beck, 2006) was obtained via seven experts experienced in Internet and smartphone addiction, consisting of five psychiatrists, one medical doctor, and one clinical psychologist. After fully comprehending the terminology, they were asked to review the items and select which should be included in the scale based on four components of addiction. Finally, 20 items that were selected by at least six experts were included in further item selection. Next, we selected the items with the highest factor loadings from the results of exploratory factor analysis in our previous study (Lin et al., 2014). In addition, the remaining items for each factor in the SPAI-SF maintained the proportion of items in the four factors of the 26-item SPAI.

The construct validity of the SPAI-SF was examined using confirmatory factor analysis (CFA), which was performed via AMOS 16.0 for Windows (AMOS Development Corporation, PA, USA). Model fit was evaluated via examining the comparative fit index (CFI), normed fit index (NFI), incremental fit index (IFI), and root-mean-square error of approximation (RMSEA). Conventionally, the model fit is acceptable if the CFI, NNFI, and IFI are 0.90 or greater and the RMSEA is below 0.08. Cronbach's α was calculated to evaluate internal consistency.

2.3 | Proposed diagnostic criteria for smartphone addiction: the convergent validity for the SPAI-SF

We proposed smartphone addiction diagnostic criteria that consisted of (A) six symptom criteria, (B) four functional impairment criteria, and (C) one exclusion criteria. The six symptom criteria were (1) recurrent failure to resist the impulse of using the smartphone, (2) use for larger/longer periods, (3) excessive use, (4) unsuccessful attempts to stop or reduce use, (5) continuing use despite problems, and (6) withdrawal. The four functional impairment criteria included three aspects of functional impairment shared with substance use and "subjective distress or is time-consuming" as the fourth functional impairment criterion, which originated in the criteria of obsessive–compulsive disorder. Compared to computer-based Internet addiction, the portability of smartphones reduces the severity of functional

impairment associated with smartphone addiction, but influences multiple other dimensions. In addition, as a brand-new addictive behaviour, we suggested a more stringent threshold for assessing functional impairment: Participants who presented three (or more) symptoms from criteria A and two (or more) functional impairments as assessed in the diagnostic interview were diagnosed as having smartphone addiction (Lin et al., in press-a).

2.3.1 | Self-report time spent on smartphone use

To assess the total duration of smartphone use, all participants reported the average time spent using smartphones during one weekday and the difference in the average time of smartphone use between weekdays and weekend days. If participants thought that their use pattern was too frequent to report their total duration, the psychiatrist helped the participants to recall the most Apps they had used. If the participants were still unable to assess their smartphone usage, they were coded as "frequent usage, very hard to estimate".

2.4 | Statistical analysis

Receiver operating characteristics (ROC) analysis was conducted to examine the diagnostic ability of the SPAI-SF for smartphone addiction. The area under the ROC curve (AUC) was used to measure the diagnostic efficacy of the SPAI-SF. The sensitivity, specificity, Youden Index, and diagnostic accuracy of the SPAI-SF score were evaluated for the diagnostic positive and diagnostic negative groups. The diagnostic accuracy indicated the percentage of all correct decisions, which was the result of dividing the number of true positives and true negatives by the number of all decisions.

The cutoff point for the SPAI-SF was optimal for diagnosis when the score was accompanied by maximal diagnostic accuracy and a high Youden Index. To confirm the validity of the SPAI-SF cutoff score proposed in this study, participants were further classified into an addicted group and a non-addicted group according to the screening cutoff point of the SPAI-SF. The demographic data and characteristics of smartphone use were further compared between these two groups by chi-square test or *t*-test. The analyses were carried out using SPSS 18.0 for Windows (SPSS, Chicago, IL, USA).

3 | RESULTS

To maintain a similar proportion of items as in the four factors of the 26-item SPAI, we determined 3, 3, 2, and 2 items with relatively high factor loadings for Factor 1 (compulsive behaviour), Factor 2 (functional impairment), Factor 3 (withdrawal), and Factor 4 (tolerance), respectively, to form the final 10-item version of SPAI (SPAI-SF). The SPAI-SF demonstrated good internal consistency in the present study (Cronbach's α = 0.84). There was also significant association between the total score of the SPAI-SF and the 26-item SPAI (r = 0.94, p < 0.01).

Table 1 shows the SPAI-SF and the results of the CFA based on a four-factor structure of smartphone addiction. Each item was constrained to load on only one factor. As a result, fit indices were acceptable (CFI = 0.97, NFI = 0.94, IFI = 0.97, and RMSEA =0.061). The standardized item loadings for the final model ranged from 0.57 to 0.90.

Among the 268 participants of the present study, according to the proposed diagnostic criteria for smartphone addiction, 63 participants were classified as the diagnostic positive group, while 205 participants were classified as the diagnostic negative group. Table 2 shows the profile of the ROC analysis for SPAI-SF between the diagnostic positive and negative group. The AUC was 0.709, indicating that the SPAI-SF had acceptable diagnostic efficiency. A cutoff point of 24/25 was best for discriminating cases of smartphone addiction from diagnostic negatives (diagnostic accuracy: 74.6%, Youden Index: 0.360, specificity: 80.5%).

All participants were further classified into an addicted group (n = 75) and a non-addicted group (n = 193) according to the screening cutoff point of 24/25 in the SPAI-SF (Table 3). The addicted group demonstrated significantly longer time spent on smartphones every week, as well a longer duration of smartphone ownership. There were no age or gender differences between the addicted and non-addicted group.

TABLE 1 Standardized item factor loadings of the short-form Smartphone Addiction Inventory

Item and factor		Factor loading
Factor 1: Compulsive behavior		
1.	Although using smartphone has brought negative effects on my interpersonal relationships, the amount of time spent on Internet remains unreduced.	.596
2.	I use smartphone for a longer period of time and spend more money than I had intended.	.633
3.	I try to spend less time on smartphone, but the efforts were in vain.	.710
Factor 2: Functional impairment		
4.	I feel aches and soreness in the back or eye discomforts due to excessive smartphone use.	.703
5.	I make it a habit to use smartphone and the sleep quality and total sleep time decreased.	.569
6.	To use smartphone has exercised certain negative effects on my schoolwork or job performance.	.649
Factor 3: Withdrawal		
7.	I feel restless and irritable when the smartphone is unavailable.	.675
8.	I feel uneasy once I stop smartphone for a certain period of time.	.896
Factor 4: Tolerance		
9.	I find that I have been hooking on smartphone longer and longer.	.764
10.	I have increased substantial amount of time using smartphone per week in recent three months.	.764

TABLE 2 Sensitivity, specificity, positive predictive rate (PPR), negative predictive rate (NPR), diagnostic accuracy (DA), and Youden Index of cutoff points in SPAI-SF between diagnostic positive and negative groups

Cutoff point	Sensitivity	Specificity	PPR	NPR	DA	Youden Index
21	82.5%	44.9%	31.5%	89.3%	53.7%	.274
22	76.2%	55.1%	34.3%	88.3%	60.1%	.313
23	71.4%	63.9%	37.5%	87.8%	65.3%	.353
24	61.9%	71.7%	40.2%	86.0%	69.4%	.336
25	55.6%	80.5%	46.7%	85.5%	74.6%	.360
26	36.5%	83.9%	41.1%	81.1%	72.8%	.204
27	27.0%	87.8%	40.5%	79.6%	73.5%	.148
28	15.9%	91.7%	37.9%	78.2%	73.9%	.076
29	9.5%	93.7%	31.6%	77.1%	73.9%	.032

Note. DA, diagnostic accuracy; NPR, negative predictive rate; PPR, positive predictive rate; SPAI-SF, short-form Smartphone Addiction Inventory.

TABLE 3 Comparison between the smartphone addict and non-addict groups according to cutoff point of 24/25 in SPAI-SF

	Addicted group (*N* = 75)		Non-addicted group (*N* = 193)			
	n	%	*n*	%	χ^2	*p*
Gender					0.233	.692
Male	64	85.3	160	82.9		
Female	11	14.7	33	17.1		
Use type					0.000	.984
Frequent users	12	16.2	31	16.3		
Non-frequent users	62	83.8	159	83.7		
	M	SD	*M*	SD	*t*	*p*
Age (year)	20.77	1.32	20.93	1.68	−0.71	.480
Time spent on smartphone of non-frequent users (hours per week)	27.44	15.08	20.13	14.07	3.40	.001
Duration of smartphone use (month)	33.95	20.29	26.52	18.36	2.88	.004
SPAI	65.95	6.96	49.30	9.97	15.45	< .001
SPAI-SF	27.29	2.16	19.47	3.77	21.19	< .001

Note. SPAI, Smartphone Addiction Inventory; SPAI-SF, short-form Smartphone Addiction Inventory.

4 | DISCUSSION

To our best knowledge, this is the first study to use psychiatrists' structured interview with proposed diagnostic criteria to examine convergent validity of a self-report questionnaire addressing smartphone addiction. On the robust basis of psychiatrists' diagnosis, we provided the cutoff point for smartphone addiction for the SPAI-SF. The cutoff point of 24/25 indicates that if half of the items were assessed as "somewhat agree", this might lead to an assessment of addiction. For example, an individual with 5 items rated "somewhat disagree" (2 points) and 5 items rated "somewhat agree" (3 points; total score = 5 × 2 + 5 × 3 = 25) will be determined as a smartphone addict. Our results also show that the cutoff point can distinguish heavy smartphone users by their time spent in smartphone use. As it is still debating whether the smartphone addiction constitutes a diagnosable entity, the SPAI-SF with cutoff point may be used as a tool to screen out potentially risk users in the general population.

In addition to the validation by diagnostic interview, the SPAI-SF was determined by factor loadings and quantified experts' opinions (CVI). The CFA showed the SPAI-SF maintains the four-factor structure of smartphone addiction. These factors are the fundamental symptoms in the substance-related and addictive disorders in the DSM-5 (APA, 2013). The 26-item SPAI is a modified version of the 26-item CIAS: Five items underwent major revision because of the unique characteristic of smartphone use versus computer-based Internet use (Lin et al., 2014). Three of the revised items remained in the SPAI-SF. These were classified as compulsive behaviour, functional impairment, and withdrawal, respectively. This result suggests that smartphone addiction shares core symptoms with Internet addiction but presents unique features in each construct of addiction.

The results showed that the SPAI-SF not only retained the core psychopathology of addiction but manifested the specific features of smartphone addiction. Three compulsive behaviour items in the SPAI-SF corresponded to DSM-5 substance-related disorder criteria, particularly the symptoms of "impaired control" (APA, 2013). The items pertaining to withdrawal and tolerance in the SPAI were also identical to their definition in the DSM-5. The three functional impairment items were consistent with those in the 10-item SAS (Kwon et al., 2013a). The first two items addressing physical discomfort and sleep quality were relatively common in daily life. In addition, the items addressing impairment in academic or occupational functioning reflected general principles of functional impairment common to nearly all mental illnesses in the DSM-5 (APA, 2013). However, the great portability of smartphones results in the unique functional

impairment characterised by distraction by frequent, short-duration smartphone use.

There are two tolerance-related items in the SPAI-SF, although it is controversial as to whether tolerance is a core symptom of smartphone addiction. Tolerance is defined as the need to spend an increasing amount of time engaged in gaming in Internet gaming disorder (APA, 2013). The two tolerance-related items of the SPAI-SF only delineate increasing smartphone use, but are not involved in "feeling the need" to increase smartphone use "in order to achieve satisfaction". The tolerance factor demonstrated the most unstable structure, with consistently the lowest eigenvalue and the fewest items in most smartphone addiction questionnaires (Kim et al., 2014; Kwon et al., 2013b; Lin et al., 2014). Furthermore, our previous studies argued that tolerance is difficult to evaluate (Lin et al., 2015) and does not contribute to the diagnosis (Lin et al., in press-b). Considering the fact that smartphone use could be essential to current lifestyles, the increasing use of smartphones, which is traditionally considered as a predominant manifestation of tolerance, may not be pathological. In addition, the need to increase smartphone use can be driven by various motives. However, these two items that investigate increasing smartphone use are still of value, especially with respect to the time course of smartphone addiction and the relapse prevention beyond the tolerance.

Withdrawal, as well as tolerance, have not been included in the definition of all addiction problems [American Society of Addiction Medicine (ASAM), 2011; Potenza, 2006; West, 2013). To including these two symptoms may not help to enhance the understanding of the specific behavioural addiction (Starcevic, 2016). The two withdrawal-related items of the SPAI-SF are both described as emotional states, i.e. restlessness, irritability, and unease. Such descriptions are consistent with the findings in previous literature, in that no study reports severe physical withdrawal symptoms in behavioural addiction. A recent systematic review on Internet gaming disorder also demonstrated that there are only emotional, but no physical, withdrawal symptoms (Kaptsis, King, Delfabbro, & Gradisar, 2016), whereas both emotional and physical withdrawal symptoms occur upon abrupt substance cessation (Starcevic, 2016). To include tolerance and withdrawal, the physiological dependence symptoms in substance addiction, may reveal theoretical flaws in smartphone addiction. The withdrawal and tolerance-related items in SPAI-SF, which are about emotions, should be considered as the specific symptoms beyond traditional withdrawal and tolerance and can be used to conceptualize smartphone addiction.

Our study participants were predominantly male (75.5%) young adults (age: 20.89 ± 1.58 years) and 28.0% of them would be evaluated as having smartphone addiction. These results do not indicate that over one quarter of healthy college students are likely to have smartphone addiction. The SPAI-SF was developed base on theoretical framework of addiction that includes withdrawal and tolerance. However, some critical comments of behavioural addiction claimed that enhanced activity engagement and a need for better equipment do not necessarily reflect tolerance of behavioural addiction (Billieux et al., 2015). Therefore, the SPAI-SF may overestimate the rate of smartphone addiction in our sample. Furthermore, adolescence is a particularly risky period for addiction (Volkow, Koob, & McLellan, 2016). The prefrontal cortex and other cortical networks that are critical for judgement and self-regulation do not fully mature until the age of 21 to 25 years old (Giedd et al., 1999). Thus, younger adults may present with more compulsive behaviours regarding smartphone addiction than individuals who are not of the Internet generation. In addition, whereas there are legal drinking and smoking ages in Taiwan and most other countries, this is not the case for smartphones, and their portability can ubiquitously interfere with an individual's normal routine, occupation, or academic functioning (Lin et al., 2014). Compared to estimates that the most severe forms of addiction will developed in approximately 10% of individuals exposed to addictive substances (Warner, Kessler, Hughes, Anthony, & Nelson, 1995), it is not surprising that 28.0% of the present sample met the criteria for smartphone addiction. All in all, it will be important to consider the cutoff point of SPAI-SF as a score for screening potential group with high risk of smartphone addiction rather than formally diagnosing a clinical case. A self-report instrument validated with psychiatrists' interview is an important but preliminary step since the diagnosis of smartphone addiction has not been widely accepted. Further studies should call more urgent attention to the core constructs of smartphone addiction.

Several study limitations should be noted when interpreting our findings. First, most of the participants were male college students, which might limit the generalization of the findings. Second, the sensitivity and specificity of the SPAI-SF is lower than instruments assessed in previous studies of smartphone addiction (Kim et al., 2014) and Internet addiction (Ko, Yen, Chen, Chen, & Yen, 2005; Ko et al., 2009). As an emerging addictive behaviour, the smartphone addiction diagnostic criteria should be confirmed by international consensus. Third, the assessment of smartphone addiction was determined solely on the basis of the participants' self-report questionnaires and responses to the diagnostic interview. Additional supporting information or App-recorded data may contribute to the confirmation of the symptoms and functional impairment criteria. Finally, the withdrawal and tolerance subscales consist of only two items. Although most guidelines for CFA broadly agree that at least three indicators per factor are desirable, models including a factor with two indicators are not unacceptable when sample size is large and factor loadings are of sufficient magnitude (Marsh, Hau, Balla, & Grayson, 1998). The present study meets these guidelines acceptably, but not in exemplary manner. Additional psychometric studies with larger sample sizes are needed to re-examine the content validity of the SPAI-SF.

In conclusion, the SPAI-SF manifests the four constructs of behavioural addiction and the characteristics of smartphone addiction. The cutoff point determined by psychiatrists' diagnostic interviews will be useful for clinical screening and epidemiological research. In the contentious field of behavioural addiction, future studies should explore the role of tolerance and withdrawal in the assessment of smartphone addiction.

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DECLARATION OF INTEREST STATEMENT

The authors have no competing interests.

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