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Test for Mobile phone dependence: psychometric properties and confirmatory factor analysis

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Abstract

The Test of Mobile Phone Dependence (TMD) is a questionnaire designed for appraising the main dimensions of problematic smartphone use in adolescence. This study evaluates the factor structure and psychometric properties of the TMD on a sample of 813 Italian middle and high school students. The original three-factor model (Abstinence, Lack of Control, and Tolerance) of the TMD was tested through a Confirmatory Factor Analysis. The results of the goodness of fit indices indicated a satisfactory solution. The overall TMD score showed a good level of internal consistency and good construct validity with the duration of use, age of possession of the first mobile phone, perceived self-efficacy, gender, and participants' age. The relationship between TMD and Nomophobia was also explored. Overall, the results indicate that the TMD is a valid and reliable assessment tool in Italian culture. However, reliability issues emerged on the subfactor Lack of Control. This indicates that the scores on this subfactor should be treated with caution.

Keywords Test of Mobile phone dependence · Problematic smartphone use · Adolescents · Italian population · Validation

Introduction

In contemporary society, smartphone use has substantially increased over the last decade. We bring our devices everywhere and, in most of our daily activities at work and during leisure time, we rely on them. In Italy, 83% of the population has at least one smartphone (We Are Social & Hootsuite, 2018), and Italians spend roughly 2 h and 20 min every day using it. Smartphone use has become increasingly common also among Italian adolescents: 86% of adolescents between 11 and 17 years old reported to use their smartphones every day. On average, they receive their first smartphone at 11 years old (Doxa Kids & Telefono Azzurro, 2016). These data show that Italian adolescents are increasingly spending much of their time with their smartphones and that smartphones are a pervasive aspect of their lives. Particularly in adolescents, the possession and use of the smartphone acknowledges personal autonomy, provides self-identity, offers entertainment, and favors the establishment and maintenance of interpersonal relationships (Oksman & Turtiainen, 2004). Thus, the fascination that the smartphone elicits from adolescents means it may be seen as a true object of desire for many in this age group.

Much research has been conducted on smartphone use in the last decade and some empirical evidence indicates that its excessive and uncontrolled use can be associated with various problems. Problematic smartphone use (PSU) has been defined as "an inability to regulate one's use of the mobile phone, which eventually involves negative consequences in daily life" (p. 1, Billieux, 2012). Evidence has accumulated that an excessive smartphone use may be associated with mental health, cognition, social, interpersonal, and academic issues, suggesting that smartphone use can result in significant negative consequences for some individuals (see review, Billieux, 2012). Studies have found that social anxiety and loneliness are associated with heavy use of smartphones, suggesting that an undue use can result in negative consequences for some individuals (Laramie, 2007). Relatedly, it has been found that PSU is associated with increased conflict with others, as well as lowered social skills and emotional intelligence (Scott, Valley, & Simecka, 2017). Additionally, PSU has been shown to be negatively correlated with psychological well-being (Kumcagiz & Gunduz, 2016). Several studies have revealed evidence that depression, anxiety (De-Sola

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Gutiérrez, de Fonseca, & Rubio, 2016; Elhai, Levine, & Hall, 2019), and low self-esteem (Hong, Chiu, & Huang, 2012) are associated with PSU, especially in populations of adolescents and young adults. Concern has been raised over the potential negative impacts that smartphone use might have on users' behavior and cognitive abilities. Research has shown that PSU is related to compromised inhibitory control (Chen, Liang, Mai, Zhong, & Qu, 2016), impaired attention, and impulsivity (Hadar et al., 2017). Relatedly, heavy smartphone use has been shown to negatively correlate with academic progress and success (Samaha & Hawi, 2016).

The results of these studies present a rationale for a justified concern surrounding potential negative psychological consequences of smartphone overuse and, also, its problematic use. Some authors have conceptualized PSU as a form of technological addiction characterized by a behavioral pattern similar to, but not exactly alike, substance addictions (Widyanto & Griffiths, 2006). However, other authors, despite acknowledging the association between PSU and several dysfunctional behaviors, have underlined that conceptualizing PSU/smartphone abuse as a form of addiction may be unwarranted. Billieux, Schimmenti, Khazaal, Maurage, and Heeren (2015), in particular, emphasize that the empirical evidence of behavioral and neurobiological similarities between PSU and substance addiction is inconsistent. They argue that tolerance, withdrawal, and loss of control, typical ways in which substance addiction expresses itself, do not appear to be present in excessive smartphone use (Billieux et al., 2015). Therefore, so far the status of PSU as a clinical disorder akin to other forms of dependency is a matter of debate, which highlights the importance of and need for further investigations. Perhaps, neither DSM-5 nor ICD-11 enlist PSU as a mental disorder. As, at the current moment, the research does not support the claim that addiction is a correct term for the problems associated with smartphone use, we will follow the suggestion of Panova and Carbonell (2018) and use the term "problematic smartphone use."

Although certain parallels exist between classically defined addiction and high use of the smartphone (Panova & Carbonell, 2018), various authors cautioned against the risks that diagnosing excessive, maladaptive, or problematic behavior as addictive may cause, namely that of generating false epidemics of misidentified pseudopatients and pathologizing common behaviors (Kardefelt-Winther et al., 2017). After all, many individuals may use their smartphones for numerous hours per day but do so productively, for instance for work or school (Bertschek & Niebel, 2016). According to Panova and Carbonell (2018), it is essential to analyze technology-related behaviors in context before pathologizing them, because the context has an important influence on why and how certain behaviors occur. Culturally oriented studies have highlighted how the values of different cultures are reflected and expressed in smartphone-related behaviors (Leonardi, Leonardi, & Hudson, 2006). Professional, academic, and social contexts should also be considered when studying smartphone use because much of it depends on professional, social, or academic demands.

As mentioned above, there is evidence that certain uses of smartphones, in particular excessive uses, are linked to negative consequences. Some people may show psychological and social issues associated with PSU (De-Sola Gutiérrez et al., 2016; Elhai et al., 2019; Fischer-Grote, Kothgassner, & Felnhofer, 2019). Therefore, studying and understanding this phenomenon is important. To study it properly, researchers must be equipped with tools that measure problematic use in a reliable and valid way. In the present study, we sought to validate the Test of Mobile Phone Dependence (TMD; Chóliz, 2012), which is a questionnaire that evaluates the main dimensions of PSU in adolescence, with a sample of Italian adolescents.

PSU, Duration of Use, and Age of First Smartphone

Usually, PSU is associated with a high frequency of smartphone utilization (Thomée, 2018), high habitual use (Lee, Kim, & Choi, 2017), and high duration of daily usage (Cha & Seo, 2018). Although several studies have shown the presence of these relationships (Fischer-Grote et al., 2019), handling the tool for many hours in a day does not necessarily imply a problematic use. For example, teenagers could utilize their smartphone in an intense but healthy/unproblematic way, employing it for several hours a day for educational reasons or staying in touch with friends, which may indicate that they may have high levels of school engagement.

The age of possession of one's first smartphone is also associated with PSU: The younger the age at which one receives their first smartphone, the greater the probability of using smartphones in problematic ways (Sahin, Ozdemir, Unsal, & Temiz, 2013). In particular, Sahin et al. (2013) found that respondents who obtained it before at an age younger than 13 years showed the highest problematic use. However, starting to use smartphones at a younger age does not necessarily imply problematic use or its negative consequences.

PSU and Self-Efficacy

According to the Social-Cognitive Theory (Bandura, 2002), self-efficacy is the belief of possessing the skills necessary to perform a task or attain an objective. Self-efficacy affects how individuals feel, think, and motivate themselves, and it is a significant determinant of behaviors (Schunk & Pajares, 2002). Self-efficacy determines how much effort people put into a particular task, how long they withstand obstacles and frustration, and the level of resistance they demonstrate when confronted with difficulties. According to this theory, individuals avoid tasks that exceed their self-perceived abilities (Bandura, 2002). Therefore, it is conceivable that individuals

who believe they lack the ability to successfully complete a particular task, such as reducing smartphone usage, will exhibit avoidant behavior and, instead, engage in problematic use of smartphones. This is consistent with some research that has evidenced a negative relationship between perceived self-efficacy and technology-related problematic use in adolescence, such as Internet problematic use (Aydn & Sari, 2011).

PSU, Gender, and Age

Several studies reported significant positive associations between gender and PSU in adolescents (Fischer-Grote et al., 2019). Research has shown that, in Western countries, girls are more likely to use smartphones in problematic ways, to send daily text messages, and to use smartphones to initiating and maintaining close social relationships (Billieux, Van Der Linden, & Rochat, 2008).

Many studies found age to be associated with it (Cocoradă, Maican, Cazan, & Maican, 2018; Lee & Ogbolu, 2018). The results obtained from various research, indicate that PSU tends to increase during adolescence and to decrease in adulthood. Some studies have found that older adolescents (14–16 years old) are at greater risk than younger adolescents (11/12 years old) (Lee & Ogbolu, 2018). Others have found that university students (aged 19 years old and over) are at less risk than high school students (Cocoradă et al., 2018). However, the relationship between age and problematic use needs to be further studied to understand the stability and durability of PSU.

PSU and Nomophobia

The term nomophobia, an abbreviation of "no mobile phone phobia", refers to the discomfort, nervousness, or anxiety caused by being out of contact with a mobile phone (Yildirim & Correia, 2015). Similar to the controversy around the concept of smartphone addiction, nomophobia is also a concept that has raised debates. On the one hand, labeling the fear of being without smartphones as a phobia might, at least in some cases, pathologize a reasonable reaction to the inability to use a device that is necessary for one's working or social goals. On the other hand, past research has highlighted how nomophobia scores are related to disorders, such as obsessiveness (Lee, Kim, Mendoza, & McDonough, 2018), and personality traits that may lead to problematic behavior (Olivencia-Carrión, Ferri-García, & Rueda, M. del M., Jiménez-Torres, M. G.,, & López-Torrecillas, F., 2018). In this study, we sought to explore the relationship between PSU and nomophobia scores.

Aims of the Study

The previously described areas of dysfunction (e.g., social, interpersonal, mental health, cognition, and academia) found to be associated with smartphone use support Billieux's (2012) conceptualization of problematic smartphone use being contingent upon negative consequences associated with the use (Harris, Regan, Schueler, & Fields, 2020). As such, many measurement tools for PSU have been developed to tap into these types of negative life consequences. A recent review (Harris et al., 2020) enlisted 16 measures designed and validated for measuring PSU in adolescence. These measures have been all designed from the diagnostic criteria of the DSM for substance addiction or gambling disorder (e.g., withdrawal, craving, tolerance). The number of items varies from 6 to 33, and the reliability is acceptable for all the measures (all Cronbach's alphas higher than .76). For further information on the available measures and their comparison, we recommend Harris and colleagues review (Harris et al., 2020). One such assessment tool is the Test of Mobile Phone Dependence (TMD; Chóliz, 2012), a questionnaire designed for evaluating the main dimensions of PSU in adolescence. We choose to investigate the TMD because it is well-known, widely used, and has shown very good psychometric properties (Harris et al., 2020). The questionnaire consists of 22 items grouped into three factors: (a) Abstinence, (b) Lack of Control and problems derived from the use, and (c) Tolerance and interference with other activities.

The objective of this study is to validate the Italian version of the TMD for adolescents, so that it can be easily and reliably used by practitioners and researchers. Considering that, to our knowledge, an Italian version is not available, this study aims to adapt the TMD to the Italian language and investigate its factor structure and indicators of reliability and validity for the scores of this questionnaire in an adolescent sample. Given that the original and several versions of TMD in other languages showed a three-factor solution, the first purpose of this study is to evaluate the factor structure of the TMD using a Confirmatory Factor Analysis (CFA). Secondly, we aim to establish the reliability of the TMD through Item Analysis. Thirdly, we want to establish the construct validity of the TMD by correlating its scores with relevant information (e.g., perceived self-efficacy, duration of use pattern). Finally, we aim to understand whether and how the TMD scores correlate with nomophobia scores with an exploratory intent.

Method

Sample and Procedure

The data used in this study come from four surveys conducted in three different Italian schools, two in the north (surveys 1 and 2) and one in the south (both surveys 3 and 4) of Italy. Data collection started in March 2019 and ended in February 2020. All surveys had been individually approved by the Research Ethics Board of Milano-Bicocca University.

The four surveys had a similar structure (Table 1). All started by asking the participant's mobile phone usage time pattern. Following, the TMD and, in survey 1 and 2, the nomophobia scale were administered. Then, an experimental manipulation was presented to half of the participants, who were asked to provide three reasons why they would reduce the use of the smartphone. In survey 1, 2, and 3, the survey continued with two other scales, measuring the intention to reduce smartphone usage and perceived self-efficacy. Survey 4, after the manipulation, continued with the intention scale as in survey 1, 2, and 3, followed by additional questions about how participants use the phone (e.g., to stay informed of family and friends' lives, not to get bored). Finally, all the surveys finished by asking participants' gender and age.

Before administering the survey, all participants had to collect the consent to participate from their parents. If parents had not signed the informed consent, the pupils were allowed to fill in the survey, but their questionnaires were not collected, and, thereby, we did not use their answers in the analysis. Paper and pencil questionnaires were administered collectively in class under the supervision of one of the authors and their teacher's presence. All participants were informed that the data collection was anonymous and that they could withdraw from the study at any time.

Overall, 820 students answered the surveys. Of these, we excluded participants who did answer less than 25% of the questions ($n = 3$, survey 1 and 2). Other exclusion criteria were: having received the first smartphone at 0 or 1 year of age ($n = 3$, survey 1) or if participants had never received a smartphone ($n = 1$, survey 1).

The final sample was composed of 813 students, 51.3% of whom were female, and the mean age was 12.96 years old

Table 1 Overview of the surveys: Sample structure and measures relevant for the present investigation and descriptive statistics

		Survey				
		Survey 1	Survey 2	Survey 3	Survey 4	Total Sample
Number of Observation		271	302	89	158	820
Number of Removed Observations		6	1	0	0	7
Survey Structure						
Usage Duration		✓	✓	✓	✓	
TMD		✓	✓	✓	✓	
NMP-Q		✓	✓	×	×	
Manipulation*		✓	✓**	✓	✓	
Self-Efficacy		✓	✓	✓	×	
Gender		✓	✓	✓	✓	
Age		✓	✓	✓	✓	
Descriptive Statistics						
Manipulation	N Control (%)	126 (48%)	98 (33%)	42 (47%)	81 (51%)	347 (43%)
	N Experimental (%)	139 (52%)	203 (67%)	47 (53%)	77 (49%)	466 (47%)
Gender	N Female (%)	127 (47%)	161 (55%)	48 (56%)	73 (47%)	409 (51%)
	N Male (%)	123 (48%)	130 (45%)	37 (44%)	81 (52%)	371 (47%)
	N Prefer no answer (%)	12 (5%)	4 (1%)	0 (0%)	1 (0.6%)	17 (2%)
Age	Min	11	11	13	13	11
	Max	15	15	16	17	17
	Mean	12.25	12.30	13.82	14.90	12.96
	SD	0.95	0.92	0.49	0.77	1.38

Note. In all studies, the measures were displayed in the same order. TMD = Test of Mobile Phone Dependence; NMP-Q = Nomophobia Questionnaire. ✓ the measure was used, × the measure was not used.

* In all studies, half of the participants were randomly assigned to either experimental or control conditions. Participants in the control condition did not respond to the experimental manipulation but proceeded directly with the next scale.

** In the second survey there were two experimental conditions and one control condition.

(SD = 1.38, range = 11–17 years old). On average, participants received their mobile phone at ten years old (SD = 1.56), and half of them reported to spend three or fewer hours on their smartphone in a typical day. Similarly, half of the participants reported having spent three or fewer hours on their smartphone the day before the survey administration.

Measures

Following, we describe the measures used in the four surveys, in the order in which they were administered.

Mobile Phone Duration of Use

We asked participants at what age they received their first mobile phone, how many hours they used the mobile phone the day before the survey, and how many hours they used the mobile phone in a typical day (i.e., "Usually (i.e., on an 'average' or 'typical' day), how long do you use your mobile phone?").

Test of Mobile Phone Dependence (TMD; Chóliz, 2012)

The TMD is composed of 22 items, designed according to the criteria contained in DSM-IV-TR for dependence disorders. The first ten items (e.g., "When I am bored, I use my mobile phone") are answered on a Likert scale ranging from 0 (never) to 4 (frequently). For the 12 remaining items (e.g., "I need to use my mobile phone more and more often") respondents used a Likert scale ranging from 0 (completely disagree) to 4 (completely agree). The test demonstrated good reliability (Cronbach's Alpha = .94; datum from original study). In this study, missing data were imputed with the median value of the item (n = 75 missing answers spread on 22 items). The TMD total score was calculated as the average of the items. Higher values are considered as indication of higher levels of PSU. In this investigation, the PSU mean score was 1.67 (SD = 0.68; n = 813).

The 22 items are grouped into three factors that compose the PSU dimension. The first factor, Abstinence, consists of nine items (8, 11, 13, 14, 15, 16, 20, 21, and 22). It refers both to the discomfort felt when unable to use mobile phones and to the use of these phones to alleviate psychological problems. The second factor, Lack of Control, consists of six items (1, 2, 3, 4, 7, and 10) that refer to the difficulty of stopping mobile phone use despite efforts to do so and to related problems. Finally, the third factor, Tolerance and interference with other activities, consist of seven items (5, 6, 9, 12, 17, 18, and 19), which refer to increasing use and interference with other important activities. In this study, we aimed to confirm this factorial structure through a Confirmatory Factor Analysis (CFA).

Nomophobia Questionnaire (NPM-Q; Yildirim & Correia, 2015)

The questionnaire includes 20 items (e.g., "I would feel uncomfortable without constant access to information through my mobile phone"), rated using a Likert scale ranging from 0 (Strongly Disagree) to 4 (Strongly Agree). The questionnaire demonstrated good reliability (Cronbach's Alpha = .95; datum from original study).

In this study, missing data were imputed with the median value of the item (n = 89 missing answers spread on 20 items). The NPM-Q total score was calculated as the average of the items and higher scores indicated higher levels of nomophobia. In our sample, the nomophobia mean score was 1.98 (SD = 0.93; n = 566). The scale showed a satisfactory reliability level in our sample (Cronbach's Alpha = .93).

Perceived Self-Efficacy

The scale consists in ten statements, describing situations in which the use of the smartphone is reduced/impeded (e.g., "How much do I feel able to spend the whole afternoon without the smartphone") or during the performance of other activities (e.g., "How much do I feel able not to watch the smartphone's display while crossing the street"). The participants had to report how they felt able to implement those behaviors on a Likert scale ranging from 0 (not at all capable) to 4 (very capable).

Also in this case, missing data were imputed with the median value of the item (n = 96 missing answers spread on 10 items). The self-efficacy total score was calculated as the average of the items and higher scores indicated higher levels of perceived self-efficacy. In our sample, the mean score of perceived self-efficacy was 2.75 (SD = 0.77; n = 651). The scale showed a satisfactory reliability level in our sample (Cronbach's Alpha = .80).

Statistical Analysis

A CFA tested the internal structure and the validity of the scale. Theoretically, the TMD was expected to assess three sub-factors that compose the PSU dimension. Therefore, the 22 items were subjected to a second-order CFA. In the CFA, the use of Maximum Likelihood, as a method for parameter estimation, assumes that the observed indicators follow a continuous and multivariate normal distribution, which is not appropriate for variables with ordinal categories. Given the ordinal nature of TMD items, we used the Diagonal Weighted Least Squares (DWLS) as a method of parameter estimation, which is well suited for ordinal data (Mîndrilă, 2010). As numerous fit statistics consider different aspects of fit, it has been recommended that researchers should report multiple fit statistics in structural equation model studies (Thompson, 1994). For this reason, a manifold approach was used to assess the model fit. The following fit indices were considered: Chi-square statistics, Comparative Fit

Index (CFI), Tuker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Root Mean-Square Residual (RMSR). Overall model fit was judged using the following cutoff values: For the CFI and TLI, fit is considered adequate if the CFI and TLI values are >0.90, and better if they are >0.95 (van de Schoot, Lugtig, & Hox, 2012); for the RMSEA, values smaller than 0.05 indicate good fit, values between 0.05 and 0.08 indicate acceptable model fit and values greater than 0.10 suggest poor model fit (Hu & Bentler, 1999); for RMSR, values smaller than 0.08 indicate good fit (Hu & Bentler, 1999).

Internal consistency was computed using Cronbach's alpha on all items taken together and, separately, on the items that constitute each latent dimension of the TMD scale. Cronbach's alpha typically ranges from 0 to 1. Internal consistency is suggested to be acceptable when $\alpha > .70$ (De Vellis, 2003). For assessing TMD reliability, we also computed the Alpha if Dropped (AiD) indices as an additional indicator of internal consistency and the Corrected Item-Total Correlations (CITC) as an indicator of item discrimination. CITCs with a value greater than .3 are considered acceptable (Wang, Wang, & Shee, 2007).

The TMD construct validity was evaluated correlating its average scores with the average scores of nomophobia using Pearson correlation, the duration of use items and the average score of the perceived self-efficacy. Specifically, we performed partial Pearson correlations between TMD scores, age of possession of the first mobile phone, and perceived self-efficacy. To provide results that are unaffected by the experimental manipulation, the statistical analyses involving the perceived self-efficacy measure (the only relevant measure that followed the experimental manipulation in the survey) were carried out only on data from participants assigned to the control groups ($n_{control}$ = 264; see Table 1 for further details), because these participants were not administered any experimental manipulation before the measures of interest. We computed partial Spearman correlations between TMD scores, time spent using the mobile phone the day before the survey, and on a typical day. All the correlations were computed partialling out for the variable survey, which indicates to which survey a participant responded.

Finally, we investigated gender and age differences in the TMD total score. Regarding gender, we performed an ANCOVA to control for the effect of survey. Regarding participants' age, we performed a partial Pearson correlation partialling out the effect of survey and age at which participants received their first mobile phone.

Data analyses were performed using R version 4.0.0 (R Development Core Team, 2017) for MacIntosh. Specifically, *lavaan* (Rosseel, 2012) for the CFA, *epmr* (Talbano, 2018) for item analysis, and *ppcor* (Kim, 2015) for computing partial correlations.

Results

Confirmatory Factor Analysis

Given the thresholds for acceptable fit reported above, the CFA suggests that the Italian version preserved the original factor structure of the original TMD. In fact, the majority of goodness of fit indices indicated a satisfactory solution, ($\chi^2(206) = 1042.84$, $p < .001$; TLI = .96; CFI = .96; RMSEA = .071, 90% CI [0.067, 0.075]; SRMR = .073).

Examination of the factor loadings (see Table 2) in the model revealed that the parameters from all three factors to each of their items were all significant, indicating that the items did indeed relate to those factors. All items exceeded the factor loading cutoff value of 0.40 (Stevens, 2001), save two items (item 2 = .27 and item 3 = .38, both on Lack of Control factor). Specifically, the item 2 (i.e., "I have put a limit on my mobile phone use, and I could not stick to it") appears problematic plausibly because it contains two aspects: setting limits, and sticking to them (i.e., it is a double question). Item 3 (i.e., "I have argued with my parents or family members about the cost of my mobile phone") appears problematic, possibly because the type of charges applied to the use of the mobile phone has changed since the TMD scale was developed in 2012. A few years ago, companies used pay-per-use tariffs (e.g., the more you call, the more you pay). Nowadays, flat rates are widespread. Therefore, the cost associated with the use of mobile phones is less of a topic of quarrel now.

Pearson's bivariate correlations between the three latent factors were statistically significant (p's < .001). Abstinence was strongly correlated with Tolerance (r = .60) and with Lack of Control (r = .48). Tolerance showed a medium-to-high correlation with Lack of Control (r = .40). These correlations indicate that the latent dimensions of the TMD are measuring related but not identical constructs, thus showing good discriminant validity (Brown, 2015). A similar correlations pattern was found by Choliz (Chóliz, 2012, p. 37): He found strong correlations between Tolerance and Abstinence (r = .68) and Lack of Control (r = .56), and a medium-to-high correlation between Abstinence and Lack of Control (r = .45).

The three latent factors are significantly related to the second-order PSU factor: All factor loadings range between 0.83 and 0.88.

Overall, the findings revealed that the scale adapted in this study forms a reasonable measurement model, and thereby, provides support for the construct validity.

Reliability

The TMD internal consistency was examined using Cronbach's alpha and demonstrated satisfactory reliability (Cronbach's α = 0.876). For the Abstinence and Tolerance

Table 2 Factor loadings for CFA and model goodness of fit indices

Factor	Item	Unstandardized Loading (SE)	Standardized Loading
First Order			
Abstinence	8. When I'm bored, I use my mobile phone.	0.346 (0.017)	0.623
	11. When I haven't used my mobile phone for a while, I feel the need to call someone, send an SMS, or use WhatsApp.	0.385 (0.019)	0.692
	13. If my mobile phone were broken for an extended period of time and took a long time to fix, I would feel very bad.	0.429 (0.020)	0.772
	14. I need to use my mobile phone more and more often.	0.395 (0.019)	0.710
	15. If I don't have my mobile phone, I feel bad.	0.448 (0.021)	0.805
	16. When I have my mobile phone with me, I can't stop using it.	0.309 (0.016)	0.556
	20. I don't think I could stand spending a week without a mobile phone.	0.342 (0.017)	0.614
	21. When I feel lonely, I use the mobile phone (calls, SMSs, WhatsApp...).	0.366 (0.018)	0.659
	22. I would grab my mobile phone and send a message or make a call right now.	0.404 (0.019)	0.726
Lack of Control	1. I have been called on the carpet or warned about using my mobile phone too much.	0.257 (0.027)	0.508
	2. I have put a limit on my mobile phone use and I couldn't stick to it.	0.136 (0.016)	0.269
	3. I have argued with my parents or family members about the cost of my mobile phone.	0.191 (0.021)	0.378
	4. I spend more time than I would like talking on the mobile phone, sending SMSs, or using WhatsApp.	0.344 (0.036)	0.680
	7. I spend more money on my mobile phone (calls, messages…) than I had expected.	0.319 (0.033)	0.631
	10. I have been criticized because of the cost of my mobile phone.	0.237 (0.025)	0.468
Tolerance	5. I have sent more than five messages in one day.	0.322 (0.025)	0.672
	6. I have gone to bed later or slept less because I was using my mobile phone.	0.278 (0.022)	0.580
	9. I use my mobile phone (calls, SMSs, WhatsApp...) in situations where, even though not dangerous, it is not appropriate to do so (eating, while other people talk to me, etc.).	0.274 (0.022)	0.571
	12. Since I got my mobile phone, I have increased the number of calls I make.	0.293 (0.023)	0.611
	17. Since I got my mobile phone, I have increased the number of SMSs I send	0.341 (0.026)	0.710
	18. As soon as I get up in the morning, the first thing I do is see who has called me on my mobile phone or if someone has sent me an SMS.	0.291 (0.023)	0.606
	19. I spend more money now on my mobile phone now than when I first got it.	0.254 (0.021)	0.529
Second Order			
PSU	Abstinence	1.494 (0.091)	0.831
	Lack of Control	1.707 (0.189)	0.863
	Tolerance	1.830 (0.165)	0.877
Model Goodness of Fit			
χ^2	Df	TLI CFI	RMSEA SRMR
1042.84	206	0.96 0.96	0.071 0.073

Note. All factor loadings and the χ^2 statistic are statistically significant at $p < .001$ level. PSU = Problematic Smartphone Use

factors, Cronbach's alpha demonstrated good internal consistency (Abstinence $\alpha = .85$ and Tolerance $\alpha = .74$). For both factors, the elimination of items did not result in an increase in alpha and the CITC were all above the considered threshold, suggesting good internal consistency and discrimination (see Table 3). The Lack of Control factor, instead, shows an unsatisfactory level of Cronbach's alpha ($\alpha = .58$). Similar to what was found in the CFA, items 2, 3 and, in addition, item 10 show poor capacity for internal consistency discrimination: Both the AiD index and CITC show values below the threshold of acceptability (see Table 3). Similar to item 3, item 10 refers to being criticized for the high costs associated with the use of the mobile phone. The item is probably problematic due to the change in the mobile phone charges from pay-per-use to flat rate.

To understand whether the reliability changes when problematic items (i.e., items 2, 3, and 10) are discarded, we repeated the reliability analysis without those items. Items removal has a slight beneficial effect on the overall scale reliability ($\alpha_{19\ items} = .881$ vs. $\alpha_{22\ items} = .876$), but detrimental on the Lack of Control sub-factor reliability ($\alpha_{19\ items} = .441$ vs. $\alpha_{22\ items} = .584$). To understand whether the number of items considered in computing the PSU average score has an impact on the correlation analyses

Table 3 Mean, standard deviation, reliability estimates, and factors correlations for the TMD Scale

Item	Item Mean (SD)	Corrected Item-Total Correlation	Alpha if Dropped	
1	1.77 (1.13)	0.40	0.900	
2	1.13 (1.27)	0.22	0.904	
3	0.69 (1.12)	0.25	0.903	
4	1.85 (1.33)	0.53	0.897	
5	2.77 (1.43)	0.48	0.898	
6	1.74 (1.37)	0.47	0.899	
7	0.53 (0.91)	0.40	0.900	
8	3.09 (1.09)	0.50	0.898	
9	1.20 (1.20)	0.52	0.899	
10	0.37 (0.86)	0.28	0.902	
11	1.73 (1.36)	0.60	0.896	
12	2.26 (1.45)	0.46	0.899	
13	1.95(1.45)	0.59	0.896	
14	1.50 (1.25)	0.60	0.896	
15	1.11 (1.32)	0.58	0.896	
16	1.44 (1.28)	0.46	0.899	
17	2.83 (1.32)	0.51	0.898	
18	2.01 (1.62)	0.48	0.899	
19	0.73 (1.08)	0.39	0.900	
20	1.74 (1.51)	0.48	0.899	
21	2.84 (1.23)	0.53	0.897	
22	1.41 (1.47)	0.61	0.895	
Correlation between factors and, on the diagonal, Cronbach's Alpha.				
		1	2	3
TMD Total	(0.88)			
1. TMD Abstinence		(0.85)		
2. TMD Lack of Control		.48	(0.58)	
3. TMD Tolerance		.60	.46	(0.74)

presented below, we performed the analyses with both the complete and the short version of the TMD scale. The correlations we found are identical in terms of relationship direction, magnitude, and statistical significance. This means that the results are the same either if we keep or remove the problematic items. For brevity, we reported the results obtained with the complete version of the TMD scale.

Construct Validity

In the construct validity analysis, we assessed the relationship between TMD scores and variables that have a theoretical link. Several partial correlations were calculated between the TMD total score and its three latent factors on the one hand, and pattern usage variables and the self-efficacy scale on the

Table 4 Correlations between the TMD scale and other relevant information assessed through partial Pearson and Spearman correlations

	NMP-Q	Age first mobile	Average usage	Day before usage	Perceived Self-Efficacy
TMD Total	.76	- .28	.53	.53	- .61
TMD Abstinence	.78	- .24	.45	.43	- .54
TMD Lack of Control	.45	- .18	.37	.36	- .54
TMD Tolerance	.60	- .26	.49	.53	- .38

Note. All correlations are statistically significant at $p < .001$ level

other hand, while controlling for the survey variable. Table 4 shows these partial correlations.

Mobile phone usage time, both the day before and the average, is strongly and positively correlated with the total score on the TMD scale and its sub-factors (from .36 to .53, p's < .001). This result is consistent with results reported in the literature, such that individuals with a higher level of PSU show longer usage time (Fischer-Grote et al., 2019).

The age at which the first mobile phone was received is negatively associated with the PSU level, such that individuals receiving the mobile phone at younger ages show higher levels of PSU. Again, this result is in line with the literature showing that the sooner individuals get a mobile phone, the greater the likelihood of developing PSU (Billieux et al., 2008; De-Sola Gutiérrez et al., 2016).

Finally, we found a strong negative relationship ($r = -.61$) between the TMD scores and perceived self-efficacy, which indicates that higher PSU levels are associated with lower perceived self-efficacy in reducing smartphone usage. This result is consistent with the findings reported in the literature and, thus, it positively contributes to the construct validity of the TMD.

Gender, Age, and PSU

To examine possible gender differences in responses to the TMD, we ran an ANCOVA with the total TMD score as the dependent variable, participants' sex as the independent variable, and survey as covariate. Results indicated that participants' gender was significantly related to PSU, and female students showed higher average TMD scores (M = 1.78, SD = 0.70) than male students (M = 1.52, SD = 0.62), F (1, 775) = 28.05, $p < .001$, Cohen's $d = .38$. We did not find a significant interaction between gender and survey, F (3, 775) = 1.92, $p = .125$.

The results also showed that the participants' TMD scores and age were positively related ($r = .20$, $p < .001$), indicating that the mean questionnaire scores increased with age.

Overall, these findings can be taken as supplemental proof of the validity of the TMD scale as the TMD total score is associated with gender and age in theoretically predictable ways. Regarding gender, these results are congruent with the literature (De-Sola Gutiérrez et al., 2016) showing that girls, on average, report relying more heavily on their mobile phones than boys. Regarding age, our result is consistent with the literature indicating that age is significantly and positively related to PSU (Fischer-Grote et al., 2019).

PSU and Nomophobia

For exploratory purposes, we assessed partial correlation between the NMP-Q scores and the TMD total score while controlling for the survey variable (see Table 4). The TMD total score had a strong and positive correlation with the NMP-Q total score ($r = .76$, $p < 0.001$). The correlations between the TMD subscales and the NMP-Q score ranged from .45 to 0.78 ($p < 0.01$), indicating statistically significant, positive and strong correlations. Such correlations pattern suggests that the TMD and NMP-Q assess similar and theoretically related constructs.

Discussion

In this study, the psychometric properties of the Italian version of the Test of Mobile Phone Dependence scale were assessed for the first time. The CFA of the twenty-two TMD items confirmed the three-factor structure. Each latent factor also loaded significantly on the overall PSU dimension. Item analysis demonstrated an overall good internal reliability and consistency of the scale. However, these analyses also showed some problems. There were two items with factor loading below 0.40, namely, Items 2 and 3 (Lack of Control factor), and an item (item 10, Lack of Control factor) that had low CITC. Such problems have impacted the reliability level of their latent factor (i.e., Lack of Control), which is not satisfactory. Thus, further testing must be done to establish whether the TMD scale could benefit from the removal or rewording of these items. For example, in items 3 and 10, the topic of discussion could be changed: Instead of focusing on the costs associated with using the mobile phone, we might ask whether parents criticize or reproach their kids for spending too much time using the mobile phone. Until a more reliable version of the TMD subscale is found, the data collected with it should be treated with caution.

The construct validity was established through a series of correlations, which showed that TMD scores had the same patterns of associations with gender, age, the intensity of usage, age of possession of the first mobile phone, that had already emerged in the literature. Indeed, the TMD scores were positively correlated with the duration of use, both average and the day before the survey, reflecting a common result reported in the literature (De-Sola Gutiérrez et al., 2016; Fischer-Grote et al., 2019). The positive association between TMD scores and participants' age is in accordance with the findings reported in the literature (Gezgin, 2018). Different studies suggest that the relationship between age and PSU takes on a quadratic distribution, such that PSU increases during adolescence (Lee & Ogbolu, 2018) and then decreases during adulthood (Pearson & Hussain, 2016). However, as stated in the introduction, there is insufficient research to make conclusions about the stability and the durability of PSU and, specifically, longitudinal studies should be conducted in this regard (Panova & Carbonell, 2018). The gender differences we observed, are consistent with the general observation that, on average, girls tend to have higher PSU scores than boys (De-Sola Gutiérrez et al., 2016; Fischer-Grote et al., 2019).

This gender difference deserves further investigation. There could be at least two different explanations of such finding: On the one hand, girls may use smartphones objectively in a more problematic way than boys. On the other hand, as a self-report measure, TMD measures how individuals feel or believe to use the smartphone problematically. Thus, a higher level of TMD scores may be due to a greater awareness of girls on how and how much they use their mobile phones. In this sense, future research could complement research on gender differences in problematic use levels by considering the use of indirect measures. Through these tools, for example, one could measure the level of implicit identification with one's smartphone to see whether females show higher identification with their smartphones than males.

The TMD scores are negatively correlated with the perceived self-efficacy. This finding, albeit not directly mirrored in the literature on PSU, is consistent with the Social-Cognitive Theory (Bandura, 2002), which states that self-efficacy is the belief of possessing the skills necessary to attain an objective (e.g., reducing smartphone usage). Individuals who believe they lack such skills will exhibit avoidant behavior and may engage in problematic use of smartphones.

Finally, we explored the relationship between TMD scores and Nomophobia. We found a strong and positive correlation between the two measures. This result means that those who showed higher levels of PSU showed higher levels of nomophobic reaction to smartphone missingness. To date, there is no research that considers either the causal pathways that may relate these two concepts or the fact that nomophobia may lead to problematic use. For example, the norms guiding online communication—the normative expectation to respond to texts, answer calls or update social media—are significant enough to demand perpetual cognitive attention, even while performing other activities (e.g., driving, crossing street). Here, the device is merely a means to fulfil the demands of a person's social role; it is not so much a reductive psychological explanation as it is a conflict of cultural expectations (Kaviani et al., 2020). Thus, much research should address this relationship.

Our study has some limitations. Although self-report measures are extensively used for assessing PSU, the nature of our self-reporting methodology could be a limitation. Responses to explicit measures are valuable, but they may be influenced by many factors such as self-presentation concerns, question comprehension, and the use of appropriate standards of comparison (Perugini, Richetin, & Zogmaister, 2010). Thus, some of the participants may have underreported their problematic behaviors, or they may have different levels of awareness on how and how much they use their mobile devices. In this sense, indirect measures could provide a complementary perspective on PSU that has been neglected so far.

In conclusions, by validating an Italian version of the TMD (Chóliz, 2012), we provide practitioners with a tool for screening Italian adolescents' risk of PSU. The study adds some empirical data concerning the possible determinants of smartphone problematic behavior without establishing a clear causality in the effects. Significant associations were found between these TMD scores, nomophobia, duration of use, participants' age, and gender, alongside a significant negative correlation with self-efficacy.

Code availability The data and materials are available at https://osf.io/x8b7w/?view_only=dc831e3a5d674e03a30c32fba0f7c5f6.

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Data availability The data and materials are available at https://osf.io/x8b7w/?view_only=dc831e3a5d674e03a30c32fba0f7c5f6.

Declarations

Ethics approval Protocol N. 442–19.02.2019 and following amendments.

Consent to participate Before administering the survey, all participants had to collect the consent to participate from their parents. If parents had not signed the informed consent, the pupils were allowed to fill in the survey, but their questionnaires were not collected, and, thereby, we did not use their answers in the analysis.

Consent for publication Participants and their parents were informed that the data collected would be anonymized, analyzed, uploaded to osf and published.

Conflict of Interest We have no conflicts of interests to disclose.

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