



The Self-perception of Text message Dependence Scale (STDS): A Brazilian-Portuguese validation and expansion of its psychometric properties

Daniel Tornaim Spritzer¹ · André Luiz Monezi Andrade² · Aurora Zamora Xavier¹ · Gabriel Teixeira da Silva² · Hyoun S. Kim³ · Katarzyna Kaliszewska-Czeremska⁴ · Stéphanie Laconi⁵ · Tasuku Igarashi⁶ · Ives Cavalcante Passos^{1,7} · Simone Hauck^{1,8}

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Abstract

Text messaging is the primary form of technology-mediated interpersonal contact and the most carried out activity on cell phones. Despite its advantages, text messaging is not exempt from risks. The present paper aimed to validate and expand the psychometric properties of the Self-perception of Text-message Dependency Scale (STDS) in a Brazilian sample of adult internet users. In this cross-sectional study, we recruited a convenience sample of Brazilian internet users aged 18 and over. A total of 1,642 ($M_{\text{age}} = 38.6$, $SD = 13.5$; 73% female) participants completed the STDS, the Mobile Phone Problem Usage Scale-27 (MPPUS), and the Problematic Internet Use Questionnaire – Short form – 9 questionnaires (PIUQ-SF-9). Multi-group confirmatory factor analysis showed measurement invariance for gender and age. Internal consistency was high when accessed by both McDonald's Omega and Cronbach's alpha. Network Analysis provided insights into the core symptoms of problematic text messaging. Convergent validity of the STDS was demonstrated by the subscale's correlation with MPPUS and PIUQ-SF-9. Due to its expanded psychometric properties and brevity, the STDS can be used in more comprehensive investigations about other excessive technology-related behaviors, such as problematic smartphone and internet use, allowing a better understanding of the mechanisms involved in problematic technology use.

Keywords Internet addiction · Texting · Problematic use · Cultural adaptation · Psychometrics · Brazilian Portuguese

Introduction

Text messaging (TM) has revolutionized human communication in recent decades and has become the primary form of technology-mediated interpersonal contact (Statista, 2020). It has increasingly become integrated into people's daily lives, work-related communications, interactions between families, as well as interpersonal and romantic relationships (GWI, 2021). TM is widely available on various platforms (from instant messaging apps to social networks and online games), enabling also the sending of voice messages, images, videos, links, gifs, stickers, and emojis (We Are Social, 2021), and it is the most carried out activity on cell phones, especially among young people (GWI, 2021;

Roberts et al., 2014; Smith & Page, 2015). Communication via text messaging has also increased in face of the challenges of the COVID-19 pandemic given the social distancing measures implemented in many countries (CTIA.org, 2021).

Despite the advantages of TM in communication and interaction between people, this practice is not exempt from risks. Problematic Text Messaging (PTM) may be defined as impaired control over texting, intense emotional reactions (anxiety, frustration, feelings of rejection) arising from texting, high importance of messaging in people's social lives, and negative consequences secondary to this behavior (Liese et al., 2019; Lu et al., 2014). Studies have linked PTM with many negative consequences, such as the increased risk of traffic accidents (resulting both from texting while driving as well as from distracted walking) (Klauer et al., 2014; Phuksuksakul et al., 2021; Ropaka et al., 2020), sleep disorders (Ferraro et al., 2015), academic difficulties (Grant et al., 2019), among others. PTM has also been associated

✉ Daniel Tornaim Spritzer
dtspritzer@gmail.com

Extended author information available on the last page of the article

with higher levels of depression (Lu et al., 2014; Panova et al., 2020), anxiety (Lu et al., 2014), emotion dysregulation (Liese et al., 2020) and impulsivity, as well as lower levels of executive function and self-directedness (Hayashi & Blessington, 2020; Lu et al., 2014). Several authors state that PTM is more prevalent in younger individuals (Ferraro, 2018; Hayashi & Blessington, 2020), but its specificities regarding gender differences are not fully established. From a nosological and taxonomic perspective, research on PTM is also relevant to increasing the understanding of problematic smartphone use (PSU) and problematic internet use (PIU), as it deepens the discussion about the potential mechanisms of these disorders (Montag et al., 2021; Rozgonjuk et al., 2021; Starcevic et al., 2021).

To date, one of the most frequently used questionnaires to evaluate PTM is the Self-Reported Scale of Text Message Dependence (STDS), developed by Igarashi et al. (2008). It is a brief instrument which assess PTM based on three dimensions: (i) emotional reaction (ER); (ii) excessive use (EU); (iii) relationship maintenance (RM). The ER dimension measures excessive preoccupation with TM while the EU dimension assesses self-perception regarding compulsive TM. Finally, the RM comprises items related to fear of relationship breakdown in the absence of TM and psychological dependence on texting to maintain social relationships. The STDS demonstrates a robust three-factor structure, good internal consistency measured by Cronbach's alpha, and good construct validity (Igarashi et al., 2008; Liese et al., 2019; Lu et al., 2011, 2014).

However, to date, no validation study has evaluated the measurement invariance of the factor structure of the STDS in different age groups. Furthermore, whether the STDS demonstrates measurement invariance to gender has only been verified in the original development of the instrument in a Japanese sample (Igarashi et al., 2008). As such, gender invariance has not been investigated in samples from other cultural backgrounds. Measurement invariance assesses the psychometric equivalence of a construct across groups, demonstrating if the scale has similar meanings to different groups, which allows for meaningful comparisons across groups (Putnick & Bornstein, 2016). Measurement invariance is considered to be a prerequisite to conducting further cross-group comparisons, with implications for the analysis of the internal factor structure of the scale as well as the correlations of its scores with external variables (Van De Schoot et al., 2015; Vandenberg & Lance, 2000). In addition, internal consistency of the STDS has only been assessed by methods that may not be suitable for psychological constructs in which variances of and covariances between items are not equal. Moreover, convergent validity has not been evaluated in comparison to any instrument that assesses problematic smartphone use, and has only been evaluated once in relation to problematic internet use (Lu et al., 2011).

Moreover, no study has used network analysis to explore the distribution of items and their relationship to gender.

Over the recent years, Brazil, like other low- and middle-income countries, has faced a significant technological transition. According to the Brazilian Internet Steering Committee (2020), in less than a decade, the number of Internet users has nearly doubled in Brazil. This number accounts for 74% of the Brazilian population aged ten and over, which corresponds to 134 million individuals. Of importance to the present research, TM is the most used form of communication (92%) followed by social networks (76%) and voice or video calls (73%) (Brazilian Internet Steering Committee, 2020). Given the high rate of TM in the Brazilian population, PTM may be relatively frequent, but to date, there is no instrument available to assess PTM in Brazil.

Given that the validation of a measurement instrument is a continuous process, this paper aimed to further explore the psychometric properties of the STDS in a sample of adult Internet users, as well as to adapt the STDS to the Brazilian population. We hypothesized that: (i) the STDS would exhibit high internal consistency levels; (ii) the three-factor solution of the STDS proposed in the original version would be similar for Brazilian adults; (iii) the invariance levels of the instrument would be equivalent for age and gender; (iv) the distribution among the instrument's items would be similar among different groups by using the Network Analysis approach; (v) the STDS' subscales would show moderate correlation with measures of PSU and PIU (convergent validity).

Methods

This cross-sectional study is part of a multicentric project in 16 countries whose main objective is to assess the cross-cultural aspects of Internet and smartphone use. The study was conducted according to the Declaration of Helsinki and was approved by the Research Ethics Committee of the Hospital de Clínicas de Porto Alegre (protocol number 89702318.2.0000.5327).

Cultural Adaptation

The instructions, items, and answers of the English version of the instrument were forward translated independently by two groups of 3 bilingual mental health professionals whose native language was Brazilian Portuguese, which produced 2 Brazilian Portuguese versions. An expert committee examined both translated versions to assess linguistic and semantic discrepancies, and a synthesized translation version was developed by consensus. Two back-translations were then produced independently by two native English speakers, and these versions were then evaluated to verify how much they

differed from the original instrument concerning their meaning using a 4-point Likert scale from 1 (much altered) to 4 (not altered). Items were revised based on the insights from the back-translations and, when necessary, consensually adjusted to maintain the meaning of the original instrument, producing a new synthesized and unified version in Brazilian Portuguese. Face validity was evaluated by 15 people who were asked for comments and suggestions regarding clarity and comprehensibility regarding each item and the whole questionnaire in line with previous studies (Spritzer et al., 2021).

Sample and Procedures

A convenience sample of Brazilian adults (18+) was recruited online via social media platforms (especially Facebook and WhatsApp) and email. Data collection was carried out anonymously through SurveyMonkey®, and the questionnaire could be accessed and answered via smartphone, computer or tablet. A total of 2,046 participants started the survey, from which 404 participants did not complete the survey, resulting in a final sample size of 1,642 (M age = 38.67; SD = 13.52; male n = 451; 27%; female n = 1,191; 73%) participants.

Measures

Sociodemographic and Technology Use Data

We collected the following information: age, sex, education level, employment, and marital status. We also collected information related to the number of hours spent on smartphones and the Internet as well as self-perceptions of problems related to TM, smartphone, and Internet use.

Problematic Text Messaging (PTM)

The Self-perception of Text-message Dependency Scale (STDS; Igarashi et al., 2008) is a self-report instrument that assesses PTM from 3 dimensions: emotional reaction, excessive use, and relationship maintenance. Each of these has five questions that are answered on a Likert scale ranging from 1 ("Strongly agree") to 5 ("Strongly disagree"). Scores range from a minimum of 15 to a maximum of 75. Previous studies have shown high internal consistency for each dimension, ranging between α = 0.78–0.91 (Igarashi et al., 2008; Lu et al., 2011). In the present study, the internal consistency of the STDS dimensions was high (McDonald's omega ranging between 0.82–0.87, Cronbach's α ranging between 0.79–0.86).

While acknowledging that the STDS has been validated as a multidimensional scale and using its 3-factor structure when evaluating factorial structure and convergent

validity, in order to facilitate comparisons to previous studies (Blessington & Hayashi, 2020; Hayashi & Washio, 2020; Hayashi et al., 2019) we opted to explore the distribution of the sociodemographic variables among different levels of PTM based on the tertiles of participants STDS final score: (i) lower tertile; (ii) middle tertile; and (iii) upper tertile. This procedure is in line with previous studies (Andrade et al., 2020) and demonstrated the most prominent effect size between groups, indicating a robust difference in self-perception of PTM ($F_{(2)} = 3,570.49$, $\eta^2 = 0.813$).

Problematic Smartphone Use (PSU)

The Mobile Phone Problem Usage Scale (MPPUS) is a 27-item instrument to assess motivation for use, addiction symptoms, and negative consequences of using a cell phone (Bianchi & Phillips, 2005). Questions are answered on a Likert scale ranging from 1 ("Totally false") to 10 ("Totally true"). Scores range from 27 to 270 with higher scores indicating an increased risk of PSU. In our sample, MPPUS has demonstrated high internal consistency (Cronbach's α = 0.93).

Problematic Internet Use (PIU)

The Problematic Internet Use Questionnaire – Short Form – 9 (PIUQ-SF-9) consists of nine items, which evaluates problematic internet use according to three dimensions: obsession, neglect, and control disorder (Koronczai et al., 2011). All items are based on a 5-point Likert scale, ranging from 1 ("never") to 5 ("almost always/always"). Total scores range from 9 to 45, and higher scores indicate a higher risk of PIU. The PIUQ-SF-9 has demonstrated high internal consistency across different studies (Cronbach's α = 0.91, Koronczai et al., 2011; Cronbach's α = 0.81–0.90, Laconi et al., 2019; Cronbach's α = 0.93, Spritzer et al., 2021).

Data Analysis

Factor Structure and Reliability

The Kaiser–Meyer–Olkin method ($KMO = 0.882$) and Bartlett's test of sphericity ($p < 0.001$) were used to assess the suitability of the data for factor analysis. Confirmatory Factor Analysis (CFA) was used to confirm the original three-factor structure of the STDS (Igarashi et al., 2008), using robust error calculation, Weighted Least Squares Mean (WLSMV) and variance-adjusted as the estimation method. We chose this method because it uses polychoric correlation and is more suitable for ordinal data (Gadermann et al., 2012). We considered factor loadings values according to Comrey and Lee's (1992) recommendations, thus excluding loadings lower than 0.45. We used the fit thresholds

recommended by Cheung and Rensvold (2002) to examine good model fit.

We conducted multigroup confirmatory factor analyses (MGCFAs) to test measurement invariance for gender and age. Regarding age, participants were classified according to the guidelines provided by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, 2020): (i) young adults (18 to 29 years, $n=477$); (ii) middle-aged adults (30 to 59 years, $n=999$); and (iii) older adults (60 years or more, $n=156$). We evaluated metric, scalar, and residual invariances in a hierarchical way, where a less restricted model was compared to a more restricted model. Measurement invariance was achieved when CFI and SRMR difference values (Δ CFI and Δ SRMR) were lower than 0.01 and 0.02, respectively. Due to the fact that unbalanced sample sizes in MGCFAs may impact the results of some parameters, we have chosen Δ CFI since it is independent of both model complexity and sample size, and is not correlated with the overall fit measures (Cheung & Rensvold, 2002; Pimenta de Devotto et al., 2020).

The internal consistency was assessed using McDonald's omega coefficient (ω) due to the fact that it performs better than Cronbach's alpha in models in which tau-equivalence cannot be assumed, as factor loadings, variances of and covariances between items are not equal (Cho, 2016). Additionally, the use of "omega if item deleted" better reflects the genuine population estimates of reliability by removing a particular scale item than "alpha if item deleted" (Dunn et al., 2014). and was considered satisfactory if higher than 0.70 (Dunn et al., 2014). Nevertheless, Cronbach's alpha (α) was also reported for the sake of comparability with previous research.

Network Analysis (NA)

We use NA as an exploratory graphical statistical technique to estimate how items in the factor structure group and how much influence each item exerts on the system (network). NA has been increasingly used to assess the psychometric properties of instruments because it allows us to identify in different ways the degree of importance of each item in the instrument. In this case, the network can be understood as the instrument itself so that the nodes (items) correlate through edges. These correlations can be positive (green edges) or negative (red edges), and the greater the strength of the correlation, the thicker the edge (Borsboom & Cramer, 2013). In this study, we assessed four measures of item centrality; (i) The number of shortest connections between any two nodes that pass through the aimed node (betweenness centrality); (ii) the magnitude of these connections (degree centrality); (iii) the average weight of each item's correlations with the other items (closeness centrality); and (iv)

the weighted weight of the item's influence on the system if it were removed from the instrument (expected influence).

We used the LASSO (Least Absolute Shrinkage and Selection Operator) regularization method to generate the graphs, using a network of partial correlations between the nodes. This technique was chosen because it allows a better-fitted model that does not consider low magnitude correlations in the graph. According to an algorithm that took into account the frequency and magnitude of the associations of the STDS items, the nodes were positioned in the system in line with previous studies (Andrade et al., 2020, 2021; de Oliveira Pinheiro et al., 2020).

Convergent Validity

We analyzed convergent validity using Spearman's correlation between the STDS subscales and: i) the MPPUS-27 and the PIUQ-SF-9, ii) self-perception of PTM, PSU, and PIU, and iii) time spent on the smartphone and the Internet. We considered in the analyses weak (<0.40), moderate (0.40—0.69) and strong (0.70 and above) correlations (Nunnally & Bernstein, 1999).

Research Data

The dataset and the syntax of the analysis presented in this study are fully available online in the Open Science Framework (OSF) repository: <https://osf.io/btq9m/>.

Results

Cultural Adaptation

The two forward translations achieved very similar results, and only minor adjustments were needed to obtain the first synthesized version. The experts suggested adding a clarification that TM refers to both messages through applications (apps) and SMS functionality in the instructions. To facilitate understanding, the expression "check my mailbox" was modified in Brazilian Portuguese for the equivalent of "check my telephone." In the back-translation, all items maintained their meaning compared with the original instrument. Concerning the face validity, all respondents rated the questionnaire as "easy to understand." One typo was identified and corrected. The final Brazilian Portuguese version of the STDS is available as supplementary material in Appendix A.

Factor Structure and Reliability

The CFA's model indicated an acceptable fit (Table 1), which corroborates the original three-factor structure of

Table 1 Confirmatory factor analyses of the STDS and MGCFA fit indexes for gender and age

	Goodness-of-fit indexes							
	χ^2 (df)	χ^2/df	RMSEA (90% IC)	SRMR	Δ SRMR	TLI	CFI	Δ CFI
Three-factor model	833.1(73)	11.412	.079 (.074-.084)	.054	-	.985	.988	-
Gender								
Male ($n=452$)	130.206 (73)	1.784	.042 (.03—.054)	.054	-	.986	.989	-
Female ($n=1.197$)	257.876 (73)	3.533	.046 (.04—.053)	.048	-	.981	.985	-
<i>Unconstrained model</i>	388.082 (146)	2.658	.045 (.04—.051)	.047	-	.983	.986	-
Metric invariance	402.393 (158)	2.547	.044 (.038—.049)	.047	.000	.984	.986	.000
Scalar invariance	409.682 (169)	2.424	.042 (.037—.047)	.048	.001	.985	.986	.000
Residual invariance	421.091 (183)	2.301	.040 (.035—.045)	.048	.000	.986	.986	.000
Age								
Young adults ($n=479$)	137.11 (73)	1.878	.043 (.032—.054)	.054	-	.978	.982	-
Middle-aged adults ($n=1.003$)	221.965 (73)	3.041	.045 (.039—.052)	.049	-	.983	.986	-
Older adults ($n=157$)	55.796 (73)	.764	.000 (.000—.013)	.067	-	1.012	1.000	-
<i>Unconstrained model</i>	414.872 (219)	1.894	.041 (.035—.047)	.049	-	.985	.988	-
Metric invariance	48.03 (243)	1.975	.043 (.037—.048)	.052	.003	.984	.985	.003
Scalar invariance	604.935 (265)	2.283	.049 (.044—.054)	.057	.005	.978	.979	.006
Residual invariance	718.846 (293)	2.453	.052 (.047—.057)	.065	.008	.975	.974	.005

STDS Self-reported Text message Dependence Scale; MGCFA Multigroup confirmatory factor analysis; RMSEA Root-mean-square error of approximation; TLI Tucker-Lewis Index; SRMR Standardized root-mean-square residual; CFI Comparative fit index. Note: The fit criteria were considered as according to Cheung and Rensvold (2002): comparative fit index ($CFI \geq .95$), Tucker-Lewis Index ($TLI \geq .95$), root mean square error of approximation ($RMSEA \leq .08$), standardized root means square residual ($SRMR \leq .05$) and the ratio between the chi-square/degrees of freedom value (χ^2/df), with the ideal values being between 2 and 3

the instrument (Igarashi et al., 2008). The MGCFA also indicated that the STDS showed optimal fit indexes when evaluating participants based on gender and age. All invariance tested in the model provided evidence that the STDS is not biased for any of the parameters analyzed (Table 1). These procedures ensured the quality of the factor structure of the STDS.

Table 2 shows the factor loadings for each item, as well as the scale reliability indices. The data indicated high levels of internal consistency for the three dimensions using both McDonald's Omega (ω ranging between 0.82—0.87) and Cronbach's alpha (α ranging between 0.79—0.86) analyses.

Network Analysis (NA)

Partial correlations using NA are shown in Fig. 1, in which analyses were performed among all participants (Fig. 1A), among Men (Fig. 1B), and Women (Fig. 1C). In all graphs, the STDS items showed a similar distribution. The strongest correlations were found between items 2 and 3, which are part of the ER factor. Also, a higher frequency of strong correlations was observed between the RM factor items among women.

Figure 2 shows four centrality levels in both the overall sample (Fig. 2A) and between men and women (Fig. 2B). The higher the centrality indices, the greater the relevance of a given item in the system (questionnaire). Items 8 ("I often

exchange many text messages in a short period of time"), 9 ("I use text messages even while I am talking with friends"), and 13 ("I think my relationships would fall apart without text messages") were the items with the most significant influence on the system (Fig. 2A). When evaluated by gender, items 9 (see above) and 11 ("I cannot maintain new friendships without text-messages") showed higher levels of centrality among men, and items 8 (see above) and 12 ("I can't form any new relationships without using text messages") among women.

Convergent Validity

As presented in Table 3, all the STDS subscales showed a moderate correlation with MPPUS-27 and PIUQ-SF-9 scores, weak to moderate correlation with self-perception of PTM, PSU, and PIU, and weak correlation with time spent on smartphones and time spent on the Internet.

Table 4 shows the sociodemographic data of the participants based on the STDS classification from the tertiles. Regarding gender, almost 80% of the "upper tertile" group participants were women. Also, the average age of the participants in the "upper tertile" group was 12 years younger (33 years) compared to those in the "lower tertile" group (45 years).

Table 2 Factor loading and reliability of STDS

Factors	Item	<i>M</i>	<i>SD</i>	Item loading	α if item deleted	ω if item deleted
Emotional reaction		2.71	1.16		.864	.868
	1	3.15	1.15	.718	.870	.874
	2	2.56	1.13	.876	.869	.872
	3	2.50	1.15	.868	.868	.872
	4	3.09	1.20	.623	.870	.874
	5	2.26	1.16	.657	.870	.873
Excessive use		2.90	1.28		.831	.835
	6	2.76	1.30	.672	.873	.877
	7	2.71	1.29	.786	.867	.872
	8	3.07	1.29	.769	.869	.874
	9	2.79	1.25	.759	.869	.874
	10	3.17	1.26	.538	.877	.881
Relationship maintenance		2.00	1.04		.791	.820
	11	1.79	.96	.798	.873	.877
	12	1.81	1.02	.819	.874	.877
	13	1.68	.93	.759	.875	.878
	14	3.12	1.38	.459	.881	.882
	15	1.63	.90	.591	.876	.879
Overall					.880	.883

STDS Self-reported Text message Dependence Scale; *M* Mean; *SD* Standard deviation; α Cronbach's alpha; ω McDonald's omega

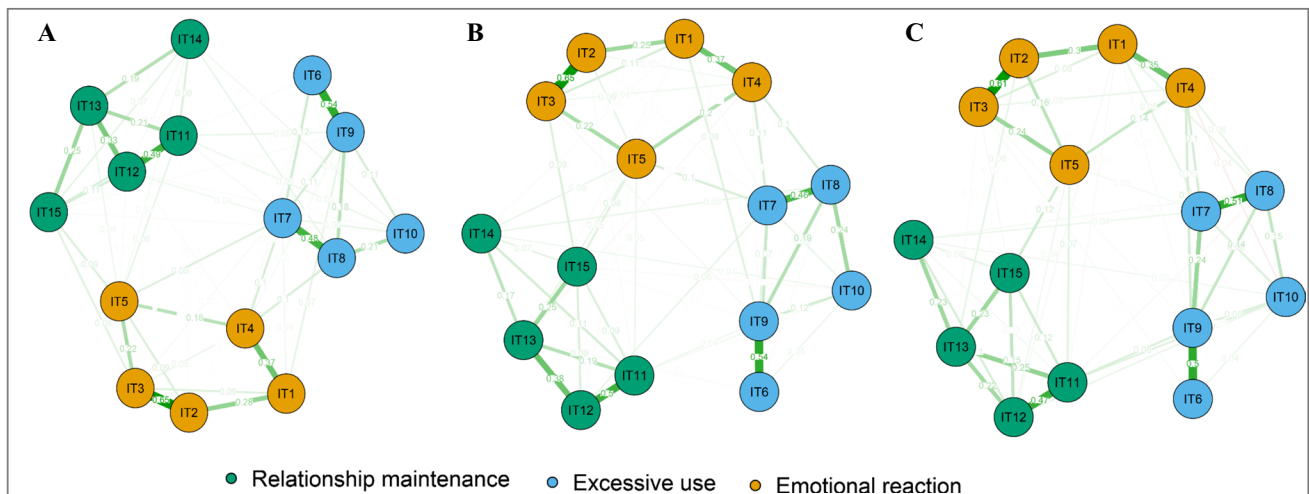


Fig. 1 Gaussian Graphical Model based on network analyses (NA) for Self-reported Text message Dependence Scale (STDS) in a Brazilian sample according to the general population (**1A**), female (**1B**)

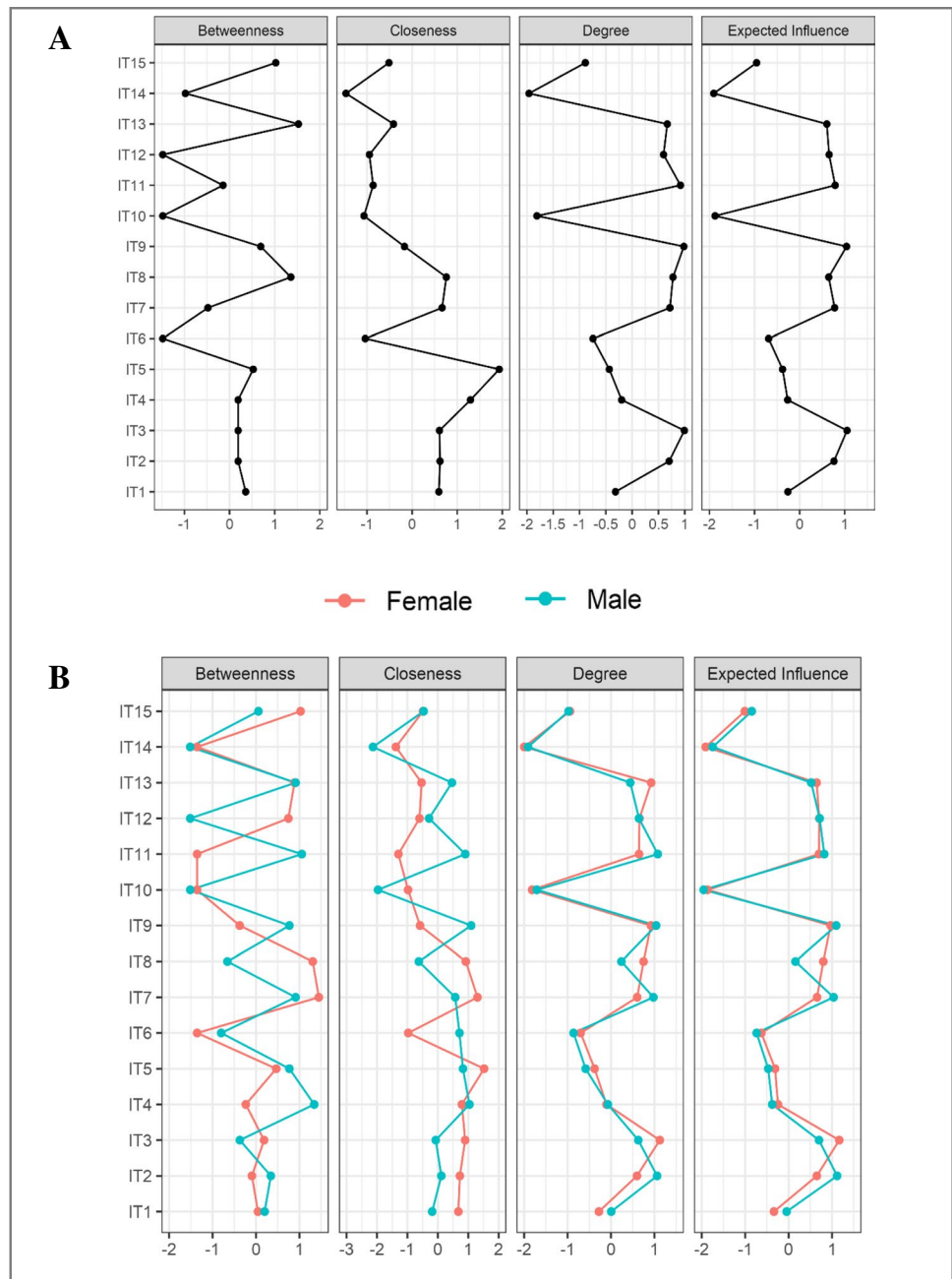
and male (**1C**). The green line represents the zero-order positive partial correlation between the variables, and thickness represents the magnitude of the correlation

Discussion

We aimed to expand the psychometric properties of the STDS in a sample of adult internet users, as well as to culturally adapt the questionnaire to the Brazilian population. The original 3-factor structure (emotional reaction, overuse, and relationship maintenance) of the STDS initially proposed by

Igarashi et al. (2008) and confirmed by several authors (Liese et al., 2019; Lu et al., 2011, 2014) was also confirmed in our study. The findings from the network analysis reinforced the factorial structure through the analysis of both partial correlations and centrality indices. Items related to the 3 dimensions of the STDS showed a high expected influence on the system for both men and women.

Fig. 2 Four-centrality indices for Self-reported Text message Dependence Scale (STDS) for the general population (**2A**) according to gender (**2B**): female (red line) and male (blue line)



To our knowledge, this is the first study to assess factor structure through multigroup confirmatory factor analysis for individuals of different ages, demonstrating measurement invariance between groups of younger and older individuals. These findings reinforce the instrument's external validity, given that the vast majority of validation studies of the STDS have assessed younger populations, especially college students (Blessington & Hayashi, 2020; Liese et al., 2019). Our data also demonstrated the factorial invariance on gender in a sample of adults from a different sociodemographic background, which had only been evaluated previously in the

original study with Japanese high school students (Igarashi et al., 2008).

The internal consistency of the Brazilian version of STDS demonstrated high levels of homogeneity, as demonstrated by the analysis of both the ω and the α indices. This is in line with previous validation studies (Igarashi et al., 2008; Lu et al., 2014). This was the first study to evaluate the internal consistency of the STDS using McDonald's omega, which has been increasingly used in psychometric studies. This is a more suitable approach for assessing reliability when the factor loadings, variances of and covariances between items

Table 3 Spearman correlation of the STDS' subscales with MPPUS-27, PIUQ-SF-9, self-perception of problem use, and time spent online

	Emotional reaction	Excessive use	Relationship maintenance
MPPUS-27	.591	.614	.468
PIUQ-SF-9	.540	.527	.465
Self-perception of problem use			
Text messages	.339	.385	.207
Smartphone	.389	.433	.264
Internet	.354	.386	.288
Time spent (hours per day)			
On smartphone	.277	.401	.192
On the Internet	.194	.300	.183

STDS Self-perception of Text-message Dependence Scale; MPPUS-27 Mobile Phone Problem Usage Scale 27; PIUQ-SF-9 Problematic Internet Use Questionnaire – Short Form – 9. Note: In all analyses, the significance level was less than .001

are not equal, while alpha assumes that variance unique to an item is comprised wholly of error (Cho, 2016).

Regarding convergent validity, all STDS subscales demonstrated moderate correlation with MPPUS-27 and PIUQ-SF-9 scores. This is not surprising since messaging is the main activity performed on mobile phones and since smartphones are the main device used to access the Internet in

Brazil (Brazilian Internet Steering Committee, 2020; GWI, 2021; Smith & Page, 2015). Self-perception of PTM, PSU, and PIU were weak to moderately correlated with the STDS subscales, which may be related to the possibility of people not recognizing that they have a problem as these technologies are increasingly integrated into people's daily lives. Correlation with time spent on smartphones and time spent on the Internet was weak, supporting the need to assess the symptoms of PTM use more comprehensively rather than assessing only time spent on smartphones and the Internet.

Network analysis has been used in recent years as a complementary procedure to traditional factor analyses, as it allows for assessing dimensionality by inferring clusters of behaviors in a network (Golino & Epskamp, 2017; Santiago et al., 2021). In our study, the network structure adequately described the dimensions of the STDS, reinforcing the three-factor structure of the instrument observed through the CFA. The results of the network analysis also showed that for both men and women, the symptoms with the greatest impact on PTM scores were related to the importance the person assigns to texting communication in their social life, either by establishing or maintaining their relationships. The insights from the core symptoms of PTM highlighted in the NA may help guide more specific prevention and intervention strategies (Borsboom & Cramer, 2013; Hayashi & Blessington, 2020), as well as further research

Table 4 Participants' sociodemographic data according to the risk of PTM (based on SDTS tertile scores)

	Upper tertile (n = 571)		Middle tertile (n = 544)		Lower tertile (n = 527)		Test	Effect size
	M	SD	M	SD	M	SD		
Age	33.6	11.3	37.6	12.8	45.2	13.8	116.6	.12
	N	%	N	%	N	%	χ^2	V
Gender							21.17	.11
Male	128	22.4	141	25.9	182	34.5		
Female	443	77.6	403	74.1	345	65.5		
Marital status							42.68	.16
In a relationship	265	46.4	272	50.1	342	65.1		
Single	306	53.6	271	49.9	183	34.9		
Educational level							29.59	.09
Up to High-School degree	41	7.2	44	8.1	29	5.5		
High-School degree + 1–4 years of study	111	19.5	88	16.3	66	12.6		
High-School degree + 5–7 years of study	140	24.6	124	23.0	93	17.8		
High-School degree + 8 or more years of study	276	48.6	284	52.6	335	64.1		
Occupation							85.93	.16
Studying only	108	18.9	85	15.6	34	6.5		
Studying and working	181	31.7	130	23.9	95	18.0		
Working only	250	43.8	288	52.9	340	64.5		
Not working, not studying	32	5.6	41	7.5	58	11.0		

STDS Self-reported Text message Dependence Scale; PTM Problematic Text Messaging; M Mean; SD standard deviation; η^2 Partial eta squared; V Cramers'V Test. Note: In all analyses, the significance level was less than .001

that investigates motivations for texting use and their relationship with personality characteristics and psychiatric comorbidities (Starcevic et al., 2021).

We also observed socio-demographic differences between individuals who scored on the highest tertile group compared to the lowest tertile group. Specifically, participants who may be experiencing PTM were younger in age, more likely to be women, single, and being a student. These findings should be interpreted with caution, as they were conducted based on the total STDS score rather than its 3-factor structure. However, these results provide preliminary clues as to who is most likely to be experiencing PTM and thus provide an avenue for potential prevention initiatives. For example, based on the socio-demographic profiles of participants who scored in the highest tertile of the STDS, education initiatives related to the potential harms of excessive TM could be geared towards women who are in their late 20 s, early 30 s and who are studying. For example, the message could include potential signs of excessive TM, consequences of PTM, and alternate ways to socialize (e.g., face-to-face). Such initiatives may help reduce the rates of PTM in the Brazilian population.

Although this study was not based on a probabilistic sample, the socio-demographic findings above can be considered from a cultural perspective. In Brazil, the fact that TM is the most used form of communication on the internet may be related to socialization motivations, which may be particularly true for single women. In addition, the low cost of texting, which is often provided free of charge may also have a significant influence on PTM, especially in a middle-income country with huge economic disparities as is the case in Brazil. Furthermore, given that cell phones are the main and usually the only means of access to the Internet for the vast majority of the Brazilian population may influence the rates of PTM in Brazil.

Our findings have some limitations that deserve attention. First, the cross-sectional design does not allow for causal inferences. Second, we tested the STDS psychometric properties based on a non-probabilistic sample, which may restrict the external validity of the instrument. On the other hand, we believe that a large number of participants and the inclusion of people up to 89 years of age may partly offset the instrument's external validity. In addition, our study used validation strategies with sophisticated statistical analyses, such as Multigroup CFA for invariance measures, McDonald's omega for internal consistency, and the Network Analysis approach providing confidence in our findings.

This study strengthens and expands the psychometric properties of the STDS by examining its factor structure, reliability, and convergent validity in a sample from a middle-income Latin American country with a very heterogeneous cultural and socioeconomic background. The Brazilian version of the STDS is a brief scale with

sound psychometric properties that can be used in further research on the mechanisms of problematic smartphone and internet use. The Brazilian version of the STDS could also be used in clinical studies as a potential outcome measure which may help in developing effective interventions for PTM. Future psychometric studies would also benefit from: (i) including clinical interviews to assess criterion validity, (ii) assess construct validity from the correlation with psychopathological and personality characteristics, (iii) test–retest validation to assess instrument stability, and (iv) compare scores on the STDS with objective measures obtained from the analysis of reports provided by the phones themselves to further examine the psychometric properties of the STDS.

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Authors' Contributions **Conceptualization:** Daniel Tornaim Spritzer, André Luiz Monezi Andrade, Katarzyna Kaliszewska-Czeremska, Stéphany Laconi, Ives Cavalcante Passos, Simone Hauck.

Methodology: Daniel Tornaim Spritzer, André Luiz Monezi Andrade.

Investigation: Daniel Tornaim Spritzer, Aurora Zamora Xavier, Simone Hauck.

Formal analysis: André Luiz Monezi Andrade, Gabriel Teixeira da Silva.

Writing – Original Draft: Daniel Tornaim Spritzer, André Luiz Monezi Andrade, Aurora Zamora Xavier, Gabriel Teixeira da Silva.

Writing – Review & Editing: Daniel Tornaim Spritzer, André Luiz Monezi Andrade, Hyoun S Kim, Katarzyna Kaliszewska-Czeremska, Stéphany Laconi, Tasuku Igarashi, Ives Cavalcante Passos, Simone Hauck.

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Data Availability The dataset and the syntax of the analysis presented in this study are fully available online in the Open Science Framework (OSF) repository (Andrade et al., 2021).

Code Availability Not applicable

Declarations

Ethics Approval The study was conducted according to the Declaration of Helsinki and was approved by the Research Ethics Committee of the Hospital de Clínicas de Porto Alegre (protocol number 89702318.2.0000.5327).

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent for Publication Patients signed informed consent regarding publishing their data.

Conflicts of Interest The authors declare that they have no conflicts of interest.


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Authors and Affiliations

Daniel Tornaim Spritzer¹  · André Luiz Monezi Andrade² · Aurora Zamora Xavier¹ · Gabriel Teixeira da Silva² · Hyoun S. Kim³ · Katarzyna Kaliszewska-Czeremska⁴ · Stéphanie Laconi⁵ · Tasuku Igarashi⁶ · Ives Cavalcante Passos^{1,7} · Simone Hauck^{1,8}

André Luiz Monezi Andrade
andre.andrade@puc-campinas.edu.br

Aurora Zamora Xavier
aurorazamoraxavier@gmail.com

Gabriel Teixeira da Silva
gabrielt.s@live.com

Hyoun S. Kim
andrews.kim@ryerson.ca

Katarzyna Kaliszewska-Czeremska
katarzyna.kaliszewska@ignatianum.edu.pl

Stéphanie Laconi
stephanielaconi.b@gmail.com

Tasuku Igarashi
tasukuigarashi@yahoo.co.jp

Ives Cavalcante Passos
ipassos@hcpa.edu.br

Simone Hauck
shauck@hcpa.edu.br

¹ Graduate Program in Psychiatry and Behavioral Sciences, Universidade Federal Do Rio Grande Do Sul,

- R. Ramiro Barcelos, 2400 - 2º andar, Porto Alegre, Rio Grande Do Sul Zipcode: 90035-003, Brazil
- ² Center of Life Science, Pontifical Catholic University of Campinas, Av. John Boyd Dunlop, S/N - Jardim Ipajussara, Campinas, SP Zipcode: 13034-685, Brazil
- ³ Department of Psychology, University of Calgary, Ottawa, ON, Canada
- ⁴ Institute of Psychology, Jesuit University Ignatianum in Krakow, ul. Kopernika 26, 31-501 Krakow, Poland
- ⁵ Centre d'Études Et de Recherche en Psychopathologie Et Psychologie de La Santé, Université Toulouse Jean Jaurès, 5, allées Antonio-Machado, 31058 Toulouse Cedex 9, France
- ⁶ Graduate School of Education and Human Development, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
- ⁷ Laboratory of Molecular Psychiatry, Centro de Pesquisa Experimental (CPE) and Centro de Pesquisa Clínica (CPC), Hospital de Clínicas de Porto Alegre, Rua Ramiro Barcelos, 2350, Rio Grande do Sul Zipcode: 90035-903 Porto Alegre, Brazil
- ⁸ Psychodynamic Psychiatry Research Laboratory, Hospital de Clínicas de Porto Alegre, Rua Ramiro Barcelos, 2350, Porto Alegre, Rio Grande do Sul Zipcode: 90035-903, Brazil