International Journal of Mental Health and Addiction
https://doi.org/10.1007/s11469-023-01013-1

ORIGINAL ARTICLE

Psychometric Properties of the Serbian Smartphone Application-Based Addiction Scale (SABAS) and Validation of the English Version Among Non-native English Speakers

Aleksandar Vujić[1,2] · **Marija Volarov**[3] · **Milan Latas**[4] · **Mark D. Griffiths**[5] · **Attila Szabo**[1,2,6]

Accepted: 14 January 2023

Abstract

The present study evaluated the psychometric properties of the Serbian Smartphone Application-Based Addiction Scale (SABAS) and the original English version of the same scale administered to a Serbian-speaking sample. In Study 1, 599 participants completed Serbian SABAS, with 189 having both test and retest data. Results suggested good internal consistency ($\alpha = .81$) and test–retest reliability ($ICC = .795$, $p < .001$, 95% CI [.731, .844], $r_{\text{test-retest}} = .803$) of the scale. Convergent validity of the SABAS was evaluated through correlations with the Smartphone Addiction Scale–Short Version (SAS-SV), as well as with anxiety, depression, worry, duration, and purpose of smartphone use. Divergent validity of the SABAS was evaluated through comparing the correlations with entertainment and productive smartphone use. The modified CFA model showed an acceptable fit ($\chi^2(8) = 25.53$, $p = .001$, CFI = .961, TLI = .926, RMSEA = .096, SRMR = .042), confirming the unidimensionality of the SABAS. In the second study, the English SABAS, completed by 335 non-native speakers from Serbia, also showed a good fit of the single-factor model ($\chi^2(9) = 12.56$, $p = .184$, CFI = .990, TLI = .984, RMSEA = .036, SRMR = 0.026), and good psychometric features. Based on the study's findings, the Serbian version of SABAS is a reliable and valid measure for screening the risk of smartphone addiction. Moreover, the English version can be used among non-native Serbian English speakers.

Keywords Behavioural addiction · Mobile phone · Psychometric · Smartphone addiction · Validation, SABAS

Problematic Smartphone Use and Smartphone Addiction

Smartphone addiction (SA) and problematic smartphone use (PSU) have been recognised as an important and clinically relevant area for research and a growing public health concern (Lopez-Fernandez et al., 2017). Although SA and PSU are frequently used as synonyms (Busch & McCarthy, 2021), some scholars prefer the use of PSU because it does

✉ Attila Szabo
szabo.attila@ppk.elte.hu

Extended author information available on the last page of the article

not imply the addictive nature of this behaviour and does not contain diagnostic labelling (Panova & Carbonell, 2018). Irrespective of terminology, it should be noted that although SA has not yet been considered a formal diagnostic disorder in *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013), criteria for smartphone addiction have been suggested (Y.-H. Lin et al., 2016).

Problematic smartphone use in its most extreme form can be defined as 'a behavioral addiction including the core components of addictive behaviours, such as cognitive salience, loss of control, mood modification, tolerance, withdrawal, conflict, and relapse' (Billieux et al., 2015, p. 157). These components come from the 'addiction components model' that posits that all addictions, whether substance-based or behaviour-based, consist of these key components (Griffiths, 2005). In the context of PSU, salience refers to the cognitive, emotional, and affective dominance of smartphone use in an individual's life. Mood modification refers to engaging in smartphone use for its arousing or calming effect, including avoidant coping mechanisms (e.g., Cho, 2020). Tolerance indicates the need to increase the frequency and duration of smartphone use over time to reach the effects that the same behaviour induced previously. Withdrawal refers to negative psychophysiological symptoms that occur when activity is stopped or abruptly decreased. Conflict denotes conflicts resulting from smartphone use, which can be intra- or interpersonal (e.g., a conflict with family members and/or occupational/educational activities due to smartphone use). Lastly, relapse refers to the rapid recurrence of previous patterns of smartphone use after a period of abstinence to the same or even higher intensity than before (Griffiths, 2005).

Recent authors consider PSU and SA to represent two different points on the same continuum, with SA lying at the upper end (a conceptualisation that is in line with McMurran's idea [1994] of the severe use-to-abuse spectrum). This differentiation between PSU and SA may be necessary because all smartphone addicts are problematic smartphone users, but not all problematic smartphone users are addicted to smartphones (Griffiths, 2016). In addition, Griffiths and others claim that the resulting detrimental consequences of behaviour distinguish addiction from excessive nonpathological behaviour (Griffiths, 2005; Szabo & Demetrovics, 2022).

For example, those who use their smartphones excessively tend to report higher levels of depression, anxiety, stress (Elhai et al., 2017), and sleep disturbances (Sohn et al., 2019; Thomée et al., 2011). Additionally, PSU can result from poor coping mechanisms where individuals use their smartphones as a distraction from negative feelings and experiences (Cho, 2020). Finally, PSU can put individuals in life-threatening situations, such as those caused by using a smartphone while driving (Barkana et al., 2004; White et al., 2004). Although the present study focuses on validating the Serbian translation of the SABAS, which contains the term 'addiction' in it, the authors perceive the SABAS as a measure of problematic behaviour that could put individuals at risk for SA. In fact, increasing scores on this instrument can be conceptualised as representing a higher PSU and therefore a higher risk of — or susceptibility to — smartphone addiction.

The Assessment of Smartphone Addiction/Problematic Smartphone Use

To date, numerous instruments assessing SA/PSU have been developed (e.g., Problematic Mobile Phone Use Questionnaire [PMPUQ]; Billieux et al., 2008; Smartphone Addiction Scale [SAS]; Kwon et al., 2013; Smartphone Addiction Inventory [SPAI]; Y.-H. Lin et al., 2014), but many of these instrument do not have any theoretical framework underpinning the items. For example, many scales have content derived from DSM criteria for gambling or substance use disorders (Flayelle et al., 2022; Harris et al., 2020b), suffer from specific shortcomings, as pointed out in previous reviews (Ellis et al., 2019; Harris et al., 2020b), and do not have satisfactory reliability, and their test–retest reliability often remains unreported (Harris et al., 2020b). Also, scales that assess SA/PSU usually correlate weakly with objectively measured rapid phone checking, which could be closely related to behavioural addiction (Ellis et al., 2019).

In general, most of these instruments are poor predictors of the objective indices of technology use in terms of patterns of use (such as phone checking and notification receiving) and usage frequency (Ellis et al., 2019). However, it could also be argued that a poor correlation between SA/PSU and use frequency exists because frequent use does not always mean problematic/addictive use (Emanuel et al., 2015). On the one hand, an individual can spend an extended amount of time using a smartphone, but their activities may be focused on fulfilling a concrete (e.g., a work-related) task, and therefore less interfering with everyday life (see De-Sola Gutiérrez et al., 2016; Tossell et al., 2015). On the other hand, an individual can use a smartphone maladaptively as a coping mechanism for a particular underlying psychological problem or need (Kardefelt-Winther, 2014, 2017).

The development of SABAS items was grounded by adapting six items from the Exercise Addiction Inventory (Griffiths et al., 2005) to fit PSU/SA, with each item representing one component of the 'addiction components model'. According to Yu and Sussman (2020), items from the Smartphone Addiction Inventory (SPAI; Y.-H. Lin et al., 2014) and the Korean Smartphone Addiction Proneness Scale for Youth (SAPS; Kim et al., 2014) could also probably assess the components of addiction from Griffiths' model. However, unlike SABAS, these scales were not explicitly derived from the 'addiction components model' (they were either based on the DSM criteria or on previous scales and findings) and have considerably more items than the SABAS.

Originally developed in Hungarian as a screening tool for SA in children (Csibi et al., 2016), the SABAS has subsequently been validated on adult population samples in different languages, such as English (Csibi et al., 2018; Mason et al., 2022), Chinese (Chen et al., 2020; Yam et al., 2019), Italian (Soraci et al., 2021), Persian (C.-Y. Lin et al., 2019), Turkish (Gökler & Bulut, 2019), Bangla (Islam et al., 2021), Indonesian (Nurmala et al., 2022), and Arabic (Vally & Alowais, 2022). The English version has been used previously in studies where participants were not strictly native English speakers (e.g., Csibi et al., 2018). The results of these studies have suggested the unidimensionality of the scale, as well as good reliability and validity. However, some findings have questioned its temporal stability (Harris et al., 2020b). To date, no studies have examined the characteristics of the Serbian version of the scale. A Serbian translation of the SABAS was used in one study in the Serbian language (Sojević et al., 2018). However, the psychometric properties (apart from Cronbach's α) were not presented. Additionally, the translation procedure did not include a back translation process, and the study was conducted exclusively on university students. Therefore, in present study, the SABAS was retranslated using back translation procedure and validated using a sample from the general Serbian population.

The Present Study

The present study comprised two studies. The goal of Study 1 was to evaluate the factor structure of the SABAS translated into the Serbian language, including item analysis, convergent validity, and test–retest reliability. The goal of Study 2 was to evaluate the English version of the SABAS completed by English-speaking Serbian participants and to compare it with the Serbian version. The Serbian SABAS was expected to have a one-factor structure and there would be good (i) internal consistency, (ii) test–retest reliability, and (iii) convergent validity, divergent validity, and (as a consequence) good construct validity. More specifically, it was expected that there would be a strong positive correlation between the SABAS and the short version of the Smartphone Addiction Scale (SAS-SV) scores, as both scales assess the same construct. It was also expected that there would be a moderate positive correlation of the SABAS score with depression and anxiety, based on previously published research (e.g., Elhai, et al., 2017), as well as a moderate positive correlation with entertainment use (van Deursen et al., 2015; Zhang et al., 2014), and a positive relationship with smartphone use duration (Haug et al., 2015). Lastly, it was expected that there would be a positive relationship between the SABAS scores and the two aspects of worry (i.e., severity and control). This is because worry is closely related to the aforementioned symptoms of anxiety and depression and has been directly investigated in the context of SA/PSU (Elhai et al., 2019).

To get some insight into the divergent validity of the SABAS, the study compared the correlation of the SABAS scores with 'entertainment smartphone use' and with 'productive smartphone use'. It was expected that there would be a significantly stronger relationship between SABAS and entertainment use than with productive use. This is based on the aforementioned findings that the use of smartphones for entertainment is related to the problematic use of smartphones, whereas focused use on concrete tasks and productive goals (such as education and the achievement of social connectedness) is not related to PSU and can have positive psychosocial effects (see De-Sola Gutiérrez et al., 2016; Horwood & Anglim, 2019). The study also examined the ability of the SABAS to differentiate between low and high-average smartphone use. It was expected that the high-use group would have significantly higher scores on the SABAS than the low-use groups (Tossell et al., 2015). Finally, the participants were classified into 'normal to mild' and 'moderate to extremely severe' anxiety and depression groups, respectively, and their differentiation concerning their SABAS scores was tested. It was expected that the 'moderate to extremely severe' group in both anxiety and depression would have significantly higher scores on SABAS than the 'normal to mild' groups.

Study 2 examined whether the English version of the SABAS scale could also be used to screen the risk of SA among non-native English speakers, in this case, among participants whose first language was Serbian but who reported having a good command of English. It was expected that the English SABAS would have good psychometric properties, including internal consistency and unidimensionality.

Study 1: Method

Sample and Procedure

A convenience sample was recruited from the general Serbian population using social media (e.g., *Facebook*) and instant messaging applications (e.g., *Viber, WhatsApp*), which were used to provide a link to the survey. Participants were required to be 18 years or older and smartphone users. Data were collected in two phases. Data from the first phase (T1) were collected at the end of January 2022 using the *Qualtrics* platform (Qualtrics, 2022). In total, 600 participants completed the survey in T1 (M_{age} = 39.82 years, *SD* = 10.87; 57.93% female). There were no missing data values. During data cleaning, one participant was identified as being under 18 years of age and was therefore excluded. The final sample comprised 599 participants. More than a third of the participants had a university or college degree (41.40%), 23.37% had a master's degree, and 5.51% had a Ph.D. Approximately a quarter of the participants had graduated from high school (23.04%), and 6.34% were university or college students at the time of data collection. Two participants only finished elementary school.

For those who agreed to participate in the second phase of Study 1, a survey link was automatically sent to an individual (via *Qualtrics*) three weeks after they completed the first phase to collect retest data (T2 data). The responses were matched using an ID code that the participants generated themselves. A total of 377 participants initially agreed to participate in the retest, although only 201 participants completed it. Since not all T2 data matched the T1 data due to invalid ID codes, only 189 responses provided valid test and retest data (62.43% female).

Ethics

Informed consent was obtained from all participants included in the study. Ethical permission for the study was obtained from the first author's university Research Ethics Board (2021/608). Participation was completely anonymous and voluntary. Those who agreed to participate in the retest were presented with the General Data Protection Regulation (GDPR) document because they had to provide their email address. No material compensation was provided for participating in the study. Participants were informed that they could withdraw from participation without any consequences.

Instruments

Smartphone Use Questions Participants were asked to estimate their daily use of smartphones on a typical weekday and a typical weekend in hours (similar to Kwon et al. [2013] and Nikolic et al. [2022]). Prior to conducting *t*-tests where 'high' and 'low' smartphone use groups were compared to the SABAS scores, weekday use was multiplied by five, and weekend use was multiplied by 2, and the two products were added up and divided by seven to get the daily average time spent on smartphones. In addition, two questions were asked to assess the frequency of smartphone use for specific purposes (i.e., entertainment, boredom, leisure), as well as the use of smartphones to fulfil concrete tasks (i.e., work, finances, and communication). The answers were given on a scale from 1 (*almost never*) to 7 (*almost always*) (see Appendix 1 for the actual questions).

Smartphone Application-Based Addiction Scale (SABAS; Csibi et al., 2018) The six-item Serbian version of the SABAS was used to assess the risk of smartphone addiction (SA). The translating procedure was broadly based on the protocol suggested by Beaton et al. (2000). More specifically, the SABAS items were translated from English to Serbian by a certified

English language teacher and an English language and literature graduate. The authors compiled a single version from these two translations, then back-translated to English by a third bilingual individual who had not previously seen the original items. The meaning of the elements in the back-translated version did not substantially change from the original version. Finally, the authors made slight changes according to their expertise and created a final version of the Serbian SABAS. Items are rated on a 6-point response scale from 1 (*strongly disagree*) to 6 (*strongly agree*), and a higher score on the scale (out of 36) indicates a greater risk of SA. The SABAS items in Serbian and English language are shown in Appendix 2.

Smartphone Addiction Scale Short Version (SAS-SV; Kwon et al., 2013; Serbian version: Nikolic et al., 2022) The ten-item Serbian translation of the short version of the SAS was used to assess the risk of smartphone addiction. Items are rated on a 6-point response scale from 1 (*strongly disagree*) to 6 (*strongly agree*). Cronbach's alpha of the SAS-SV scale in the present study was very good ($\alpha = 0.88$).

Depression Anxiety Stress Scale (DASS-21; Lovibond & Lovibond, 1995; Serbian version: Jovanovic et al., 2014) This instrument is a 21-item measure typically used to assess symptoms of depression, anxiety, and stress, in both clinical and nonclinical settings. In the present study, only the depression and anxiety subscales were used, comprising 14 items (seven items each). Participants are instructed to rate the presence of symptoms they experienced during the past seven days, using a 4-point response scale from 0 (*did not apply to me at all)* to 3 (*applied to me very much or most of the time*). Cronbach's alpha of the two subscales in the present study were very good (depression: $\alpha = 0.88$; anxiety: $\alpha = 0.81$).

Worry Two questions were formulated for the purpose of the present study to assess two components of worry (i.e., Hirsch & Mathews, 2012; Hirsch et al., 2013), namely, worry severity ('On a scale from 1 to 5, indicate how much you usually worry') and perceived control over worrying (e.g., 'I feel like I usually do not have control over how much I worry'). The items were rated on 5-point response scales, with higher scores indicating higher intensity of worry and the lower perceived control over worry, respectively.

Data analysis

Both exploratory factor analysis (EFA), with principal axis factoring (a recommended method when multivariate normality is violated [Costello & Osborne, 2005]), and confirmatory factor analysis (CFA) were performed on two randomly selected subsamples, using a pseudorandom number generator to select the cases from the data. Each subsample consisted of approximately 50% of the sample. The number of factors in EFA was determined using minimum rank parallel analysis, the Guttman-Kaiser criterion, and the scree diagram. Loadings > 0.50 were considered acceptable (Hair et al., 2010). The model fit in CFA was considered acceptable if χ^2 was non-significant, and the comparative fit index (CFI) and the Tucker-Lewis index (TLI) were > 0.90, and the root mean square error of approximation (RMSEA) and the standardised root mean square residual (SRMR) were < 0.08 (Hu & Bentler, 1999). Parameters were estimated using robust maximum likelihood (MLR) due to the nonnormal multivariate distribution of the items.

The mean inter-item correlation (MIC), squared multiple correlations (SMC), and corrected item-total correlations were calculated as a measure of item discrimination. The corrected item-total correlation and SMC both represent how well an item is related to the rest of the items. Corrected item-total correlation should be > 0.30 (Field et al., 2012), and for SMC values > 0.20 can be considered acceptable (see Dinić, 2019). Finally, Cronbach's α if the item is deleted, was computed. Additionally, convergent validity was assessed using Pearson's correlation coefficient r. Divergent validity was assessed by testing the difference in the correlations between the SABAS score and entertainment use and productive use, using the test of dependent correlations difference (Steiger, 1980). The internal consistency of the SABAS was assessed with Cronbach's α and ω_{total}. The composite reliability (CR) and the average variance extracted (AVE) were also computed. Test–retest reliability was determined with the r and intraclass correlation coefficient (*ICC*, two-way mixed effects, single measure, absolute agreement). An *ICC* of 0.75 indicates good test–retest reliability (Koo & Li, 2016). To examine the ability of the scale to discriminate between 'normal to mild' and 'moderate to extremely severe' levels of anxiety/depression, t-tests with SABAS score as the outcome measure used.

Regarding depression, participants were classified into the first group if they scored ≤ 13 ('normal to mild') points and into the second group if their score was > 14 ('moderate to extremely severe'). As for anxiety, the cut-off for the first group was ≤ 9 ('normal to mild'), and for the second group was > 10 ('moderate to extremely severe'). These scores are comparable to the scores obtained with DASS-42, since they were multiplied by two (Lovibond & Lovibond, 1995). Furthermore, a t-test was used to test the difference between the 'low' average weekly smartphone use group, which comprised 151 participants (25% of the lowest scores on average smartphone use) and the 'high' smartphone use group (25% of the highest scores on average smartphone use), which comprised 160 participants. Finally, to check for the gender differences among variables, a series of t-tests was used with adjusted significance levels, and Cohen's d measures of effect size.

Data were analysed in R programming language (R Core Team, 2022) using 'tidyverse' (Wickham et al., 2019), 'lavaan' (Rosseel, 2012), 'psych' (Revelle, 2022), 'rstatix' (Kassambara, 2021), 'dlookr' (Ryu, 2022), 'irr' (Gamer & Lemon, 2019), 'semTools' (Jorgensen et al., 2021), 'semPlot' (Epskamp, 2022), 'stringdist' (van der Loo, 2014), 'fuzzyjoin', 'EFA.MRFA' (Navarro-Gonzalez & Lorenzo-Seva, 2021), 'mvnormalTest' (Zhang et al., 2020), 'MVN' (Korkmaz et al., 2014), and 'diffcor' (Blötner, 2022) packages. The data, including the test–retest data and the R analysis code, are available upon request from the corresponding author.

Study 1: Results

Descriptive Statistics

The descriptive statistics, along with the gender differences, are shown in Table 1. Gender differences were found in SABAS scores, anxiety, and worry severity, with females scoring higher than males on all three scales. Considering the univariate distribution, the SABAS scores were right-skewed. However, their distribution did not significantly deviate from the normal distribution since the skewness and kurtosis values were within the acceptable

Table 1 Descriptive statistics of the total sample ($N=599$), male subsample ($n=252$), and female subsample ($n=347$) with mean differences and effect sizes

Scale	Total		Males		Females		*t*(*df*)	*d*
	M	*SD*	*M*	*SD*	*M*	*SD*		
SABAS	15.77	5.67	15.06	5.79	16.28	5.53	-2.59(526)*	-0.21
SAS-SV	22.33	8.76	21.80	9.17	22.71	8.45	-1.23(514)	-0.10
Entertainment	5.10	1.39	5.07	1.39	5.13	1.39	-0.52(542)	-0.04
Productive	5.74	1.33	5.63	1.42	5.82	1.26	-1.61(501)	-0.13
Weekday use	3.89	2.40	3.90	2.43	3.88	2.38	0.08(534)	0.01
Weekend use	4.47	3.02	4.52	3.19	4.44	2.89	0.32(508)	0.03
Anxiety	2.90	3.10	2.44	2.76	3.24	3.28	-3.27(584)**	-0.27
Depression	3.39	3.84	3.29	3.80	3.46	3.88	-0.55(547)	-0.05
Worry severity	3.29	1.00	3.11	0.97	3.43	1.00	-3.87(551)**	-0.32
Worry control	2.57	1.22	2.47	1.18	2.65	1.24	-1.81(558)	-0.15

p-values were adjusted using Benjamini–Hochberg method. *M*, mean score; *SD*, standard deviation; *d*, Cohen's *d* effect size; *SABAS*, Smartphone Application-Based Addiction Scale; *SAS-SV*, Smartphone Addiction Scale–Short Version; *Entertainment*, entertainment use of smartphones; *Productive*, productive use of smartphone

*$p<.05$. **$p<.01$

range of ± 1.0 (George & Mallery, 2020). Anxiety and depression scores were highly right-skewed, meaning that only a small number of participants exhibited higher scores on the two scales. This is to be expected since the sample was drawn from a non-clinical population. As for multivariate normality of the SABAS items, both Mardia's test (multivariate skewness was 330.91, $p<0.001$, and multivariate kurtosis was 4.70, $p<0.001$) and Henze-Zirkler test ($HZ=4.96$, $p<0.001$) indicated the violation of this assumption. No multicollinearity among SABAS items was found, since no inter-item correlation was > 0.80, and the determinant of the item correlation matrix was 0.164, and therefore greater than 0.00001 (Field et al., 2012).

The Structure of the SABAS

The sample was randomly split, and 300 participants were included in the EFA. The Kaiser–Meyer–Olkin coefficient was good ($KMO=0.81$), and the Bartlett's sphericity test was significant, $\chi^2(15)=507.38$, $p<0.001$, suggesting that the data were adequate for factor analysis (Field et al., 2012). The minimum rank parallel analysis, the Guttman-Kaiser criterion, and visual inspection of the scree diagram indicated that only one factor should be extracted. The single factor explained 41.3% of the variance of the original data. All loadings in the pattern matrix were > 0.50, except for Item 1, which was > 0.40.

The CFA was conducted on the second half of the sample ($N=299$). Six items loaded onto a single factor, representing smartphone addiction. However, several problems emerged during both the global and local model fit inspection. The model fit was as follows: $\chi^2(9)=41.95$, $p<0.001$, CFI = 0.928, TLI = 0.881, RMSEA = 0.122, and SRMR = 0.046. The χ^2 fit index is highly dependent on sample size, so it was no surprise that it was significant for this model. The CFI and SRMR showed an acceptable fit. However, TLI and RMSEA were not in an acceptable range, which raised concerns. One reason for this could be the sample size, but in the CFA, the sample was not too small. Furthermore, models with small degrees of freedom tend to have an inflated RMSEA (Kenny et al., 2015). On the other hand, the TLI is largely dependent on the size of the correlations between the observed variables in the model. However, it could not be determined whether this caused the TLI to be below the threshold. Therefore, the analysis relied on inspection of local misfit and modification indices. Item 1 had high standardised residuals with other items, all $z>|2|$ (except with Item 4). The standardised residuals of Item 4 with Items 5 and 6 were also high. In contrast, SRMR still indicated an acceptable discrepancy between observed and model-implied covariance. Modification indices suggested that allowing the errors of Items 1 and 5 and Items 4 and 6 to correlate would improve the model fit.

The modification index (MI) was highest for the correlated errors of Item 1 and Item 5 (MI = 21.04). The next highest MI was for Item 4 and Item 6 pairing (MI = 20.23). In addition, the expected parameter change (EPC) was the highest for this pair of items. Therefore, the model was modified by allowing the errors of Items 4 and 6 to correlate since they could be mutually more related than the other items. They seemed to reflect increased smartphone use over time, followed by reduced control over smartphone use. The correlation of the two items' errors was $r = 0.34$. Table 2 shows standardised loadings and communalities of EFA, and standardised loadings and R^2 of the modified CFA model. The fit indices of the modified model were: $\chi^2(8) = 25.53$, $p = 0.001$, CFI = 0.961, TLI = 0.926, RMSEA = 0.096, and SRMR = 0.042. The modified model, with unstandardized parameters, is presented in Fig. 1.

All standardised loadings were > 0.50 in the modified model, satisfying previously established criteria (Hair et al., 2010). Item 1, reflecting the salience aspect of addiction, performed weakly since it had the lowest loadings in both EFA and CFA, communality, and the proportion of explained variance by the latent factor. Nevertheless, it was concluded that the unidimensionality of the Serbian translation of the SABAS was supported.

Item Analysis and Reliability of the Serbian SABAS

Item 1 had the lowest corrected item-total correlation while still being acceptably high. Item 1 and Item 2 had the lowest SMC, indicating that those two were less correlated with the remaining items. The mean average response on items was 2.63 ($SD = 0.94$), which is lower than the theoretical mean ($M = 3.5$). This finding means that, in general, participants tended to agree less with the items. Item 5 appeared to be the 'most difficult', and Item 4 the 'easiest'

Table 2 Results of the exploratory factor analysis and modified model of the confirmatory factor analysis of items in the Smartphone Application-Based Addiction Scale

Item	Addiction component	EFA ($N = 300$)		CFA ($N = 299$)		
		Std. loading	Communality	Std. loading	*S.E*	R^2
1	Salience	.44	.19	.52	-	.27
2	Conflict	.54	.29	.58	.15	.34
3	Mood modification	.66	.44	.66	.23	.43
4	Tolerance	.73	.54	.67	.23	.45
5	Withdrawal	.65	.42	.76	.14	.58
6	Relapse	.78	.60	.68	.22	.46

All parameters in the CFA were significant at $p < .001$. *Std. loading*, standardised loading; *S.E.*, standard error

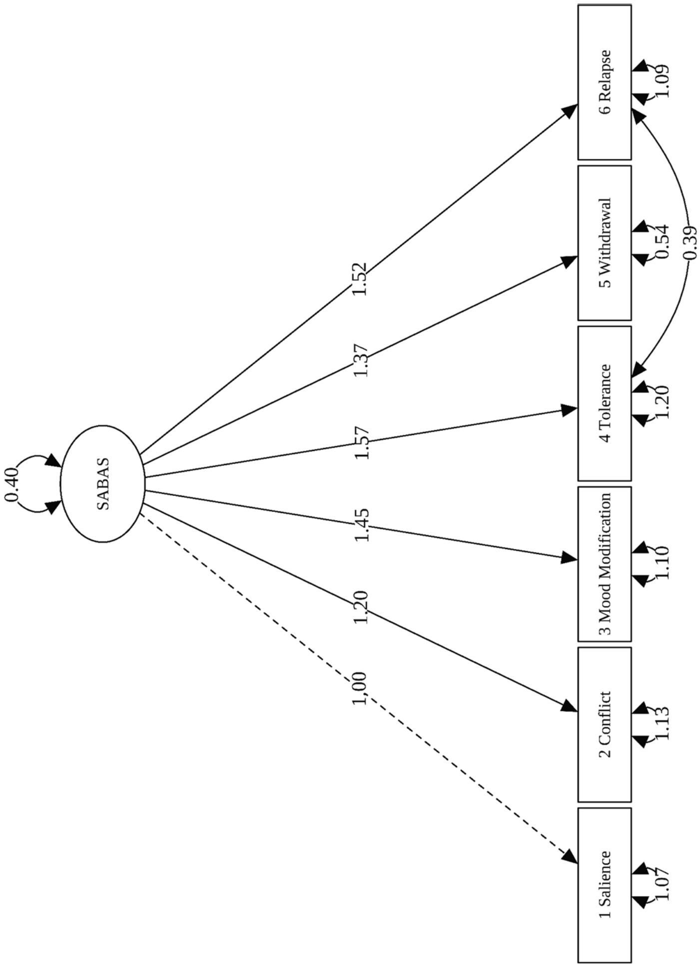

Fig. 1 Serbian SABAS modified model with unstandardised coefficients

(Table 3). However, 'the easiest' item on the scale had the average response closest to the theoretical mean. The internal consistency of SABAS was characterised as 'very good', with the Cronbach's alpha being $\alpha = 0.81$ and $\omega_{total} = 0.81$. The MIC was 0.41, which lies in the range from 0.20 to 0.50, suggesting that the scale was homogenous (Clark & Watson, 1995). Average variance extracted (AVE) calculated for the 299 participants from the T1 sample (a subsample used to carry out CFA) was 0.45, while it was 0.44 for the whole sample ($N = 599$) which suggests that the item variance was not well explained by the SA latent variable. The CR was 0.82 ($N = 299$), indicating good internal consistency (Fornell & Larcker, 1981; Lam, 2012).

The test–retest reliability was assessed with 189 participants, as described in the Method section. The intra-class coefficient suggests good reliability, $ICC = 0.795$, 95% CI [0.731, 0.844], $F(188, 149) = 9.1$, $p < 0.001$. Pearson correlation between SABAS scores at T1 and T2 was $r = 0.803$, $p < 0.001$, 95% CI [0.745, 0.848], again indicating good test–retest reliability of the scale.

Convergent and Divergent Validity of the Serbian SABAS

To examine the convergent validity of SABAS, correlations with SAS-SV, anxiety, depression, entertainment use, and worry aspects were calculated (Table 4). As expected, the SABAS had the highest correlation with the SAS-SV, indicating that the two scales shared approximately 62% variance. Next, SABAS score and entertainment smartphone use correlated strongly and positively, while the correlation with productive use was much lower, although still significant. The correlations of the SABAS score with hours used during a typical weekend and a typical weekday were positive and moderate, with the relationship slightly higher with the duration of smartphone use during the weekend. The correlations between SABAS scores and anxiety and depression scores were also positive and moderate. As expected, the correlation of SABAS scores with worry severity and perceived control over worry was somewhat lower and could be described as low and positive. In addition, SABAS and SAS-SV scores showed a very similar pattern of correlations with other measures. The scores on the SABAS correlated significantly higher with entertainment smartphone use, than with productive use ($Z = 8.90$, $p < 0.001$).

Moderate differences in SABAS scores were observed between the two anxiety and depression groups (Lovibond & Lovibond, 1995). 'Normal to mild' depression group

Table 3 Inter-item correlations and item statistics of the Smartphone Application-Based Addiction Scale ($N = 599$)

Item	Correlation					*M*	*SD*	Item-total	*SMC*	*α* if deleted
	1	2	3	4	5					
1	1					2.44	1.18	.42	.22	.81
2	.32	1				2.22	1.35	.50	.25	.79
3	.23	.35	1			3.15	1.40	.57	.38	.78
4	.32	.40	.54	1		3.25	1.50	.65	.48	.76
5	.42	.38	.47	.42	1	2.11	1.12	.62	.42	.77
6	.30	.39	.48	.61	.54	2.60	1.35	.66	.48	.76

All correlations were significant at $p < .001$ (adjusted using the Benjamini–Hochberg method). *Item-total*, corrected item-total correlation; *SMC*, squared multiple correlation; *α if deleted*, *α* if item is removed from the scale

Table 4 Pearson correlations of Smartphone Application-Based Addiction Scale, Smartphone Addiction Scale–Short Version, smartphone duration use, and purpose of use, anxiety, depression, and aspects of worry ($N = 599$)

	1	2	3	4	5	6	7	8	9	10
1 SABAS	1									
2 SAS-SV	.79***	1								
3 Weekday	.33***	.40***	1							
4 Weekend	.39***	.44***	.64***	1						
5 Entertainment	.52***	.53***	.44***	.47***	1					
6 Productive	.16***	.15***	.21***	.19***	.40***	1				
7 Anxiety	.31***	.35***	.18***	.20***	.23***	.03	1			
8 Depression	.29***	.28***	.09*	.10*	.16***	-.06	.71***	1		
9 Worry severity	.20***	.22***	.14***	.14**	.23***	.11**	.43***	.35***	1	
10 Worry control	.24***	.28***	.07	.09*	.21***	.02	.52***	.49***	.67***	1

p-values were adjusted using the Benjamini–Hochberg method; *SABAS*, Smartphone Application-Based Addiction Scale; *SAS-SV*, Smartphone Addiction Scale–Short Version; *Entertainment*, entertainment use of smartphones; *Productive*, productive use of a smartphone; *Worry severity*, the excessiveness of worrying; *Worry control*, perceived control over worrying

*$p < .05$. **$p < .01$. ***$p < .001$

($N = 498$) had a mean score of 15.10 ($SD = 5.51$) on the SABAS, which was significantly lower compared to the 'moderate to extremely severe' group ($N = 101$), which had a mean score of 18.80 ($SD = 5.48$), $t(144) = 6.14$, $p < 0.001$, $d = 0.67$. As for anxiety, the first group ($N = 457$), had a mean score of 15.0 ($SD = 5.56$) on average, while the second group ($N = 142$) had a mean score of 18.30 ($SD = 5.24$), which were also significantly different, $t(247) = 6.55$, $p < 0.001$, $d = 0.62$. Additionally, the 'high' smartphone use group ($N = 160$), had a mean SABAS score of 18.5 ($SD = 5.67$), which was significantly higher than the 'low' smartphone use group ($N = 151$) average of 12.7 ($SD = 4.93$), $t(307) = 9.71$, $p < 0.001$, with a large effect size, $d = 1.10$.

Study 1: Discussion

Analysis showed that the structure of the SABAS was unidimensional, based on both EFA and CFA analyses. The global fit of the Serbian SABAS was somewhat weak, and a modification needed to be imposed. Errors in Item 4 ('Over time, I fiddle around more and more with my smartphone.') and Item 6 ('If I try to cut the time I use my smartphone, I manage to do so for a while, but then I end up using it as much or more than before.') were allowed to correlate since there is a specific similarity in the content of both items. The similarity of the content between the two items may be more obvious in the Serbian version of the scale. They corresponded with the tolerance and relapse aspects of the addiction, and both items might reflect the decreasing control over smartphone use over time. It should also be noted that in the Arabic study of the SABAS, two pairs of item errors were allowed to correlate (Items 2 and 5, and Items 5 and 6) to improve the fit, and the authors concluded that the unidimensionality was supported (Vally & Alowais, 2022).

The latent variable of smartphone addiction explained the most variance in Item 5, referring to withdrawal symptoms, followed by relapse, tolerance, and mood modification. Exploratory factor analysis indicated that smartphone addiction was best defined by relapse, tolerance, and mood modification, followed by withdrawal. The results of both EFA and CFA suggest that salience and conflict components play a less significant role in defining the construct. It is possible that these two items do not reflect impairing aspects of smartphone use, as do items referring to withdrawal or relapse, for example. Thinking about a smartphone as a particularly important thing in one's life could be considered commonplace nowadays since it makes a broad range of activities possible or much easier to perform. This is not necessarily related to functional impairment.

Similarly, conflicts that arise from because of an individual's smartphone use could be rare nowadays, since peers, elders, and younger individuals use smartphones often in their social circles. If conflicts caused by smartphone use occur, they are probably not very serious or damaging to an individual. The results further suggest that in the Serbian version, there is a considerable covariance between tolerance and relapse that the latent factor could not explain, which resulted in allowing residuals of the items to covary.

Despite the need for model modification, SABAS appears to be a short, reliable, and valid measure for screening the risk of smartphone addiction (i.e., problematic smartphone use). The Serbian translation of the SABAS showed good psychometric properties, including internal consistency, test–retest reliability, homogeneity, and convergent validity. There is also some evidence supporting divergent validity, primarily reflected in a stronger relationship of the SABAS with entertainment use than with productive use. As expected and consistent with previous studies, the SABAS score was closely related to the SAS-SV total score, which is a valid and reliable measure of SA (Harris et al., 2020a).

Furthermore, in line with expectations and the results of previous studies (e.g., Elhai et al., 2017), SABAS scores were moderately and positively related to anxiety and depression, supporting the convergent validity of the scale. The difference in SABAS scores between the lower and higher anxiety/depression groups could be in line with the compensatory internet use theory (Kardefelt-Winther, 2014). Individuals may engage in internet use (or, in this case, smartphone use) to relieve negative moods, and if the motivation to use a specific technology is rooted in escaping real-life problems or compensating for unmet needs, an individual would likely increase the use of technology, for the compensation to take effect (Kardefelt-Winther, 2014). Unfortunately, this coping style maintains and aggravates emotional problems, which can lead to SA/PSU.

Next, correlations of weekday and weekend use in hours with SABAS were similar to correlations of those measures with the SAS-SV in the present study as well as in previous studies (e.g., Nikolic et al., 2022). The moderate strength of the relationship between SA/PSU and the duration of use supports the aforementioned assumption that the frequency or duration of use is not crucial in determining the SA/PSU. Despite this result, in accord with the previous findings, individuals with higher smartphone use also had higher SABAS scores (Tossell et al., 2015), suggesting the scale's ability to discriminate between low and heavy smartphone users. Finally, females had a slightly more pronounced risk of smartphone addiction than males, concurring with findings of previous studies (e.g., De-Sola Gutiérrez et al., 2016).

Study 2: Method

Participants

The English SABAS data were originally collected for a study on hedonic smartphone use (Vujić & Szabo, 2022). Data initially contained 410 responses collected online from English-speaking participants from various countries, but the majority were from Serbia ($N = 335$, 81.7%), and only these data were included in the study. Therefore, the English language was not the participants' native language, but they were required to have a good command of English to participate in the research. In addition, participants were required to be smartphone users and be at least 18 years old. The mean age of this sample was 32.73 years ($SD = 11.09$), and the additional demographic characteristics are presented in Table 5. The participants were recruited online, using *Qualtrics* (Qualtrics, 2022) platform, by sharing the link to the survey on various social networks.

Instruments

Smartphone Application-Based Addiction Scale (SABAS; Csibi et al., 2018) This was the original English version of the scale (see full description in Study 1).

Data analysis

Apart from the descriptive statistics and item correlations, the analysis included CFA with MLR estimation, followed by item analysis, which included the calculation of Cronbach α, ω_{total}, CR, MIC, and AVE. It was expected that among the non-native English speakers, the English SABAS would show a unidimensional structure, good internal consistency, and acceptable AVE and MIC values.

Table 5 Demographic characteristics of the sample in Study 2 ($N = 335$)

Variable	Category	%
Gender	Male	24.78
	Female	75.22
Living with a spouse	With spouse	52.84
	Without spouse	47.16
Education	High school	24.18
	Postgraduate	17.31
	University	58.51
Health	Excellent	20.90
	Good	56.72
	Average	17.91
	Below average	4.18
	Poor	0.30
Living area	Metropolitan area	17.31
	Large town	54.33
	Small town	21.79
	Village	6.57

Study 2: Results

Confirmatory factor analysis and the reliability of the English SABAS

Table 6 shows the raw and standardised loadings and R^2 of the English SABAS CFA model. A single-factor model showed an excellent global fit, $\chi^2(9) = 12.56$, $p = 0.184$, CFI = 0.990, TLI = 0.984, RMSEA = 0.036, SRMR = 0.026. Items 4, 3, and 6 had the highest loadings, while Item 2 (conflict) and Item 1 (salience) had the lowest loading and therefore did not meet the rule of being > 0.50, although all standardised loadings were > 0.40. Mardia's test indicated significant multivariate skewness of the data (154.16, $p < 0.001$), but not kurtosis (0.2416, $p = 0.809$). Henze-Zirkler test suggested that the data did not have a multivariate normal distribution ($HZ = 2.48$, $p < 0.001$).

The English SABAS had a low AVE (0.37), while the CR was 0.76. It should be noted that the participants in Sample 1 ($N = 599$) who completed the Serbian SABAS and the participants in Sample 2 ($N = 335$) who completed the original English SABAS were

Table 6 Factor loadings from confirmatory factor analysis of the English version of the Smartphone Application-Based Addiction Scale

Item	Addiction component	Loading	*S.E*	*z*-value	Std. loading	R^2
1	Salience	1	-	-	.492	.242
2	Conflict	0.895	0.145	6.176	.466	.218
3	Mood modification	1.686	0.222	7.610	.717	.515
4	Tolerance	1.549	0.201	7.705	.719	.517
5	Withdrawal	1.030	0.142	7.258	.515	.265
6	Relapse	1.404	0.195	7.201	.616	.379

All loadings were significant at $p < .001$; *S.E.*, standard error; *Std. loading*, standardised loading different in several aspects. The Study 1 sample was significantly older than Study 2 sample, $t(680) = 9.44$, $p < 0.001$, $d = 0.65$. The effect size could be characterised as medium (Cohen, 1988). Importantly, participants who completed the English SABAS had significantly higher scores, $t(707) = 2.53$, $p = 0.011$, with the effect size being very small, $d = 0.17$.

The reliability of English SABAS was $\alpha = 0.76$ ($\omega_{total} = 0.76$), CR = 0.77, and a MIC = 0.35. The average response on items was 2.79 (*SD* = 0.92). There were no extremely high or low item-total correlations. The most endorsed items were Item 4 (tolerance), Item 3 (mood modification), and Item 6 (relapse). The least endorsed item was Item 2 (conflict). Item correlations and item statistics are shown in Table 7.

Study 2: Discussion

The English version of SABAS showed acceptable psychometric properties when completed by non-native English language speakers from Serbia. Although it had a slightly weaker internal consistency, was less homogenous, and had lower factor loadings in CFA compared to the Serbian SABAS, the English SABAS showed better overall model fit, undoubtedly supporting the unidimensional structure of the scale. However, less than 40% of the item variance was captured by the construct, leaving considerable variance that can be accounted for by error. The reliability of the scale was considered acceptable. Unlike the Serbian SABAS, the latent variable of 'smartphone addiction' in the English SABAS explained the largest amount of variability in Item 4 ('Over time, I fiddle around more and more with my smartphone'), representing tolerance, and Item 3 ('Preoccupying myself with my smartphone is a way of changing my mood, I get a buzz, or I can escape or get away, if I need to'), representing mood modification. It is concluded that, with some caution, the English version of SABAS could be used for quick screening for the risk of smartphone addiction among English speakers whose first language is Serbian.

Table 7 English Smartphone Application-Based Addiction Scale, inter-item correlations and item statistics ($N = 335$)

Item	Correlation					*M*	*SD*	Item-total	*SMC*	α if deleted
	1	2	3	4	5					
1	1					2.56	1.30	.44	.20	.74
2	.28	1				2.11	1.23	.42	.18	.75
3	.32	.29	1			3.15	1.50	.59	.38	.70
4	.36	.32	.54	1		3.24	1.38	.59	.38	.70
5	.33	.25	.39	.32	1	2.56	1.28	.46	.22	.74
6	.27	.34	.44	.44	.31	3.10	1.46	.53	.29	.72

All correlations were significant at $p < .001$ (adjusted using the Benjamini–Hochberg method). *Item-total*, corrected item-total correlation; *SMC*, squared multiple correlation; *α if deleted*, α if item is removed from the scale

General Discussion

The first study evaluated the psychometric properties of the Serbian version of SABAS. The SABAS was translated into the Serbian language since, to the authors' knowledge, regarding PSU, only the SAS-SV was previously back-translated, evaluated, and published (Nikolic et al., 2022). The SABAS differs from SAS-SV because it is based on the components model of addiction, has a transparent theoretical background, and is shorter than the SAS-SV. Therefore, the SABAS validation in the Serbian language is an asset to the Serbian research community.

It is concluded that the results of the present study supported the unidimensionality Serbian SABAS, as well as having good psychometric properties, which is in accordance with previous validations of SABAS in English and other languages (Chen et al., 2020; Csibi et al., 2018; Gökler & Bulut, 2019; Islam et al., 2021; Lin et al., 2019; Nurmala et al., 2022; Soraci et al., 2021; Vally & Alowais, 2022; Yam et al., 2019). This short instrument allows a researcher to assess the risk of smartphone addiction, defined by six components of addiction (Griffiths, 2005).

The second study examined whether English SABAS could be used to screen for SA among individuals from the Serbian population. For this purpose, a subset of the data used in a previous study was also used here. Internal consistency was higher in the Serbian SABAS than in the English SABAS in Study 2, and the former generally showed better psychometric properties than the English version. This finding was expected since in Study 2 the participants did not complete the scale in their native language. Overall findings suggest that Serbian SABAS should be preferred for assessing PSU/SA among individuals who speak Serbian as their first language, but the English version can be used in circumstances where the instrument is administered to English-speaking Serbian participants, for example, in cross-cultural studies.

Limitations and Future Directions

Given the limitations of the two studies, the findings should be treated with caution. For instance, a convenience sample was used, and the data were collected online. Therefore, self-selection bias may be present. Next, only 31.5% of participants took part in the retest due to not giving consent for participation, giving an incorrect ID code, or simply due to not responding. Lastly, in Study 1, the divergent validity of the Serbian version of the SABAS was assessed mainly by comparing the relationship of the SABAS with entertainment and productive use. Future research should consider this and administer a measure that is theoretically completely unrelated to smartphone addiction, as well as thoroughly evaluate the criterion validity of the SABAS.

As for Study 2, a convenience online sample was also used. Additionally, English language proficiency was not controlled, although it was explicitly required in the recruitment text. In other words, how the participants specifically understood the items is not known. Next, in Study 2, the AVE was low, indicating the low average reliability of the English SABAS items when administered to non-native English speakers. This should be considered in future use of the English SABAS on non-native English-speaking populations. Finally, the test–retest reliability should also be evaluated on the English version.

The main practical value of the present study is the translation and validation of a theoretically based measure that can be used for the screening of the risk of smartphone addiction among the Serbian population. Smartphone addiction has the potential to be a diagnostic entity. Therefore, having a brief psychometrically robust validated instrument would be of great importance for practitioners and researchers. The present study also showed that the English version of the SABAS can be used to appraise the risk of smartphone addiction among non-native English speakers from the Serbian population, which could potentially generalise to populations from other cultures as well, making it a useful tool for future cross-cultural studies.

Appendix 1

Questions related to the smartphone use purpose.

Serbian (as presented in the survey)	
Entertainment	Concrete task
Koliko često koristite telefon za zabavu, iz dosade ili iz navike (npr. gledanje video klipova, provođenje vremena na društvenim mrežama, slušanje muzike, surfovanje po Internetu itd.)? Odgovor označite na skali od 1 do 7.	Koliko često koristite telefon da biste ispunili neki konkretan zadatak (npr. komunikacija sa porodicom i prijateljima, plaćanje računa, navigacija, korišćenje telefona u vezi sa poslom ili učenjem itd.)? Odgovor označite na skali od 1 do 7.
English translation	
Entertainment	Concrete task
How often do you use your smartphone for fun, out of boredom or habit (e.g., watching videos, scrolling through social media, listening to music, surfing on the Internet, etc.)? Use the seven-point scale to answer.	How often do you use your smartphone to fulfil a certain task (e.g., communication with friends and family, paying bills, navigation, using a smartphone for work or for study purposes etc.)? Use the seven-point scale to answer.

Appendix 2

Contents of the Serbian and the English Smartphone Application-Based Addiction Scale items.

Item	Component	Serbian	English
1	Salience	Moj telefon mi je najvažnija stvar na svetu.	My smartphone is the most important thing in my life.
2	Conflict	Dešavale su se svađe između mene i moje porodice (ili prijatelja) zbog moje upotrebe telefona.	Conflicts have arisen between me and my family (or friends) because of my smartphone use.
3	Mood modification	Koristim telefon kako bih popravio/la svoje raspoloženje (to mi pruža trenutno zadovoljstvo ili način da pobegnem od realnosti ili problema).	Preoccupying myself with my smartphone is away of changing my mood (I get a buzz, or I can escape or get away, if I need to).
4	Tolerance	Kako vreme prolazi, sve više traćim vreme na svom telefonu.	Over time, I fiddle around more and more with my smartphone.
5	Withdrawal	Ako ne mogu da koristim svoj telefon kada hoću, budem nesrećan/a, razdražljiv/a ili promenljivog raspoloženja.	If I cannot use or access my smartphone when I feel like, I feel sad, moody, or irritable.
6	Relapse	Ukoliko pokušam da smanjim vreme provedeno na telefonu, to mi uspe na neko vreme, posle čega počnem da ga koristim isto toliko često ili čak više nego ranije.	If I try to cut the time I use my smartphone, I manage to do so for a while, but then I end up using it as much or more than before.

Acknowledgements ELTE Eötvös Loránd University is thanked for covering the Open Access fee for this article.

Funding Open access funding provided by Eötvös Loránd University.

Data Availability The data and the R analysis code are available upon request from the first author (vujic.aleksandar@ppk.elte.hu).

Declarations

Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5).

Conflict of Interest The authors declare no competing interests.

References

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.) American Psychiatric Publishing. https://doi.org/10.1176/appi.books.9780890425596

Barkana, Y., Zadok, D., Morad, Y., & Avni, I. (2004). Visual field attention is reduced by concomitant hands-free conversation on a cellular telephone. *American Journal of Ophthalmology, 138*(3), 347–353. https://doi.org/10.1016/j.ajo.2004.04.016

Beaton, D. E., Bombardier, C., Guillemin, F., & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine, 25*(24), 3186–3191. https://doi.org/10.1097/00007632-200012150-00014

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

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

Blötner, C. (2022). diffcor: Fisher's z-Tests Concerning Difference of Correlations. R package version 0.7.2. https://CRAN.R-project.org/package=diffcor

Busch, P. A., & McCarthy, S. (2021). Antecedents and consequences of problematic smartphone use: A systematic literature review of an emerging research area. *Computers in Human Behavior, 114*, 106414. https://doi.org/10.1016/j.chb.2020.106414

Chen, I.-H., Strong, C., Lin, Y.-C., Tsai, M.-C., Leung, H., Lin, C.-Y., Pakpour, A. H., & Griffiths, M. D. (2020). Time invariance of three ultra-brief internet-related instruments: Smartphone Application-Based Addiction Scale (SABAS), Bergen Social Media Addiction Scale (BSMAS), and the nine-item Internet Gaming Disorder Scale- Short Form (IGDS-SF9) (Study Part B). *Addictive Behaviors, 101*, 105960. https://doi.org/10.1016/j.addbeh.2019.04.018

Cho, Y. G. (2020). Excessive and problematic smartphone use and poor mental health in adolescents. *Korean Journal of Family Medicine, 41*(2), 73–74. https://doi.org/10.4082/kjfm.41.2E

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7*(3), 309–311. https://doi.org/10.1037/1040-3590.7.3.309

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates.

Costello, A. B., & Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research, and Evaluation, 10*, 7. https://doi.org/10.7275/JYJ1-4868

Csibi, S., Demetrovics, Z., & Szabó, A. (2016). Development and psychometric validation of the Brief Smartphone Addiction Scale (BSAS) with schoolchidren. *Psychiatria Hungarica: A Magyar Pszichiatriai Tarsasag Tudomanyos Folyoirata, 31*(1), 71–77.
Csibi, S., Griffiths, M. D., Cook, B., Demetrovics, Z., & Szabo, A. (2018). The psychometric properties of the Smartphone Application-Based Addiction Scale (SABAS). *International Journal of Mental Health and Addiction, 16*(2), 393–403. https://doi.org/10.1007/s11469-017-9787-2
De-Sola Gutiérrez, J., Rodríguez de Fonseca, F., & Rubio, G. (2016). Cell-phone addiction: A review. *Frontiers in Psychiatry, 7*, 175. https://doi.org/10.3389/fpsyt.2016.00175
Dinić, B. (2019). *Principi psihološkog testiranja*. Univerzitet u Novom Sadu, Filozofski fakultet. http://digitalna.ff.uns.ac.rs/sadrzaj/2019/978-86-6065-540-2
Elhai, J. D., Dvorak, R. D., Levine, J. C., & Hall, B. J. (2017). Problematic smartphone use: A conceptual overview and systematic review of relations with anxiety and depression psychopathology. *Journal of Affective Disorders, 207*, 251–259. https://doi.org/10.1016/j.jad.2016.08.030
Elhai, J. D., Rozgonjuk, D., Yildirim, C., Alghraibeh, A. M., & Alafnan, A. A. (2019). Worry and anger are associated with latent classes of problematic smartphone use severity among college students. *Journal of Affective Disorders, 246*, 209–216. https://doi.org/10.1016/j.jad.2018.12.047
Ellis, D. A., Davidson, B. I., Shaw, H., & Geyer, K. (2019). Do smartphone usage scales predict behavior? *International Journal of Human-Computer Studies, 130*, 86–92. https://doi.org/10.1016/j.ijhcs.2019.05.004
Emanuel, R., Bell, R., Cotton, C., Craig, J., Drummond, D., Gibson, S., Harris, A., Harris, M., Hatcher-Vance, C., Jones, S., Lewis, J., Longmire, T., Nash, B., Ryans, T., Tyre, E., Walters, D., & Williams, A. (2015). The truth about smartphone addiction. *College Student Journal, 49*(2), 291–299.
Epskamp, S. (2022). semPlot: Path diagrams and visual analysis of various sem packages. R package version 1.1.5. Retrieved from: https://cran.r-project.org/web/packages/semPlot/index.html
Field, A. P., Miles, J., & Field, Z. (2012). *Discovering statistics using R*. Sage.
Flayelle, M., Schimmenti, A., Starcevic, V., & Billieux, J. (2022). The pitfalls of recycling substance-use disorder criteria to diagnose behavioral addictions. In: Heather, N., Field, M., Moss, A. C. & Satel, S. (Eds.), *Evaluating the brain disease model of addiction* (1st ed.) (pp. 339–349). Routledge. https://doi.org/10.4324/9781003032762-34
Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39–59. https://doi.org/10.2307/3151312
Gamer, M., & Lemon, J. (2019). irr: Various coefficients of interrater reliability and agreement. R package version 0.84.1. https://CRAN.R-project.org/package=irr
George, D., & Mallery, P. (2020). *IBM SPSS statistics 26 step by step: A simple guide and reference* (16th ed.). Routledge. https://doi.org/10.4324/9780429056765
Gökler, M., & Bulut, Y. (2019). Validity and reliability of the Turkish version of the Smartphone Application Based Addiction Scale [In Turkish]. *Journal of Cognitive-Behavioral Psychotherapy and Research, 8*(2), 100–106. https://doi.org/10.5455/JCBPR.38288
Griffiths, M. D. (2005). A 'components' model of addiction within a biopsychosocial framework. *Journal of Substance Use, 10*(4), 191–197. https://doi.org/10.1080/14659890500114359
Griffiths, M. D. (2016). Problem gambling and gambling addiction are not the same. *Journal of Addiction and Dependence, 2*(1), 1–3. https://doi.org/10.15436/2471-061X.16.014
Griffiths, M. D., Szabo, A., & Terry, A. (2005). The Exercise Addiction Inventory: A quick and easy screening tool for health practitioners. *British Journal of Sports Medicine, 39*(6), e30–e30. https://doi.org/10.1136/bjsm.2004.017020
Hair, J. F. Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Pearson Prentice Hall. https://doi.org/10.2307/2007941
Harris, B., McCredie, M., & Fields, S. (2020a). Examining the psychometric properties of the Smartphone Addiction Scale and its short version for use with emerging adults in the U.S. *Computers in Human Behavior Reports, 1*, 100011. https://doi.org/10.1016/j.chbr.2020.100011
Harris, B., Regan, T., Schueler, J., & Fields, S. A. (2020b). Problematic mobile phone and smartphone use scales: A systematic review. *Frontiers in Psychology, 11*, 672. https://doi.org/10.3389/fpsyg.2020.00672
Haug, S., Castro, R. P., Kwon, M., Filler, A., Kowatsch, T., & Schaub, M. P. (2015). Smartphone use and smartphone addiction among young people in Switzerland. *Journal of Behavioral Addictions, 4*(4), 299–307. https://doi.org/10.1556/2006.4.2015.037
Hirsch, C. R., & Mathews, A. (2012). A cognitive model of pathological worry. *Behaviour Research and Therapy, 50*(10), 636–646. https://doi.org/10.1016/j.brat.2012.06.007

Hirsch, C. R., Mathews, A., Lequertier, B., Perman, G., & Hayes, S. (2013). Characteristics of worry in generalized anxiety disorder. *Journal of Behavior Therapy and Experimental Psychiatry, 44*(4), 388–395. https://doi.org/10.1016/j.jbtep.2013.03.004

Horwood, S., & Anglim, J. (2019). Problematic smartphone usage and subjective and psychological well-being. *Computers in Human Behavior, 97*, 44–50. https://doi.org/10.1016/j.chb.2019.02.028

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Islam, S., Sujan, S. H., Tasnim, R., Mohona, R. A., Ferdous, M. Z., Kamruzzaman, S., Toma, T. Y., Sakib, N., Pinky, K. N., Islam, R., Siddique, A. B., Anter, F. S., Hossain, A., Hossen, I., Sikder, Md. T., & Pontes, H. M. (2021). Problematic smartphone and social media use among Bangladeshi college and university students amid COVID-19: The role of psychological well-being and pandemic related factors. *Frontiers in Psychiatry, 12*, 647386. https://doi.org/10.3389/fpsyt.2021.647386

Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., & Rosseel, Y. (2021). semTools: Useful tools for structural equation modeling. R package version 0.5–5. Retrieved October 3, 2022. from: https://CRAN.R-project.org/package=semTools

Jovanovic, V., Gavrilov-Jerkovic, V., Zuljevic, D., & Brdaric, D. (2014). Psychometric evaluation of the depression anxiety stress scales-21 (DASS-21) in a Serbian student sample. *Psihologija, 47*(1), 93–112. https://doi.org/10.2298/PSI1401093J

Kardefelt-Winther, D. (2014). Problematizing excessive online gaming and its psychological predictors. *Computers in Human Behavior, 31*, 118–122. https://doi.org/10.1016/j.chb.2013.10.017

Kardefelt-Winther, D. (2017). Conceptualizing Internet use disorders: Addiction or coping process? *Psychiatry and Clinical Neurosciences, 71*(7), 459–466. https://doi.org/10.1111/pcn.12413

Kassambara, A. (2021). rstatix: Pipe-friendly framework for basic statistical tests. R package version 0.7.0. https://CRAN.R-project.org/package=rstatix

Kenny, D. A., Kaniskan, B., & McCoach, D. B. (2015). The performance of RMSEA in models with small degrees of freedom. *Sociological Methods & Research, 44*(3), 486–507. https://doi.org/10.1177/0049124114543236

Kim, D., Lee, Y., Lee, J., Nam, J. K., & Chung, Y. (2014). Development of Korean Smartphone Addiction Proneness Scale for youth. *PloS One, 9*(5), e97920. https://doi.org/10.1371/journal.pone.0097920

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine, 15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Korkmaz, S., Goksuluk, D., & Zararsiz, G. (2014). MVN: An R package for assessing multivariate normality. *The R Journal., 6*(2), 151–162. https://doi.org/10.32614/RJ-2014-031

Kwon, M., Kim, D.-J., Cho, H., & Yang, S. (2013). The Smartphone Addiction Scale: Development and validation of a short version for adolescents. *PloS One, 8*(12), e83558. https://doi.org/10.1371/journal.pone.0083558

Lam, L. W. (2012). Impact of competitiveness on salespeople's commitment and performance. *Journal of Business Research, 65*(9), 1328–1334. https://doi.org/10.1016/j.jbusres.2011.10.026

Lin, Y.-H., Chang, L.-R., Lee, Y.-H., Tseng, H.-W., Kuo, T. B. J., & Chen, S.-H. (2014). Development and validation of the Smartphone Addiction Inventory (SPAI). *PloS One, 9*(6), e98312. https://doi.org/10.1371/journal.pone.0098312

Lin, Y.-H., Chiang, C.-L., Lin, P.-H., Chang, L.-R., Ko, C.-H., Lee, Y.-H., & Lin, S.-H. (2016). Proposed diagnostic criteria for smartphone addiction. *PloS One, 11*(11), e0163010. https://doi.org/10.1371/journal.pone.0163010

Lin, C.-Y., Imani, V., Broström, A., Nilsen, P., Fung, X. C. C., Griffiths, M. D., & Pakpour, A. H. (2019). Smartphone application-based addiction among Iranian adolescents: A psychometric study. *International Journal of Mental Health and Addiction, 17*(4), 765–780. https://doi.org/10.1007/s11469-018-0026-2

Lopez-Fernandez, O., Kuss, D. J., Romo, L., Morvan, Y., Kern, L., Graziani, P., Rousseau, A., Rumpf, H.-J., Bischof, A., Gässler, A.-K., Schimmenti, A., Passanisi, A., Männikkö, N., Kääriänen, M., Demetrovics, Z., Király, O., Chóliz, M., Zacarés, J. J., Serra, E., … Billieux, J. (2017). Self-reported dependence on mobile phones in young adults: A European cross-cultural empirical survey. *Journal of Behavioral Addictions*, *6*(2), 168–177. https://doi.org/10.1556/2006.6.2017.020

Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety Stress Scale*. The Psychological Foundation of Australia.

Mason, A., Winter, T., Riordan, B. C., Griffiths, M. D., & Scarf, D. (2022). Evaluation of the English version of the Smartphone Application Based Addiction Scale (SABAS) among an adolescent sample. *Psych, 4*, 961–968. https://doi.org/10.3390/psych4040071

McMurran, M. (1994). *The psychology of addiction*. Taylor & Francis.

Navarro-Gonzalez D. & Lorenzo-Seva U. (2021). EFA.MRFA: Dimensionality assessment using minimum rank factor analysis. R package version 1.1.2. Retrieved from https://CRAN.Rproject.org/package=EFA.MRFA

Nikolic, A., Bukurov, B., Kocic, I., Soldatovic, I., Mihajlovic, S., Nesic, D., Vukovic, M., Ladjevic, N., & Grujicic, S. S. (2022). The validity and reliability of the Serbian version of the Smartphone Addiction Scale-Short version. *International Journal of Environmental Research and Public Health, 19*(3), 1245. https://doi.org/10.3390/ijerph19031245

Nurmala, I., Nadhiroh, S. R., Pramukti, I., Tyas, L. W., Zari, A. P., Griffiths, M. D., & Lin, C.-Y. (2022). Reliability and validity study of the Indonesian Smartphone Application-Based Addiction Scale (SABAS) among college students. *Heliyon, 8*(8), e10403. https://doi.org/10.1016/j.heliyon.2022.e10403

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

Qualtrics (2022). Survey research suite: Research coreTM. Provo, Utah, USA. February 2022. http://www.qualtrics.com

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Revelle, W. (2022). psych: Procedures for personality and psychological research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych version = 2.2.3.

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Ryu, C. (2022). dlookr: Tools for data diagnosis, exploration, transformation. R package version 0.6.0. Retrieved from https://CRAN.R-project.org/package=dlookr

Sohn, S. Y., Rees, P., Wildridge, B., Kalk, N. J., & Carter, B. (2019). Prevalence of problematic smartphone usage and associated mental health outcomes amongst children and young people: A systematic review, meta-analysis and GRADE of the evidence. *BMC Psychiatry, 19*(1), 356. https://doi.org/10.1186/s12888-019-2350-x

Sojević, M., Pećanac, D., & Latas, M. (2018). Connection of depression, anxiety and impulsivity with the way of using modern mobile phones among students. *Medicinski Podmladak, 69*(4), 27–34. https://doi.org/10.5937/mp69-17929

Soraci, P., Ferrari, A., Antonino, U., & Griffiths, M. D. (2021). Psychometric properties of the Italian version of the Smartphone Application-Based Addiction Scale (SABAS). *International Journal of Mental Health and Addiction, 19*(4), 1261–1273. https://doi.org/10.1007/s11469-020-00222-2

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87*(2), 245–251.

Szabo, A., & Demetrovics, Z. (2022). Passion and addiction in sports and exercise. *Routledge*. https://doi.org/10.4324/9781003173595

Thomée, S., Härenstam, A., & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study. *BMC Public Health, 11*, 66. https://doi.org/10.1186/1471-2458-11-66

Tossell, C., Kortum, P., Shepard, C., Rahmati, A., & Zhong, L. (2015). Exploring Smartphone Addiction: Insights from Long-Term Telemetric Behavioral Measures. *International Journal of Interactive Mobile Technologies, 9*(2), 37. https://doi.org/10.3991/ijim.v9i2.4300

Vally, Z., & Alowais, A. (2022). Assessing risk for smartphone addiction: Validation of an Arabic version of the Smartphone Application-Based Addiction Scale. *International Journal of Mental Health and Addiction, 20*(2), 691–703. https://doi.org/10.1007/s11469-020-00395-w

van Deursen, A. J. A. M., Bolle, C. L., Hegner, S. M., & Kommers, P. A. M. (2015). Modeling habitual and addictive smartphone behavior. *Computers in Human Behavior, 45*, 411–420. https://doi.org/10.1016/j.chb.2014.12.039

van der Loo, M. P. J. (2014). The stringdist package for approximate string matching. *R Journal, 6*(1), 111–122. https://cran.r-project.org/web/packages/stringdist/index.html

Vujić, A., & Szabo, A. (2022). Hedonic use, stress, and life satisfaction as predictors of smartphone addiction. *Addictive Behaviors Reports, 15*, 100411. https://doi.org/10.1016/j.abrep.2022.100411

White, M. P., Eiser, J. R., & Harris, P. R. (2004). Risk perceptions of mobile phone use while driving. *Risk Analysis, 24*(2), 323–334. https://doi.org/10.1111/j.0272-4332.2004.00434.x

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D.,

Seidel, D., Spinu, V., … Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software, 4*(43), 1686. https://doi.org/10.21105/joss.01686
Yam, C.-W., Pakpour, A. H., Griffiths, M. D., Yau, W.-Y., Lo, C.-L.M., Ng, J. M. T., Lin, C.-Y., & Leung, H. (2019). Psychometric testing of three Chinese online-related addictive behavior instruments among Hong Kong university students. *Psychiatric Quarterly, 90*(1), 117–128. https://doi.org/10.1007/s11126-018-9610-7
Yu, S., & Sussman, S. (2020). Does smartphone addiction fall on a continuum of addictive behaviors? *International Journal of Environmental Research and Public Health, 17*(2), 422. https://doi.org/10.3390/ijerph17020422
Zhang, K. Z. K., Chen, C., & Lee, M. K. O. (2014). Understanding the role of motives in smartphone addiction. *Pacific Asia Conference on Information Systems*, 18.
Zhang Y, Zhou M, Shao Y. (2020). mvnormalTest: Powerful tests for multivariate normality. R package version 1.0.0. https://CRAN.R-project.org/package=mvnormalTest

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Aleksandar Vujić[1,2] · Marija Volarov[3] · Milan Latas[4] · Mark D. Griffiths[5] · Attila Szabo[1,2,6]

[1] Doctoral School of Psychology, Faculty of Education and Psychology, ELTE Eötvös Loránd University, Budapest, Hungary

[2] Institute of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary

[3] Department of Psychology, Faculty of Sport and Psychology, Educons University, Novi Sad, Serbia

[4] Faculty of Medicine, University of Belgrade, Belgrade, Serbia

[5] International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK

[6] Institute of Health Promotion and Sport Sciences, ELTE Eötvös Loránd University, Budapest, Hungary