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Further exploration of the psychometric properties of the revised version of the Italian smartphone addiction scale – short version (SAS-SV)

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Abstract
Problematic smartphone use (PSU) is an emerging public and social issue, potentially connected to the significant increase in smartphone applications. Different scales have been designed and developed to identify the risk of smartphone addiction, and the 10-item Smartphone Addiction Scale - Short Version (SAS-SV) is one of the most used instruments to assess the risk of PSU. The main objective of the present study was to provide further psychometric properties of the Italian version of the SAS-SV. The study was conducted with a convenience sample of 858 Italian university students. Parallel and confirmatory factor analyses were performed to confirm if the one-factor structure fitted the data well. In addition, because previous studies have emphasised gender and age differences in the SAS-SV, measurement invariance was also tested. Network analysis, predictive validity, and convergent validity were also explored. The parallel analysis results suggested removing Item 3 (feeling pain) because its factor loading was low, resulting in a nine-item SAS-SV. The measurement invariance showed that the SAS-SV performed similarly for gender and age. However, partial scalar invariance across gender and age was observed. Furthermore, gender differences indicated that more females than males scored higher on SAS-SV. No significant age differences were found. The receiver operating characteristic (ROC) curve results indicated a cut-off of 29 points as the best for the SAS-SV (AUC = 0.85). Moreover, among males, the cut-off was 25 (AUC = 0.84), and among females, the cut-off was 30 (AUC = 0.84). The SAS-SV showed a strong association with problematic social media use (PSMU) and other variables related to smartphone use (e.g., time spent on *Facebook, Instagram*, and *WhatsApp*). Overall, the present study results indicate that the nine-item SAS-SV appears to be a valid and reliable instrument to assess PSU risk among Italian university students.

Keywords Problematic smartphone use · Smartphone addiction · Smartphone addiction scale · University students · Psychometrics · Network analysis

Introduction

Smartphones have become a popular technological device through which individuals can communicate, process, and share information and access the internet via various mobile applications. Given the increasing awareness concerning technology-related addictions, the extant literature has reported negative consequences of smartphone overuse, including an association with anxiety and depression (Elhai et al., 2017), as well as social problems, such as low-income

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family and peer relationships (e.g., Hawi & Samaha, 2019; Wang et al., 2017), potentially fatal injuries from traffic accidents (Kim et al., 2017), and problematic social media use (e.g., Rozgonjuk et al., 2018).

The construct of problematic smartphone use (PSU) has been much debated, particularly its conceptualization as a behavioural addiction (see Busch & McCarthy, 2021, for a review). Due to insufficient support from an addiction framework (Panova & Carbonell, 2018), some researchers have identified the disorder as 'problematic smartphone use' rather than 'smartphone addiction' (SA). According to Kuss and Griffiths (2017), SA might best be used as an umbrella term (like 'internet addiction') to describe the totality of problematic smartphone behaviours rather than the addiction to the physical device itself.

Moreover, a newly revised taxonomy underlying Internet Use Disorders (IUDs) by Montag and colleagues (Montag et al., 2021) defined smartphone use disorder (SmUD)/problematic smartphone use (PSU) as a specific 'mobile form' of IUD and referred to excessive smartphone use as PSU rather than SA. In the present study, and in line with previous researchers, the term 'problematic smartphone use' is used to indicate a compulsive and dependent smartphone use that interferes with users' daily lives (Billieux et al., 2015; Elhai et al., 2019; Huang et al., 2021; Panova & Carbonell, 2018). Although PSU has not yet been considered a specific mental health disorder in the latest (fifth) edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013), prior research focused on the development and adaptation of screening instruments designed to examine specific patterns of the problematic use with clinical symptoms among adolescents and young adults, as well as to identify those most vulnerable to PSU (e.g., Fryman & Romine, 2021; Harris et al., 2020a). The results of a recent systematic review identified 78 different scales developed to assess, identify, or characterize the risk of smartphone addiction and/or PSU, which have evaluated their theoretical foundation and psychometric properties (Harris et al., 2020b). However, despite the richness of self-report instruments devoted to assessing the construct, most developed scales lack sufficient reliability and test-retest consistency.

One of the most used scales in this research field is the Smartphone Addiction Scale (SAS) (Kwon et al., 2013b), which was developed in South Korea. The original SAS version includes 33 items assessing six factors (daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance). Moreover, to reduce the burden on respondents, the SAS was shortened to 10 items (SAS-SV; Kwon et al., 2013a), which has already been validated in different international samples, including French-speaking Belgian and Spanish adults (Lopez-Fernandez, 2017), Italian adolescents and young adults (De Pasquale et al., 2017), Moroccan adults (Sfendla et al., 2018), Chinese adults (Luk et al., 2018), Egyptian adolescents (Fathalla, 2019), Indonesian junior high school students (Arthy et al., 2019), Pakistani colleges and university students (Khalily et al., 2019), Chinese children and adolescents in Hong Kong (Cheung et al., 2019), Iranian adolescents (Fallahtafti et al., 2020), Brazilian university students and general adult population adults (Andrade et al., 2020), Mexican university students (Escalera-Chávez & Rojas-Kramer, 2020), American adults (Harris et al., 2020a), and Serbian medical students (Nikolic et al., 2022).

According to Lopez-Fernandez (2017), the SAS-SV includes 10 items assessing the risk of six-related PSU symptoms: 'loss of control' (Items 1 and 8), 'disruption' (Items 2 and 10), 'disregard' (Items 3 and 7), 'withdrawal' (Items 4 and 5), 'preoccupation' (Item 6), and 'tolerance' (Item 9). These criteria were established based on the symptoms of dependence on substance use and disorders related to pathological gambling from the DSM-III and DSM-IV (Andrade et al., 2020; Lopez-Fernandez, 2017).

Within the Italian context, De Pasquale et al. (2017) initially explored the factor structure of the SAS-SV using a sample comprised predominantly of adolescents with a mean age of 18 years. The confirmatory factor analysis results indicated that Item 1 (missing work), Item 2 (hard time concentrating), and Item 3 (feeling pain) exhibited low factor loadings and item-total correlation, indicating the need to conduct more robust statistical analyses. However, no further Italian studies have been carried out on samples of emerging adults (i.e., young adults aged over 18 years). Moreover, because the preliminary Italian study has assessed only the reliability coefficients of the SAS-SV, this does not mean that the items are related to the construct or possess the established validity (Harris et al., 2020a). Finally, the psychometric evaluation of the Italian adaptation of the SAS-SV did not examine either convergent or divergent validity. Therefore, the purpose of the present study was to address these gaps by providing more robust validity evidence for the Italian version of the SAS-SV.

Based on the extant literature, the present study was expected to confirm the original one-factor structure of the SAS-SV because it is the most prevalent factor solution reported (H_1). Regarding smartphone use, the results of a recent systematic literature review reported inconsistent findings in the relationship between PSU and sociodemographic variables such as gender and age (Busch & McCarthy, 2021). Moreover, it was expected that females would have higher PSU scores than males (H_2) (Casale et al., 2021; Cheung et al., 2019; Servidio et al., 2021b; Sfendla et al., 2018). To date, although several prior studies have explored gender differences in PSU, results are still inconclusive, as suggested in a recent review (Busch & McCarthy, 2021). Therefore, the present study also tested the scale's

measurement invariance. This step is essential given the number of prior psychometric studies that have validated the SAS-SV but have overlooked gender and age-related measurement issues. Moreover, to better explore the psychometric properties of the Italian version of the SAS-SV, a network analysis was performed to evaluate the strength of the associations between items. This statistical approach was adopted in a previous SAS-SV validation study (i.e., Andrade et al., 2020).

Regarding the predictive validity of the SAS-SV, a Receiver Operating Characteristics (ROC) analysis was conducted. However, no specific predictions were made about the cut-offs of the scale because no previous studies in the Italian context have ever explored the diagnostics of the scale. Finally, the convergent validity of the SAS-SV was tested through its relationship with problematic social media use (PSMU) and other related variables (e.g., use of *Facebook, Instagram*, and *WhatsApp*). Positive associations between PSU and these variables were expected (H_3). It has previously been demonstrated that smartphones and social media are inextricably related because of the social component in contemporary smartphone use (Cleary et al., 2020; Kuss & Griffiths, 2017) and other related variables.

Method

Participants and procedure

An initial sample of 867 Italian-speaking university students was mainly recruited online and in-person during university lectures. At the end of the data cleaning procedures, the final sample size comprised 858 participants aged 18 and 43 years ($M = 22.68$, $SD = 3.70$; 72.1% females). After informing participants that taking part in the study was voluntary and anonymous, they provided informed consent according to the Helsinki declaration, the ethical rules of the Italian Psychological Association, as well as formal approval by the research team's university ethics committee.

Measures

The survey included socio-demographic questions concerning gender, age, and daily time spent on *Facebook, Instagram*, and *WhatsApp* via their smartphones.

The short Italian version of the Smartphone Addiction Scale (SAS-SV) was used to assess smartphone addiction risk (De Pasquale et al., 2017; original version: Kwon et al., 2013a). The SAS comprises ten items (e.g., *"Having my smartphone in my mind even when I am not using it"*) concerning daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationships, overuse, and tolerance. Each item is rated on a six-point Likert-type scale from 1 (*strongly disagree*) to 6 (*strongly agree*). A total score is computed, with higher scores indicating greater problematic smartphone use. In the present study, the scale showed good internal consistency: McDonald's $\omega = 0.799$, $M = 2.63$, $SD = 0.56$, 95% CI [0.79, 0.82], and Cronbach's $\alpha = 0.801$, $M = 2.63$, $SD = 0.56$, 95% CI [0.78, 0.82].

The Italian version of the Bergen Social Media Addiction Scale (BSMAS) was used to assess problematic social media use (Monacis et al., 2017; original version: Andreassen et al., 2016). The instrument comprises six items (e.g., *"How often during the last year have you tried to cut down on the use of social media without success?"*) reflecting core addiction elements (i.e., salience, mood modification, tolerance, withdrawal, conflict, and relapse) (Griffiths, 2005). Each item is rated on a five-point Likert-type scale from 1 (*very rarely*) to 5 (*very often*). A total score is calculated, with higher scores indicating a greater risk of problematic social media use. In the present study, the scale showed good internal consistency: McDonald's $\omega = 0.74$, $M = 2.17$, $SD = 0.50$, 95% CI [0.71, 0.76], and Cronbach $\alpha = 0.73$, $M = 2.17$, $SD = 0.50$, 95% CI [0.71, 0.76].

Data analysis

Statistical analyses included the following steps: (i) data cleaning was performed. The response to the items of the main variables was required to progress in the online survey, and therefore, there were no missing data; (ii) univariate normality of the SAS-SV was assessed by examining skewness and kurtosis values for each item. Nine participants on the SAS-SV had absolute values of skewness > 3.0 and kurtosis > 8.0 and were therefore removed from the data analysis (final sample size for all subsequent analyses comprised 858 participants); (iii) to explore whether the assumption of multivariate normality was met, the Mardia index of multivariate skewness and kurtosis was computed. The Mardia's skewness index for the collected data was 8.13, and the Mardia's kurtosis was 130.34, indicating that data were not multivariate normally distributed (Mardia, 1970).

Other statistical analyses involved: (i) descriptive statistics of the sample characteristics, and patterns of problematic smartphone use and problematic social media use; (ii) parallel factor analysis (PFA) with optimal implementation was run to ascertain the suitability of the data for the subsequent statistical analyses; (iii) confirmatory factor analysis (CFA). Given the ordinal nature of SAS-SV items, diagonal weighted least squares (DWLS) was used as a parameter estimation method, which produces more accurate estimates (Li, 2016) to ascertain the model fit of the factorial structure of the SAS-SV. For the CFA, multiple indices (Hu & Bentler, 1999) were used to evaluate the model fit (adopted cut-offs in parentheses): the chi-square (χ^2) test value with the associated p-value ($p > 0.05$), comparative fit

index (CFI ≥ 0.95), Tucker-Lewis Index (TLI ≥ 0.95), root-mean-squared error of approximation (RMSEA ≤ 0.06) and its 90% confidence interval, and standardized root mean square residual (SRMR < 0.08); (iv) reliability of the SAS was evaluated using two different indicators of internal consistency (McDonald's ω and Cronbach's alpha); (v) multigroup confirmatory factor analysis (MG-CFA) (van de Schoot et al., 2012) was performed to test measurement invariance across gender and age groups on a set of nested models. The analysis included configural, metric, and scalar invariance. According to Cheung and Rensvold (2002), invariance can be assumed when the value is 0.01 or less, in absolute values. Because the χ^2 difference is sensitive to model complexity and sample size, the comparison of two nested models is recommended using cut-offs values of ΔCFI < 0.01 and ΔRMSEA < 0.015 for metric and scalar invariances (Chen, 2007); (vi) network analysis was used to estimate which items were grouped through their correlation strength (internal consistency). The analysis was performed using EBICglasso estimator (Extended Bayesian Information Criterion Graphical Least Absolute Shrinkage and Selection Operator) with at least absolute shrinkage and selection operator (LASSO) regularization method to estimate a network of partial correlations between items. This method allows small edge weights to shrink to zero to avoid the multiplicity problem with spurious correlations for a parsimonious network (Epskamp et al., 2018). Blue lines represent positive partial correlations between nodes/variables, while orange lines represent negative partial correlations. Thicker edges show stronger correlations, and the thinner edges indicate weaker correlations. Three measures of centrality were assessed in the present study: (a) betweenness: to identify the connection strength between two items; (b) closeness: to identify the proximity between two items in the network; and (c) degree: to identify the number of connections each node has based on all possible links; (vii) predictive validity was analysed by comparing the total score of the SAS-SV with the total score of the BSMAS using the Receiver Operating Characteristics (ROC) analysis. The SAS-SV scores were compared with the BSMAS classification based on the proposed cut-off of 19 (Bányai et al., 2017), which identifies the risk of problematic social media use. More specifically, the area under the curve (AUC) measures the performance to classify smartphone use as problematic. Further analysis computed the deciles to identify the baseline of the PSU risk. Therefore, participants who scored in the 90th percentile can be classified at risk of PSU at baseline; and (viii) convergent validity was analysed using Pearson correlational analysis between the total SAS-SV scores, the BSMAS scores, and time spent on *Facebook, Instagram*, and *WhatsApp.*

Descriptive analyses were performed using SPSS version 26. The exploratory factor analysis was computed with the Software Factor version 11.05 (Lorenzo-Seva & Ferrando, 2006). Confirmatory factor analysis and invariance measurement were conducted using the *lavaan* R-package (Rosseel, 2012). Estimates and plots from the network analysis were performed with JASP version 0.16, and with R-packages *bootnet*, *qgraph* (Epskamp et al., 2012). *NetworkComparisonTest* (van Borkulo et al., 2016) was used to test the invariant network structure, the invariant edge strength, and the invariant global strength between groups (Epskamp et al., 2018). The R package *pRoc* was used to compute the ROC curve (Robin et al., 2011).

Results

Descriptive statistics

The current results showed that females (total score: 24.69, $SD = 8.28$) scored higher on the SAS-SV than males (total score: 22.91, $SD = 7.56$), which were significantly different: $t(856) = -2.87$, $p < 0.01$, $d = -0.22$. The average time spent per day on smartphone social applications was 2.11 h on *Facebook* ($M_{male} = 1.50$, $M_{female} = 2.33$), 3.11 h on *Instagram* ($M_{male} = 1.83$, $M_{female} = 3.59$), and 5.45 h on *WhatsApp* ($M_{male} = 3.69$, $M_{female} = 6.11$). As for age, the scores obtained on SAS-SV were 24.36 ($SD = 8.08$) for young adults and 23.65 ($SD = 8.25$) for adults, respectively, indicating no statistically significant differences ($p = 0.28$).

Parallel factor analysis

The Bartlett test indicated a significant correlation between the ten items of the SAS-SV: $\chi^2(45) = 2.323.15$, $p < 0.001$, and the KMO criterion was also good (0.81). The communalities suggested that each item shared some common variance with the other scale items and ranged from 0.31 to 0.77. The cumulative proportion of variance was 0.48%. Factor loadings varied between 0.47 and 0.70. Following the rule in exploratory factor analysis, items with factor loadings < 0.40 were not retained (Kline, 2016). More specifically, all the SAS-SV items loaded 0.47 or higher except for Item 3 (0.33; *"Feeling pain in the wrists or at the back of the neck while using a smartphone"*), which was excluded for the subsequent analyses (see Table 1). Therefore, the parallel factor analysis results indicated that nine out of ten items assessed the same latent construct and were suitable for the CFA.

Confirmatory factor analysis and reliability

A CFA was run to assess the adequacy of the one-factor solution with nine items. The results provided an unsatisfactory fit to the data, χ^2 (27, $N = 858$) = 325.83, $p < 0.001$, CFI = 0.904, TLI = 0.873, RMSEA = 0.114, 90% CI [0.10,

Table 1 Descriptive statistics, factor loadings and reliability of the Italian short version of the Smartphone Addiction Scale-Short Form

Item	*M*	*SD*	Item loading	Corrected item-total *r*	α if item deleted	ω if item deleted
1. ENG: Missing planned work due to smartphone use ITA: Non riesco a fare un lavoro pianificato a causa dell'utilizzo dello smartphone	2.62	1.51	0.47	0.40	0.79	0.80
2. ENG: Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use ITA: Ho difficolta di concentrazione in classe, mentre si fanno i compiti o mentre si sta lavorando, a causa dell'utilizzo dello smartphone	2.61	1.48	0.58	0.49	078	0.79
3. ENG: Feeling pain in the wrists or at the back of the neck while using a smartphone ITA: Sento dolore ai. polsi, alla schiena o al collo mentre uso lo smartphone	2.12	1.39	0.33	0.29	0.80	0.81
4. ENG: Won't be able to stand not having a smartphone ITA: Non sarei capace di resistere senza uno smartphone	3.57	1.59	0.57	0.46	0.78	0.79
5. ENG: Feeling impatient and fretful when I am not holding my smartphone ITA: Mi sento impaziente ed irritabile quando non ho il mio smartphone	2.31	1.33	0.71	0.56	0.77	0.78

Table 1 (continued)

Item	*M*	*SD*	Item loading	Corrected item-total *r*	α if item deleted	ω if item deleted
6. ENG: Having my smartphone in my mind even when I am not using it ITA: Ho il mio smartphone in mente anche quando non lo sto usando	1.89	1.12	0.62	0.54	0.78	0.78
7. ENG: I will never give up using my smartphone even when my daily life is already greatly affected by it ITA: Non rinuncerei mai all'uso del mio smartphone dal momento che la mia vita quotidiana è molto influenzata da esso	2.51	1.37	0.65	0.53	0.78	0.78
8. ENG: Constantly checking my smartphone so as not to miss conversations between other people on *Twitter* or *Facebook* ITA: Controllo costantemente il mio smartphone in modo da non perdere le conversazioni tra le altre persone su *Twitter* o *Facebook*	2.46	1.48	0.52	0.46	0.78	0.79
9. ENG: Using my smartphone longer than I had intended ITA: Uso il mio smartphone più a lungo di quanto dovrei	3.64	1.55	0.56	0.51	0.78	0.79

Table 1 (continued)

Item	*M*	*SD*	Item loading	Corrected item-total *r*	α if item deleted	ω if item deleted
10. ENG: The people around me tell me that I use my smartphone too much	2.60	1.56	0.60	0.54	0.77	0.78
ITA: Le persone intorno a me mi dicono che uso troppo il mio smartphone						

SD = standard deviation. Item loadings are based on the results of the parallel factor analysis. The results from the analysis showed good values of reliability (Item 3 was not computed): Cronbach's α was 0.803, and McDonald's ω was 0.808

0.12], SRMR = 0.096. After the analysis, the modification fit indices (Byrne, 2012) suggested the inclusion of the correlation between error terms for Item 1 and Item 2 (MI = 153.22), Item 1 and Item 9 (MI = 34.31), and Item 9 and Item 10 (MI = 38.62). The results of the new analysis indicated an improvement in the fit of the model, χ^2 (24, N = 858) = 98.31, $p < 0.001$, CFI = 0.976, TLI = 0.964, RMSEA = 0.060, 90% CI [0.05, 0.073], SRMR = 0.052. All item factor loadings were significantly positive ($p < 0.001$), with standardized coefficients ranging from 0.27 to 0.69, on the latent factor. The results of the reliability analyses are shown in Table 1.

Multigroup confirmatory factor analysis

Two measurement invariance analyses were performed on the Italian short version of the nine-item SAS-SV. The first model for gender was tested by estimating the SAS-SV model separately for males and females and the second for age (young adults vs. adults). The fit indices of the unconstrained models (see Table 2) indicated configural invariance across gender, χ^2 (48, N = 858) = 109.95, $p < 0.001$, CFI = 0.980, TLI = 0.970, RMSEA = 0.055, 90% CI [0.041, 0.068], SRMR = 0.050 and age, χ^2 (48, N = 858) = 107.00, $p < 0.001$, CFI = 0.981, TLI = 0.972, RMSEA = 0.054, 90% CI [0.040, 0.067], SRMR = 0.050, and therefore a satisfactory fit for both groups. Given the lack of scalar invariance, the possibility of partial invariance was evaluated, as recommended by Byrne (2012). The modification indices (MI) for the inter-group intercept constraints from the scalar model were explored to identify if any specific constraints were notably contributing to the lack of fit. The MI suggested that for gender, Item 7 and Item 8 were statistically significant, whereas Item 1 was significant for age. Therefore, two partial invariance models were estimated, including the relaxing of the items mentioned above. Overall, except for Item 1, Item 7, and Item 8, the result suggested that both gender and age had the same basic conceptualization of problematic smartphone use and interpreted the items similarly.

Network analysis

The EBICglasso domain-level network of the Italian short version of the nine-item of SAS-SV is shown in Fig. 1. The network's colour was based on the six symptoms proposed by Lopez-Fernandez (2017). Most of the items (nodes) exhibited positive correlations, indicating that the increase in the score of one item led to an increase in the scores of other scale items. The withdrawal symptoms (S4 and S5) showed a weak correlation in both groups (r_{male} = 0.17; r_{female} = 0.26). The nodes S1 and S8 (*loss of control*) were weakly related among males (r = 0.12), but not in females

Table 2 Fit indices for multi-group confirmatory factor analysis evaluating measurement invariance of the one-factor structure of the Italian short version of the Smartphone Addiction Scale-Short Form

Model	χ^2	df	$\Delta\chi^2(\Delta df)$	Δdf	CFI	TLI	RMSEA	SRMR	ΔCFI
Male: base model	27.85	24	-	-	0.999	0.991	0.026	0.055	-
Female: base model	82.09	24	-	-	0.976	0.964	0.062	0.056	-
Configural invariance	109.95	48	-	-	0.980	0.970	0.055	0.050	-
Metric invariance	122.31	56	$12.34^{(ns)}$	8	0.979	0.973	0.053	0.053	-0.001
Scalar[a] invariance	163.73	64	31.06^{***}	2	0.968	0.964	0.060	0.060	-0.001
Partial scalar invariance	132.66	62	$10.35^{(ns)}$	6	0.977	0.974	0.052	0.055	-0.002
Young adults (18–25 years): base model	87.16	24	-	-	0.974	0.961	0.063	0.056	-
Adults (26–50 years): base model	18.83	24	-	-	1.00	1.00	0.000	0.049	-
Configural invariance	107.00	48	-	-	0.981	0.972	0.054	0.050	-
Metric invariance	114.93	56	$7.93^{(ns)}$	8	0.981	0.976	0.050	0.052	0.000
Scalar[b] invariance	133.10	64	7.95^{**}	1	0.978	0.975	0.050	0.055	-0.001
Partial scalar invariance	125.15	63	$10.21^{(ns)}$	7	0.980	0.977	0.048	0.054	-0.001

$^{**}p < 0.01$. $^{***}p < 0.001$

ns = not significant. [a]Releasing constrained intercepts: Items 7 and item 8. [b]Releasing constrained intercept: Item 1

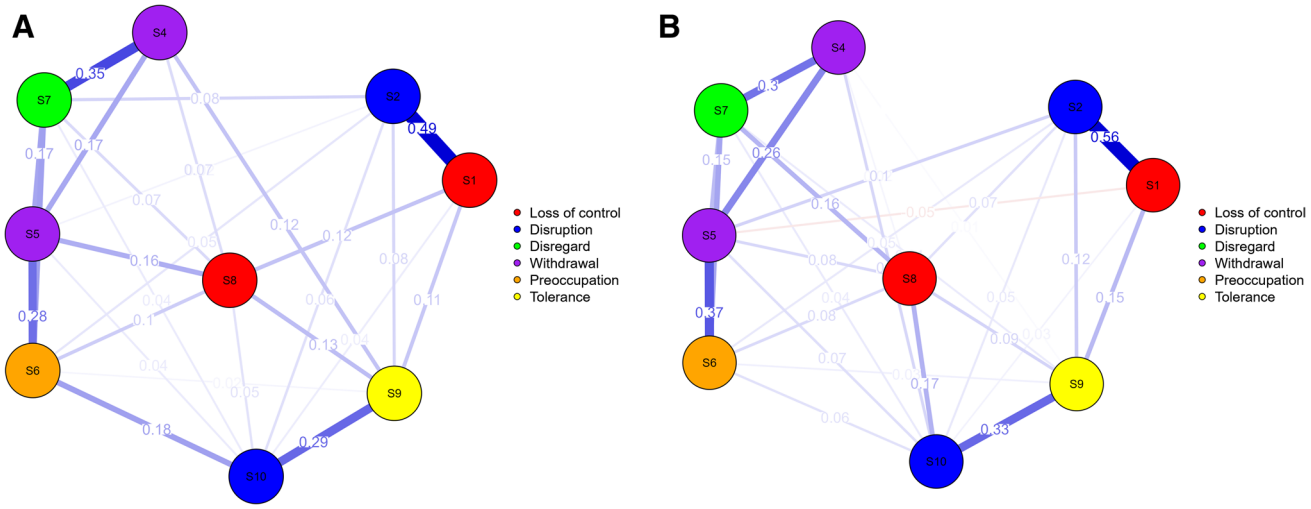

Fig. 1 EBICGlasso network structure of the nine-item of the Italian version of the SAS-SV. **a** Male. **b** Female

($r = 0.00$). The remaining nodes underlying each symptom showed poor associations.

Significant associations were observed between nodes underlying different symptoms: the nodes S5 (*Feeling impatient and fretful when I am not holding my smartphone*) and S6 (*Having my smartphone in my mind even when I am not using it*) ($r_{male} = 0.28$; $r_{female} = 0.37$), which evaluated respectively symptoms of withdrawal and preoccupation, showed a strong correlation, probably due to their cognitive content. Furthermore, the nodes S4 (*Won't be able to stand not having a smartphone*) and S7 (*I will never give up using my smartphone even when my daily life is already greatly affected by it*) which assessed symptoms of withdrawal and disregard for the physical or psychological consequences due to the smartphone use respectively, were significantly associated ($r_{male} = 0.35$; $r_{female} = 0.30$). This association underlined the role of withdrawal symptoms in the risk of developing behavioural addictions. Finally, the nodes S9 (*Using my smartphone longer than I had intended*) and S10 (*The people around me tell me that I use my smartphone too much*), which evaluated symptoms of tolerance and family/work/school disruption respectively, were significantly associated ($r_{male} = 0.29$; $r_{female} = 0.33$).

The strength of correlations amongst males (Fig. 1a) was between nodes S1 and S2 ($r = 0.49$), nodes S4 and S7 ($r = 0.35$), nodes S5 and S6 ($r = 0.28$), nodes S4 and S5 ($r = 0.17$), and nodes S9 and S10 ($r = 0.29$). Among females (Fig. 1b), the strongest correlations were between nodes S1 and S2 ($r = 0.56$), nodes S4 and S7 ($r = 0.30$), nodes S6 and S5 ($r = 0.37$), nodes S4 and S5 ($r = 0.26$), and nodes S9 and S10 ($r = 0.33$). According to the centrality plot (Fig. 2), Item

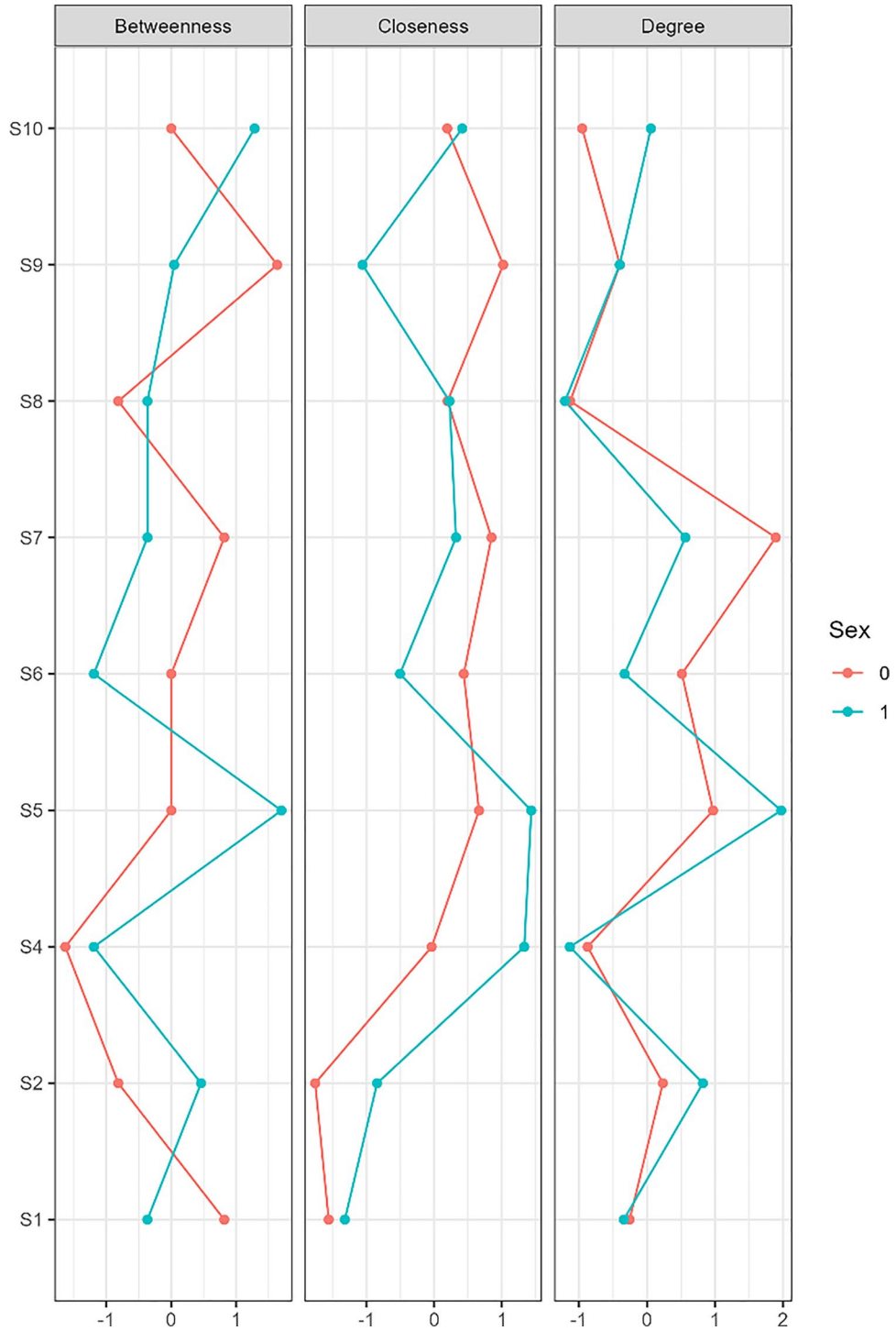

Fig. 2 Centrality measures of the nine-item Italian version of the SAS-SV. *Note*: 0 = male; 1 = female

S5 was one of the most important for females because it had higher connectivity and proximity to other items and exhibited a more central position in the network. Among females, Item S5 was the most influential because it satisfied the criteria of all the three centrality measures. Among males, Item S7 was the most meaningful. Moreover, the global strength between the networks was not significant ($S = 0.27$, $p = 0.12$).

Predictive validity: ROC and decile results

The ROC curve showed that the general cut-off for the Italian short version of SAS-SV (nine-item) was 29 (sensitivity = 76.92%; specificity = 77.59%; AUC = 0.85, CI [0.81, 0.88]; Youden index $J = 0.54$). Moreover, among males, the cut-off value was 25 (sensitivity = 90.91%;

specificity = 63.39%; AUC = 0.84, CI [0.73, 0.96]; Youden index $J = 0.54$). Among females, the cut-off value was 30 (sensitivity = 75.27%; specificity = 79.43%; AUC = 0.84, CI [0.81, 0.88]; Youden index $J = 0.55$). Additionally, considering that there are currently no available diagnostic criteria for PSU-SV, the ROC criteria for determining cut-offs with the deciles of the distribution of the PSU-SV scores were compared. Those in the top 10 decile were used to define the high risk of problematic smartphone use. Based on the results, participants who scored in the 90th decile of PSU-SV (males score ≥ 32; female score ≥ 36) were classified as at high risk of developing the PSU (see S1 for more details). When the criterion of 75th centile (upper quartile) was used as the cut-off, for females, the score was near 30, equivalent to the cut-off obtained from the ROC curve, while the score was near 28 for males (higher than that obtained from ROC curve).

Convergent validity

Table 3 shows the results of the convergent validity. As expected, SAS-SV was positively associated with the time spent on mobile apps (i.e., *Facebook, Instagram*, and *WhatsApp*). In addition, a significant positive association was found between SAS-SV and problematic social media use (BSMAS).

Discussion

The present study contributes to the growing field of problematic smartphone use (PSU) by further exploring the psychometric properties of the SAS-SV in the Italian context. The present study had the following aims to: (i) provide robust evidence about the factorial structure of the Italian version of the SAS-SV, (ii) evaluate scale reliability, (iii) establish gender and age measurement invariance, (iv) estimate the strength of the correlations between the items of the SAS-SV by applying network analysis, (v) provide diagnostic criteria of the SAS-SV for predicting smartphone addiction among the Italian sample, and (vi) investigate convergent reliability with existing measures in the smartphone use literature. The revised (nine-item) Italian version of the SAS-SV appeared to be a reliable and valid measure for PSU assessment with good psychometric properties and invariance across gender and age among a sample of Italian participants. Furthermore, results from measurement invariance supported the three levels of analysis (configural, metric, and scalar), suggesting that the SAS-SV is comparable across the two groups. Finally, mean differences indicated that females scored higher on PSU than males, consistent with the previous literature (Busch & McCarthy, 2021; Casale et al., 2021; Cheung et al., 2019; Servidio et al., 2021b, 2022; Sfendla

Table 3 Convergent validity (Pearson *r* correlation) of Italian version of the Smartphone Addiction Scale-Short Form (9-item), and SAS-SV symptoms as proposed by Lopez-Fernandez (2017)

	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. SAS-SV total score	24.2	8.12	1											
2. Loss of control	5.08	2.29	0.75***	1										
3. Disruption	5.21	2.45	0.79***	0.59***	1									
4. Withdrawal	5.88	2.52	0.73***	0.34***	0.38***	1								
5. Preoccupation	1.89	1.12	0.62***	0.33***	0.36***	0.49***	1							
6. Disregard	2.51	1.37	0.65***	0.33***	0.33***	0.56***	0.45***	1						
7. Tolerance	3.64	1.55	0.63***	0.43***	0.52***	0.27***	0.26***	0.25***	1					
8. Time spent per day on mobile *Facebook*	2.11	1.86	0.10**	0.05	0.08*	0.09**	0.10**	0.03	0.06	1				
9. Time spent per day on mobile *Instagram*	3.11	2.36	0.23***	0.14***	0.21***	0.19***	0.09*	0.11***	0.21***	0.46***	1			
10 Time spent per day on mobile *WhatsApp*	5.45	4.67	0.17***	0.08*	0.17***	0.16***	0.10*	0.07*	0.09	0.47***	0.71***	1		
10. 11. BSMAS total score	13	4.36	0.61***	0.51***	0.50***	0.40***	0.36***	0.34***	0.44***	0.15***	0.30***	0.20***	1	
11. 12. Gender	-	-	0.09***	0.02	0.10	0.13***	0.04	-0.03	0.09	0.12***	0.23***	0.23***	0.18***	1

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$. SAS-SV = Smartphone Addiction Scale – Short version. BSMAS = Bergen Social Media Addiction Scale. Gender (0 = male, 1 = female) is point serial correlation (r_{pb})

et al., 2018). Using latent class analysis, one study indicated that gender differences depended on the kind of device used (Lee et al., 2018). More specifically, females had greater problematic smartphone behaviour because they spent more time on their smartphones, while males had greater problematic internet use (associated with internet gaming disorder) because they spent more time on their computers. Similar findings were also found in a largescale study of over 23,000 Norwegian participants indicating that females were significantly more likely to experience problematic social media use and males were significantly more likely to experience problematic online gaming (Andreassen et al., 2016). Given that most social media use takes place on smartphones and online gaming is more likely to take place on computers and dedicated gaming consoles, the gender differences are arguably what would be expected. Furthermore, in line with a previous study, no significant difference emerged among the age of the participants (Fallahtafti et al., 2020).

The results of the analyses provided evidence of the validity and reliability of the one-factor structure of the SAS-SV, confirming the original version of the scale and the existing data reported in the literature (Andrade et al., 2020; De Pasquale et al., 2017; Luk et al., 2018; Servidio, 2019, 2021). However, the parallel factor analysis results suggested removing Item 3 because it had a low factor loading. This finding is partially consistent with previous studies. More specifically, some researchers have retained Item 3 even though it had a low factor loading (Andrade et al., 2020; De Pasquale et al., 2017; Fallahtafti et al., 2020). However, in another study, Item 3 was removed from the final scale (Escalera-Chávez & Rojas-Kramer, 2020). Therefore, H_1 was partially confirmed because Item 3 on the SAS-SV did not have a significant factor loading among the present sample of Italian participants. However, this result could be attributed to the difference in the lifestyle of Italian individuals, and further studies should be conducted to explain the observed lack of significance of this item.

The configural and metric invariance results suggested that the SAS-SV factor structure was partially the same across gender and age groups, providing support for the one-factor structure of the scale. Therefore, the same factor pattern structure was established. Even though complete scalar invariance across groups was not confirmed, a partial scalar invariance model showed a good fit, with the only two non-invariant parameters being the threshold of Item 7 and Item 8 for the gender group and Item 1 for the age group. Because partial invariance is sufficient to compare groups on a latent variable (Byrne, 2012) and most items on the SAS-SV factor were invariant across groups (gender and age), the results demonstrated that the SAS-SV is an appropriate instrument to assess differences in problematic smartphone use about gender and age. However, non-scalar invariance may indicate potential measurement bias and suggests that participants systematically rated the items either higher or lower during the different administration of the SAS-SV. Although the SAS-SV demonstrated measurement invariance, findings suggest significant differences between males and females (supporting H_2). Indeed, the results indicated that males and females were dissimilar in their endorsement of the SAS-SV, with females exhibiting higher scores than males, contributing to the current body of PSU literature concerning gender differences (Cheung et al., 2019; Servidio et al., 2021a; Sfendla et al., 2018).

Based on the network analysis results, partial correlations were found among items assessing withdrawal, disregard, and preoccupation symptoms, and tolerance and disruption, suggesting high levels of concerns about mobile devices, indicating the importance of these symptoms in assessing the risk of the use of mobile devices PSU. Similar findings were reported in a previous study Andrade et al. (2020). Although smartphone addiction is not included in the DSM-5 (APA, 2013), it has been recognized that excessive use, withdrawal, tolerance and negative repercussions are all factors that many addicted to their smartphones may experience (Fryman & Romine, 2021). For example, individuals who cannot access their smartphones can experience impatience, anxiety, and intolerance, increasing the risk of developing problematic smartphone use. As regards the mean values of the nine-item SAS-SV, only Item 5 (*Feeling impatient and fretful when I am not holding my smartphone*) showed higher connectivity (betweenness) with the other items, shorter connection with other items (closeness), and a higher frequency of strong correlation (degree). This result is partially consistent with the findings of a previous study, suggesting that items related to withdrawal, tolerance, and disregard should be considered with attention since these symptoms refer to the cognitive dimension of problematic use of mobile devices (Andrade et al., 2020). Additionally, Item 6 (*Having my smartphone in my mind even when I am not using it*) and Item 7 (*I will never give up using my smartphone even when my daily life is already greatly affected by it*) exhibited higher betweenness, closeness, and degree, only among males; in contrast, a higher closeness and degree was observed for both males and females. Therefore, based on the results of the present study, differences emerged between males and females, indicating the importance to consider gender differentiation in assessing the risk of PSU.

The present study's predictive validity results suggested a different cut-off value for gender based on the ROC analysis using the BSMAS as the gold standard. The general cut-off value of the SAS-SV was 29. Meanwhile, the cut-off value based on ROC was 25 for males and 30 for females. Moreover, the data utilizing deciles indicated that participants who scored higher than 32 among males and 36 among females could be considered at very high risk of PSU. These cut-offs, considering differences based on gender, could be helpful

when conducting clinical screening interviews to investigate the potential risk of technological addiction.

Regarding convergent validity, the SAS-SV correlated positively with all the variables related to smartphone use (supporting H_3). These results are in line with previous studies indicating a positive association between SAS-SV score and measures related to internet disorders (Andrade et al., 2020; Nikolic et al., 2022; Servidio et al., 2021a). Indeed, a strong and positive association was found between the total SAS-SV score and its symptoms (as proposed by Lopez-Fernandez (2017) and the BSMAS score. These findings corroborate the view that smartphone use and social media use are inextricably linked because their use covers individuals' social connection needs (Cleary et al., 2020). Therefore, these measures are helpful to assess the risk of technological addictions.

The contribution of the present study is threefold. First, to the best of the current authors' knowledge, the study is the first to evaluate the psychometric properties of the Italian version of the SAS-SV based on different validity models (criterion, convergent, and predictive validity) and by using robust statistical methods. Second, using different statistical analyses (e.g., parallel factor analysis, confirmatory factor analysis, and network analysis) provides more robust conclusions about the SAS-SV's psychometric properties and estimating and monitoring the risk of PSU among the Italian population. Third, the conformation of a validated instrument with good psychometric properties can be used confidently in future Italian studies. Overall, it would be helpful to examine the effectiveness of prevention and treatment protocols and compare data with results from other countries.

Limitations and conclusion

The present study has several limitations. Firstly, the lack of internal consistency of the scale, such as test-retest reliability and its limited generalizability to the broader population, because of the study's convenience sample of university students. Another potential limitation is using self-report scales and potential bias related to self-report methods (e.g., social desirability). Therefore, future studies should combine self-report methods and objective measures to collect smartphone usage data. Furthermore, the present sample included more females than males. Therefore, more gender-representative samples are required to increase the generalizability of the current results. Finally, since problematic smartphone use appears to have specific patterns according to the age of the participants (Csibi et al., 2021) and the present study did not examine older age groups (e.g., adults aged 55–60 + years who are beginning to use social media more). Future studies should examine the role of different age groups in the development of the PSU risk which would ensure that preventive measures can be more age targeted. Despite these limitations, the nine-tem Italian version of the SAS-SV appears to be a psychometrically robust measure for assessing PSU risk among Italian university students.

Data availability The datasets generated during this study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they do not have any interests that could constitute a real, potential or apparent conflict of interest with respect to their involvement in the publication. The authors also declare that they do not have any financial or other relations (e.g. directorship, consultancy or speaker fee) with companies, trade associations, unions or groups (including civic associations and public interest groups) that may gain or lose financially from the results or conclusions in the study. Sources of funding are acknowledged.

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