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Problematic smartphone use: An empirically validated model

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ABSTRACT

Given the prominent role that smartphones have in everyday life, research in the field has proliferated. From a theoretical perspective, problematic smartphone use (PSPU) is described as a multi-faceted phenomenon entailing a variety of dysfunctional manifestations (e.g., addictive, antisocial and dangerous use). To date, however, there is still a lack of empirical evidence supporting the identification of PSPU as a potential behavioural addiction. Driven by theory, the aim of the present study was to provide an empirically validated model by testing the contribution of specific factors leading to PSPU. Relationships among individual characteristics (internalised psychopathology, impulsivity and personality traits) and PSPU uses (addictive, antisocial and dangerous) were investigated according to the updated version of the theoretical framework provided by the Pathway Model of problematic smartphone use (Billieux et al., 2015). An online survey was administered to a convenience sample ($N = 511$) of smartphone users in order to examine their daily engagement, problematic usage patterns and related psychological correlates. Path analysis revealed important information about different PSPU components and results are discussed in light of the available literature. Recommendations for future research are proposed to further investigate the problematic behaviour, including the study of additional variables, such as the fear of missing out (FoMO), nomophobia and excessive social media use.

1. Introduction

As the advancement of information and communication technologies (ICT) continues to progress at a fast pace, the use of mobile phones and smartphones is drastically increasing. According to the Pew Research Center (Rainie & Perrin, 2017), the share of people who reported owning a smartphone has more than doubled since 2011, reaching 77% of the American population. This percentage sharply rises when considering younger generations, with 92% of 18- to 29-year-olds declaring to be in possession of this device. In the United Kingdom, a recent Mobile Consumer Survey conducted by Deloitte (2017) analysing the usage habits of 4,150 people showed how mobile phone use is affecting daily life, with 66% of 16-19-year-olds admitting to check their phone in the middle of the night and 74% to use it while walking.

From a developmental perspective, it may be concerning that young individuals have been reported to be the most enthusiastic adopters of technology (ITU, 2017; Kuss, van Rooij, Shorter, Griffiths, & van de Mheen, 2013) and that adolescence represents a critical period for the onset of addictive behaviours. Given the on-going neurological, physiological and psychosocial changes in adolescence (Cerniglia et al., 2017; Crone & Konijn, 2018; Meeus, 2011), shedding new light on the psychological factors underlying the onset and maintenance of problematic technology-related behaviours is warranted.

The rapid trend in smartphone adoption is boosted by the wide variety of non-traditional phone activities that can now be carried out while “on-the-go”, such as purchasing items, geo-localizing or banking online (Roberts, Yaya, & Manolis, 2014). Despite the numerous potential advantages, including health promotion practices (Bert, Giacometti, Gualano, & Squilini, 2014) or mobile distance learning (Shin, Shin, Choo, & Beom, 2011), several research findings highlighted a number of harmful or potentially problematic behaviours that can be associated with smartphone use; including dependence-related symptoms (Chóliz, 2010), stress and sleep disturbances (Thomée, Harenstam, & Hagberg, 2011), financial problems (Billieux, Van der Linden, & Rochat, 2008), dangerous driving (Sun & Jia, 2016), or antisocial and prohibited use (Nickerson, Isaac, & Mak, 2008). Moreover, the possibility to be constantly connected to the Internet has been found to enhance the potentially unregulated and excessive use of smartphones for entertainment purposes, such as social networking, video gaming and gambling, or streaming services (Andreassen et al., 2016; James, O'Malley, & Tunney, 2017; Kuss & Griffiths, 2017). Due to the extensive range of opportunities that these devices provide, some scholars stress

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the risk for them to become multi-addictive platforms (Lopez-Fernandez, Kuss, Griffiths, & Billieux, 2015). Importantly, as it has been argued in previous studies, it is not technology, including smartphones, that is addictive *per se;* technology represents a medium, a tool through which individuals can satisfy specific needs by engaging in behaviours than can become problematic and even pervasive, as in the case of checking habits (Baggio et al., 2018; Kuss & Griffiths, 2015; Oulasvirta, Rattenbury, Ma, & Raita, 2012). For instance, people can fulfil their need for relatedness by connecting to online Social Networking Sites (SNSs) the use of which, if excessive and compulsive, may lead to unhealthy outcomes in the emotional, relational and performance spheres (Andreassen, 2015). Addressing the issue, a recent meta-analytic review conducted by Marino, Gini, Vieno, & Spada (2018) evidenced how problematic Facebook use is associated with perceived psychological distress, including symptoms of social anxiety and depression.

In a first comprehensive review of Problematic Mobile Phone Use (PMPU), Billieux (2012) identified particular individual risk factors and psychological characteristics that are related to a dysfunctional use, such as personality traits, impulsivity and low self-esteem. In a follow-up work, Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths (2015) acknowledged that excessive reassurance seeking behaviours and uncontrolled behaviours associated with impulsivity and extraversion may have a relevant impact upon daily functioning and proposed a model where they hypothesized that these factors influence different "pathways" leading to addictive, antisocial and risky patterns of usage.

In recent years, a growing body of evidence has been accumulated in order to provide a further understanding of PMPU within an epidemiological perspective. Among Chinese undergraduates, the prevalence of PMPU was estimated to be 21.3%, with students from high income families and with more perceived stress considered at greater risk (Long et al., 2016). In a study involving British adolescents, Lopez-Fernandez, Honrubia-Serrano, Freixa-Blanxart, & Gibson (2014) reported that 10% of students were classified as problematic users; whilst stressing the difficulty in comparing scientific findings due to the diversity of instruments and classification criteria that are used in research.

As Billieux et al. (2015) advised, however, the amount of available empirical data about PMPU prevalence, aetiology and course at the present time is still scant. Therefore, there is an impelling need to carefully investigate what the World Health Organization (WHO) (2015) has recognised as a public health concern. For example, prolonged or excessive smartphone engagement has been associated with physical health issues (e.g., obesity, impaired vision, musculoskeletal problems), as well as psychosocial problems, such as sleep disturbances, risky sexual behaviours and aggressive behaviours (Thomée et al., 2011; WHO, 2015). Accordingly, a deeper understanding of the psychological processes involved in maladaptive and potentially functionally impairing smartphone use is required (Billieux et al., 2015).

2. Problematic mobile phone use

2.1. Psychopathology and personality traits

As previous research disclosed, higher levels of PMPU have been found to be associated with the construct of impulsivity, corresponding to a diminished impulse control that leads to deregulated actions and short-term based decision-making, and considered as a hallmark of addictive behaviours (Weafer, Mitchell, & de Wit, 2014). Some studies indicated the component of urgency, representing the tendency to experience strong impulses during intense emotional contexts, to be a robust predictor of excessive mobile phone use (Billieux et al., 2008; Billieux, Gay, Rochat, & Van der Linden, 2010). It was postulated that individuals may experience difficulties in deferring the use of the device in order to quickly relieve adverse mood states (Billieux et al., 2010). A recent study conducted in a self-selected community sample also highlighted that the urgency trait mediates the relation between symptoms of Post-Traumatic Stress Disorder (PTSD) and problematic smartphone use (Contractor, Weiss, Tull, & Elhai, 2017).

With the aforementioned purpose in mind, individuals may feel the urge to reach for their smartphone even in risky situations, which might be susceptible to increase driving errors and lead to crashes (Pearson, Murphy, & Doane, 2013). Crucially, it has also been documented that car accidents taking place when people use their phone are more frequently fatal (Violanti, 1998). Car accidents due to mobile phone distraction are particularly frequent in young drivers (Cazzulino, Burke, Muller, Arbogast, & Upperman, 2014). Moreover, in a study that showed the association between impulsivity and dangerous behaviours, Lantz and Loeb (2013) found that a very large proportion of participants (82%), although recognising the dangerousness of texting while driving, was still willing to do it at least sometimes.

According to Billieux et al. (2015), impulsivity traits may also be related to antisocial patterns of usage. Some people may feel compelled to use their smartphones even in the presence of others, potentially causing feelings of rejection or neglect in partners and friends, a phenomenon referred to as "phubbing" (Chotpitayasunondh & Douglas, 2016; Kuss et al., 2018). This behaviour may become a paradox, as individuals disconnect from face-to-face interactions to satisfy their need for social connectedness via their smartphones, reducing the quality of interpersonal relationships (Rotondi, Stanca, & Tomasuolo, 2017).

Moreover, specific personality traits have been identified to be associated with PMPU, including psychological predictors of PMPU (Bianchi & Phillips, 2005). The Big Five personality traits (McCrae & Costa, 1999) were successively examined in many of the studies regarding PMPU (Butt & Phillips, 2008; Hussain, Griffiths, & Sheffield, 2017). Specifically, PMPU was found to be related to higher levels of *neuroticism* (Ehrenberg, Juckes, White, and Walsh, 2008; Takao, 2014), defined as the tendency to experience dysphoric states and emotional instability, such as vulnerability, anxiousness and depressed mood (Costa & McCrae, 1992) and *extraversion* (Augner & Hacker, 2012; Montag et al., 2014), entailing traits of gregariousness, and excitement seeking (Costa & McCrae, 1992). As Bianchi and Phillips (2005) suggested, since especially young extraverts are more inclined to take risks, they may inappropriately use their smartphones in dangerous situations.

Furthermore, the authors of the present paper found lower levels of *conscientiousness* to be connected to Problematic Mobile Phone Use, since this psychological trait is mainly defined by self-control and premeditation (Costa & McCrae, 1992), the lack of which has been found to characterise the construct of impulsivity previously associated with PMPU (Billieux et al., 2008; 2015). This hypothesis is also supported by precedent findings showing that lower levels of conscientiousness were related to the broad concept of Internet addiction (Kuss et al., 2013; Stavropoulos, Kuss, Griffiths, & Motti-Stefanidi, 2016).

In addition to impulsivity and personality traits, excessive mobile phone use was found to be comorbid with other psychopathologies, as in the case of PTSD symptoms (Contractor, Weiss, & Elhai, 2018) or internalised psychopathology, including symptoms of anxiety, stress and depression (Babadi-Akashe, Zamani, Abedini, Akbari, & Hedayati, 2014; Elhai, Dvorak, Levine, & Hall, 2017; Wang, Wang, Gaskin, & Wang, 2015). Smartphones may serve as instruments that guarantee personal safety, especially for individuals with panic disorder (King, Valenca, & Nardi, 2010), and it may be an avoidance strategy of direct interactions for people presenting with social anxiety (Enez Darcin et al., 2016). Smartphones may also be used as a dysfunctional coping mechanism displayed to face negative affect, such as loneliness and interpersonal stress (Murdock, 2013); in a way similar to the use of the Internet as a strategy to cope with adverse emotional states (Kardefelt-Winther, 2014), in accordance with the self-medication hypothesis of addictive behaviours (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Kuss and Griffiths, 2017). Past research demonstrated that deficits in emotion regulation are related to a wide range of psychopathological

symptoms (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Cisler, Olatunji, Feldner, & Forsyth, 2010; Joormann & Gotlib, 2010). For example, difficulties in emotion regulation can be considered as potential risk factors for the development of addictive disorders (Nikmanesh, Kazemi, & Khosravy, 2014). From this perspective, a recent study by Elhai and Contractor (2018) showed that the proneness to rely on specific cognitive emotion regulation strategies (e.g., rumination and cognitive reappraisal) characterizes heavy smartphone users.

Additionally, it is worth noting that, besides being associated with problematic use, some forms of psychopathology, including stress and depression, have also been found in longitudinal studies as outcomes of excessive smartphone use (Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2015; Thomée et al., 2011).

In the absence of interruption of such a maladaptive mechanism, as addressed by Kim, Seo and David (2015), there may be a risk for a vicious cycle between psychopathology and smartphone addiction, so that an increased level of perceived distress may lead to increased smartphone use which, in turn, may inadvertently increase the level of stress. The phenomenon known as *technostress* (Brod, 1984) concerns the negative outcomes and affective consequences derived from an overload of information and communication made available by computer technologies. Innovative research carried out in Korea by Lee, Chang, Lin and Cheng (2014) confirmed that compulsive and continuous smartphone usage was positively associated with users' technostress, paving the way for future studies to explore bidirectional relationships.

2.2. 2 A conceptual framework to study problematic mobile phone use

PMPU is a complex and multi-faceted behavioural pattern, with a heterogeneity of manifestations (e.g., addictive-like symptoms and risky use) and of related risk factors (e.g., comorbid psychopathology, personality traits, and psychological factors). For this reason, Billieux et al. (2015) argued that PMPU should be precisely investigated in its unique features, rather than being considered as a behavioural addiction a priori. Since the issue of identifying the aetiology and course of PMPU is increasing in relevance, the approach of conceptualising it by directly borrowing criteria and screening tools developed for other behavioural addictions (e.g., substance abuse or pathological gambling) is considered an oversimplification (Billieux et al., 2015; Kardefelt-Winther et al., 2017). Moreover, recycling substance use criteria and applying them to common behaviours is susceptible to artificially inflate their prevalence rates and apparent severity (Deleuze, Long, Liu, Maurage, & Billieux, 2018). Altogether, these limitations stress the urgent need to study PMPU based on a theoretically sound approach that avoids a priori recycling what is known from previous substance abuse research. To address the demand for a theoretical rationale for studying PMPU, Billieux et al. (2015) proposed an integrative pathway model to theoretically anchor future research. Basing their work on available data in the literature, they conceptualised the phenomenon within three main pathways: the (1) *excessive reassurance pathway*, (2) *impulsive pathway* and (3) *extraversion pathway*.

According to the authors (2015), the *excessive reassurance pathway* is characterised by a constant need to obtain reassurance from others via smartphones, potentially leading to the development of addiction-like symptoms. Individuals classified as "dependent users" displayed insecure attachment styles and low self-esteem, which may increase their preoccupation with relationship maintenance and lead them to send a larger amount of text messages (Ha, Chin, Park, Ryu, & Yu, 2008; Lu, Katoh, Chen, Nagata, & Kitamura, 2014). Moreover, increased emotional instability is related to addictive use, since people with higher levels of neuroticism, general and social anxiety manifest excessive smartphone engagement (Igarashi, Motoyoshi, Takai, & Yoshida, 2008; Lepp, Barkley, & Karpinski, 2014). As Elhai et al. (2017) underlined, this pathway is relevant to negative reinforcement, as it involves a series of actions (e.g., recurrent smartphone checking) aimed at alleviating negative emotions, such as anxiety and stress.

The second outlined pathway includes *impulsivity* as a core element, a construct which is considered to be particularly critical for the various manifestations of PMPU. The lack of planning and low levels of self-control were regarded as predictors not only of an antisocial pattern of use, as people may feel compelled to use their devices in prohibited areas or act in an aggressive way, but also of an overuse of phones in terms of addictive behaviours and risky behaviours, such as the tendency of phoning while driving (Billieux et al., 2008). This last dangerous pattern of use, which also includes sensation seeking behaviours and unsafe sexting, is mainly defined within the *extraversion pathway*. According to Billieux et al. (2015), this pathway describes individuals who experience a persistent need for stimulation and high sensitivity to rewards; they regularly desire to pursue activities of pleasure and excitement, which could result in risky behaviours (e.g., using the phone in a cognitively demanding situation) or to a need to constantly communicate with others. These hedonic behaviours are typically enacted to promote positive mental states; nevertheless, if performed without an adequate level of self-control, they may become hazardous, as it can happen in young extravert drivers with the tendency of underestimating dangers (Bianchi & Phillips, 2005).

Given the connections among traits and behaviours, Billieux et al. (2015) suggested that the three PMPU pathways should not be accounted for as mutually exclusive; indeed, interactions among different factors may occur in certain cases of problematic mobile phone use.

2.3. 3 aim of the present research

Although clearly outlined, the pathway model of problematic mobile phone (Billieux et al., 2015) as a whole has not yet been supported by direct empirical evidences, although some aspects of the model (e.g., one of the specific pathways postulated) received preliminary support in recent studies. In addition to this, fast-paced technological developments have led to the adoption of smartphones (i.e., Internet-enabled phones), which warrants an updated conceptualisation of problematic mobile phone use, which will be referred to as Problematic Smartphone Use (PSPU) in this paper. To date, there is still a lack of theory-driven empirical research aimed at testing and validating a PSPU model; this will corroborate the scientific knowledge in the field and offer researchers and practitioners a reliable guide for a better specification and understanding of the condition. Providing initial support to the model would therefore constitute a useful step in the process of investigating the phenomenon.

To address this gap in research, the aim of the present study is to test the updated pathway model (Kuss et al., 2018), by providing evidence using empirical data collected from a population of smartphone users. The three elucidated patterns of PSPU (addictive use, antisocial use and dangerous use) were considered to be important categories. On the basis of the previously discussed findings in the literature, the main contributing factors of internalised psychopathology, personality traits and impulsivity were examined in the model. The following a priori hypotheses were formulated. First, the excessive reassurance pathway and impulsive pathways might both result in *addictive use.* Indeed, addictive patterns of use might be both promoted by impulsive personality and/or an overwhelming need to cope with negative affect. Second, *antisocial use* could primarily depend on the impulsive pathway. Third, *dangerous use* might be influenced by both the impulsive and the extraversion pathways. In line with the suggestion made by Billieux et al. (2015), the three pathways were not considered as mutually exclusive, as it may occur that in certain cases of PSPU, the pathways are associated with one another, and therefore interactions between them have been postulated, as shown in Fig. 1.

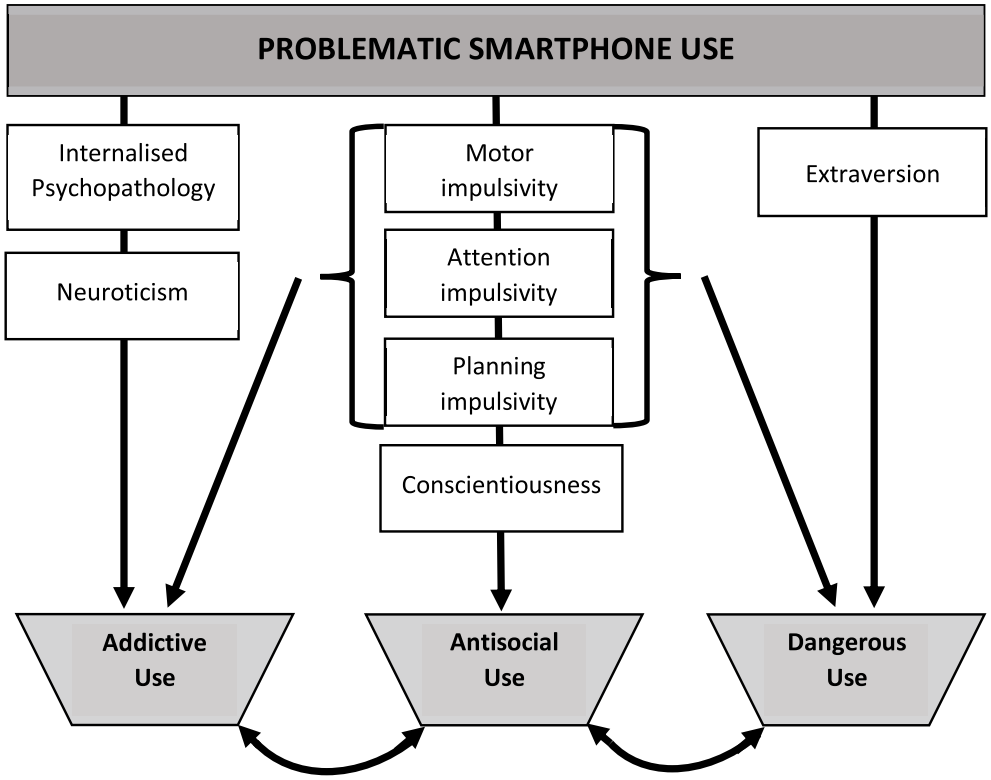


Fig. 1. A Diagram showing the Variables and Pathways tested in the PSPU Model.

3. Method

3.1. Study design

With the aim of providing preliminary empirical evidence to the pathway model of PSPU, the present study used a quantitative methodological approach. An online survey was administered to investigate mobile experiences, personality and PSPU. This survey was conducted using the survey hosting software Qualtrics. To explore the different patterns of mobile phone usage, the updated PMPU-Q-R (Kuss et al., 2018) was administered to a population of smartphone owners. The survey comprised three validated clinical instruments that together contributed to the assessment of the psychological factors hypothesized to be related to problematic smartphone use. The Depression, Anxiety and Stress Scale-21 (Lovibond & Lovibond, 1995) was included as a measure for internalised psychopathology. In order to investigate the dimensions of impulsivity and personality traits, the Barratt Impulsiveness Scale-15 (Patton, Stanford, & Barratt, 1995; Spinella, 2007) and the Big Five Inventory-10 (Rammstedt & John, 2007) were adopted, respectively. Another study, aiming to validate an updated version of the PMPU-Q-R, has already been published based on the current dataset (Kuss et al., 2018).

3.2. Study recruitment

Data for this study came from a sample comprising 511 smartphone users, recruited via snowball sampling and university participants-recruitment pools. Participants were invited to access the online survey by clicking on a web link provided. In order to engage smartphone owners, offline advertisements were distributed through university networks and online advertisements were posted on social media and academic platforms as they constitute virtual spaces highly visited on a daily basis. Online announcements were released on commonly used forums, Facebook, Twitter and Reddit networks. A requisite condition to be eligible for the study was the possession and usage of a smartphone and fluent or native English language skills.

3.3. Ethical considerations

Participants provided informed consent before taking part in this study. If a participant was under the age of 18, consent from a parent or guardian was required. Participation was entirely voluntary and respondents were given the opportunity to withdraw the data from the study at any stage. All personal information were stored securely on a protected database, and, at the completion of the research, all identifying information was destroyed. This study received ethical approval by the Business, Law, and Social Sciences Ethics Committee at Nottingham Trent University and it complied with the ethical regulations and codes of the British Psychological Society.

3.4. Participants' Socio-demographics

The mean age of participants was 25.5 years old (SD = 9.9), ranging from 13 to 68 years. Participants were primarily females (78.3%), from the United Kingdom (91.9%) and with further education (55.9%). Of the participants, 44.7% reported owning a smartphone for 5–10 years and 27.9% for more than 10 years. Table 1 shows the details of the demographics of the sample included in this study.

Participants were encouraged to answer some questions on their smartphone use. Specifically, inquiries regarded the number of calls and texts per day, as well as the amount of time spent on their device. Questions were formulated similarly to the following example: “On average, how many times do you make calls with your mobile phone?”. The majority of participants (93%) made up to five calls per day. Texts per day were more equally distributed with 9.8% participants reporting 0–5 texts per day, 12.5% reported sending 5–10 texts per day, 16% reported 20–30 texts per day, 7.6% reported 30–40 texts per day, and a high percentage of participants (38%) reported sending more than 40 texts per day. Of the subjects, only 2% estimated spending less than 30 min in terms of time on the phone per day, 6.6% estimated 30 mins-

Table 1
Survey participant demographics.

Participant Demographics	*n* (%)
Gender	
Male	107 (20.9)
Female	401 (78.3)
Prefer not to say	3 (0.06)
Country of Origin	
United Kingdom	470 (91.9)
USA	10 (0.2)
Ireland	4 (0.8)
Other	27 (5.3)
Level of Education	
No formal qualifications	4 (0.8)
GCSEs	13 (2.5)
Further education	286 (55.9)
Vocational qualifications	8 (1.6)
Higher education	122 (23.8)
Postgraduate Degree	79 (15.4)
No. of years owned a Mobile Phone	
< 1 year	43 (8.4)
0–2 years	76 (14.8)
3–4 years	20 (3.9)
5–10 years	229 (44.7)
> 10 years	143 (27.9)

Note. Rounding may have led to percentages that do not equal 100.

Table 2
Details of phone use questions.

Self-reported calls per day	*n* (%)
0-1	262 (51.2)
2-5	214 (41.8)
5-10	27 (5.3)
> 10	8 (1.6)
Self-reported texts per day	*n* (%)
0-5	50 (9.8)
5-10	64 (12.5)
10-20	82 (16)
20-30	79 (15.40
30-40	30 (7.6)
> 40	198 (38.7)
Self-reported time spent on phone p/day	*n* (%)
< 30 min	10 (2)
30 mins-1 hour	34 (6.6)
1–2 h	134 (26.2)
3–5 h	219 (42.8)
5–10 h	92 (18)
> 10 h	22 (4.3)

Note. Rounding may have led to percentages that do not equal 100.

1 hour, 26.2% estimated spending 1–2 h, 42.8% estimated 3–5 h, 18% estimated 5–10 h and the remaining 4.3% estimated spending more than 10 h on the phone per day. The details of responses to the phone use questions are outlined in Table 2.

The frequency in the use of applications accessed through the mobile phone was measured using an 8-point Likert-scale. Participants were asked to rate their use from 1 = "least frequently used app" to 8 = "most frequently used app". According to the results, the three most frequent uses of smartphones included, in order: social networking (74%), texting (61%) and browsing (60%). The least frequent uses of smartphones included: gaming (7%) and looking for information about health (6%). The frequencies in the use of smartphones for calls, banking and shopping were more evenly distributed, suggesting individual preferences.

3.5. Validated measures of assessment

3.5.1. Problematic Mobile Phone Use Questionnaire

In order to measure the different smartphone use patterns, a recently validated 17-item version of the Problematic Mobile Phone Use Questionnaire was administered (Kuss et al., 2018). This instrument has been developed as an updated revision of the original PMPU-Q, originally conceived by Billieux et al. (2008) to assess both actual use and problematic use. The questionnaire examined, through the use of 16 questions rated on a 4-point Likert-scale, three facets of PSPU, with higher scores suggesting more problematic use: (1) *addictive use (7 items)*, reflecting perceived dependence on the smartphone (e.g., "It is hard for me to turn my mobile phone off", item 5; "I feel lost without my mobile phone", item 7); (2*) antisocial use (7 items)*, entailing the tendency to use mobile phones in contexts where they are banned (e.g., "I don't use my mobile phone in a library, cinema or hospital", item 10; "I try to avoid using my mobile phone when people need silence", item 12); (3) *dangerous use (2 items)*, which consists of an unequivocally risky behaviour (e.g., "I use my mobile phone while driving", item 13; "I try to avoid using my mobile phone when driving on the motorway", item 16). A more detailed analysis of the respective items and subscales is provided in the validation paper (Kuss et al., 2018).

The original fourth subscale of "financial problems" was excluded from the questionnaire, due to recent research findings showing its inconsistency as actual problematic use (Hanafizadeh, Keating & Khedmatgozar, 2014). According to another study conducted using the same dataset, the three-factor solution exhibited an adequate fit to the data in Confirmatory Factor Analysis (CFA) and most of the indexes of model fit presented acceptable values to fit the variance in scores (Kuss et al., 2018). The calculated Cronbach's alpha for this measure indicated good reliability ($\alpha = 0.86$). The PMPU-Q was therefore considered a valid instrument to assess different types of dysfunctional behaviours related to smartphone use.

3.5.2. Internalised psychopathology

Since previous findings reported that excessive and addictive use of mobile phones was associated with symptoms of anxiety, depression and general distress (Boumosleh & Jaalouk, 2017; Elhai et al., 2017; Jeong, Kim, Yum, & Hwang, 2016; Panova & Lleras, 2016), the present research included measures of internalised psychopathology to investigate its relation with PSPU and perceived dependence. In particular, the Depression Anxiety Stress Scale-21 was adopted as a highly used self-report instrument for these three constructs, presenting excellent levels of reliability and internal validity (Henry & Crawford, 2005; Osman et al., 2012). This is a short-version of the original 42-item scale developed by Lovibond and Lovibond (1995) and it is used to assess symptoms of negative affectivity experienced in the previous two weeks by means of a 4-point Likert scale, from 0 = "Did not apply to me at all" to 3 = "Applied to me very much". The DASS-21 consists of three main subscales and a total scale specifically conceived to evaluate the dimensions of (1) depression (dysphoria, inertia and anhedonia, hopelessness, devaluation of life), (2) anxiety (autonomic arousal, subjective experience, situational anxiety and skeletal muscle effects) and (3) stress (impatience, hyperarousal, difficulty relaxing, overreaction). Example items are as follows: "I felt that life was meaningless" (item 21) for depression, "I experienced breathing difficulty" (item 4) for anxiety, and "I found it hard to wind down" (item 1) for stress.

We initially intended to use the DASS scale in the original three factor format, with stress, anxiety, and depression subscales. However, exploratory analyses indicated strong correlations between the three facets of the DASS and high variance inflation factors (VIF) for the three subscales, as evidenced in Table 3. This was a strong indication of multi-collinearity between the DASS subscales, which can obscure true predicted relationships between variables (Toebe and Cargnelutti Filho, 2013). Thus, to ensure an accurate statistical analysis not adversely impacted by the relationships between the DASS subscales, we decided to combine the depression, stress, and anxiety scores to use overall indication of participant internalised psychopathology. This method was recommended for multicollinearity issues within path analysis by

Table 3
Correlation and VIF scores between internalised psychopathology subscales.

Variable	VIF	1	2	3
1. Stress	2.98			
2. Anxiety	2.53	.69**		
3. Depression	3.34	.75**	.73**	

Note. Significance Codes in comparison with models: *p < .05. **p < .01. ***p < .001. Values are reported to two decimal points.

Billings and Wroten (1978). Moreover, combing the DASS scores was conceptually acceptable as psychopathology scores are often comorbid and symptoms for depression, stress and anxiety can have similar presentations (Caspi & Moffitt, 2018). However, it must be noted that multicollinearity reduces the predictive power to determine which symptoms of psychopathology may have a stronger impact in the proposed model (Billings & Wroten, 1978). As a single measure of internalised psychopathology within our sample, reliability analysis indicated excellent reliability across the scale items (α = 0.94).

3.5.3. Impulsivity

The multi-faceted construct of impulsivity (Enticott & Ogloff, 2006) was considered important to be investigated, as several researchers have found it to be related to PMPU (Billieux et al., 2008; Lopez-Fernandez et al., 2015; Mei et al., 2018). More specifically, to measure the different aspects of the construct, a short form of the Barratt Impulsiveness Scale was included in the survey (Patton et al., 1995; Spinella, 2007). This widely used tool assesses three distinct impulsivity components: (a) *nonplanning*, such as the lack of future orientation or forethought (e.g., "I say things without thinking", item 3), (b) *motor impulsivity* (e.g., "I act on the spur of the moment", item 2), and (c) *attention impulsivity*, that is the inability to focus attention or to concentrate (e.g., "I am restless at lectures or talks", item 11). Items were rated on a 4-point Likert scale ranging from 1 = "rarely/never" to 4 = "almost always". As Spinella demonstrated (2007), the BIS-15 Cronbach's alpha for the total scale was very good (α = 0.81) and the test-retest reliability was high (r = 0.79), according to the findings of Meule et al., (2015). Excellent reliability for the scale was also found within the present sample (motor impulsivity α = .82, attention impulsivity α = .72, non-planning impulsivity α = .8).

3.5.4. Personality traits

In the present research, the personality dimensions of Neuroticism, Extraversion, and Conscientiousness were selected as personality traits consistent with modelled problematic smartphone use (Billieux et al., 2015; McCrae & Costa, 1999). These were measured by using the Big Five Inventory-10 (Rammstedt & John, 2007), an abbreviated version of the original BFI-44. The BFI-10 was a short self-report questionnaire that invited participants to describe their personality by completing the sentence "I see myself as someone who..." on a 5-point Likert scale. Examples include: "is relaxed, handles stress well" (item 4), for the domain of *Neuroticism*, and "does a thorough job" (item 8), for the domain of *Conscientiousness*. Results from multiple samples and for two languages showed acceptable psychometric properties of the instrument in terms of test-retest reliability, convergent and discriminant validity (Rammstedt & John, 2007). In the present study, reliability for these two item subscales was calculated by correlation scores (Eisinga, Te Grotenhuis, & Pelzer, 2013), which indicated that the two items worked significantly and moderately well together (extraversion $r = 0.45$, $p < .01$, conscientiousness $r = 0.3$, $p < .01$, neuroticism $r = 0.42$, $p < .01$).

3.6. Model analysis

Path analysis was conducted in order to test the fit of the correlation matrix against models (Garson, 2013). This method is useful to determine the fit of a priori theoretical models, as it allows the testing of a complex set of relationships amongst variables. Unlike latent variable analysis, this method does not allow to determine the impact of individual scale items to the fit of the model. However, in the present study and as noted in the preceding section, the reliabilities of the measured variables in this study were good to excellent. Furthermore, by using path analysis, we are afforded an overarching view of the magnitude and significance of the hypothesized relationships (Garson, 2004; Stage, Carter, & Nora, 2004), thus meeting the aim of empirically testing a theoretically postulated model. Moreover, the sample size obtained in this study allows for a robust manifest variable analysis (i.e., path analysis), with greater predictive power than a latent variable analysis of this size.

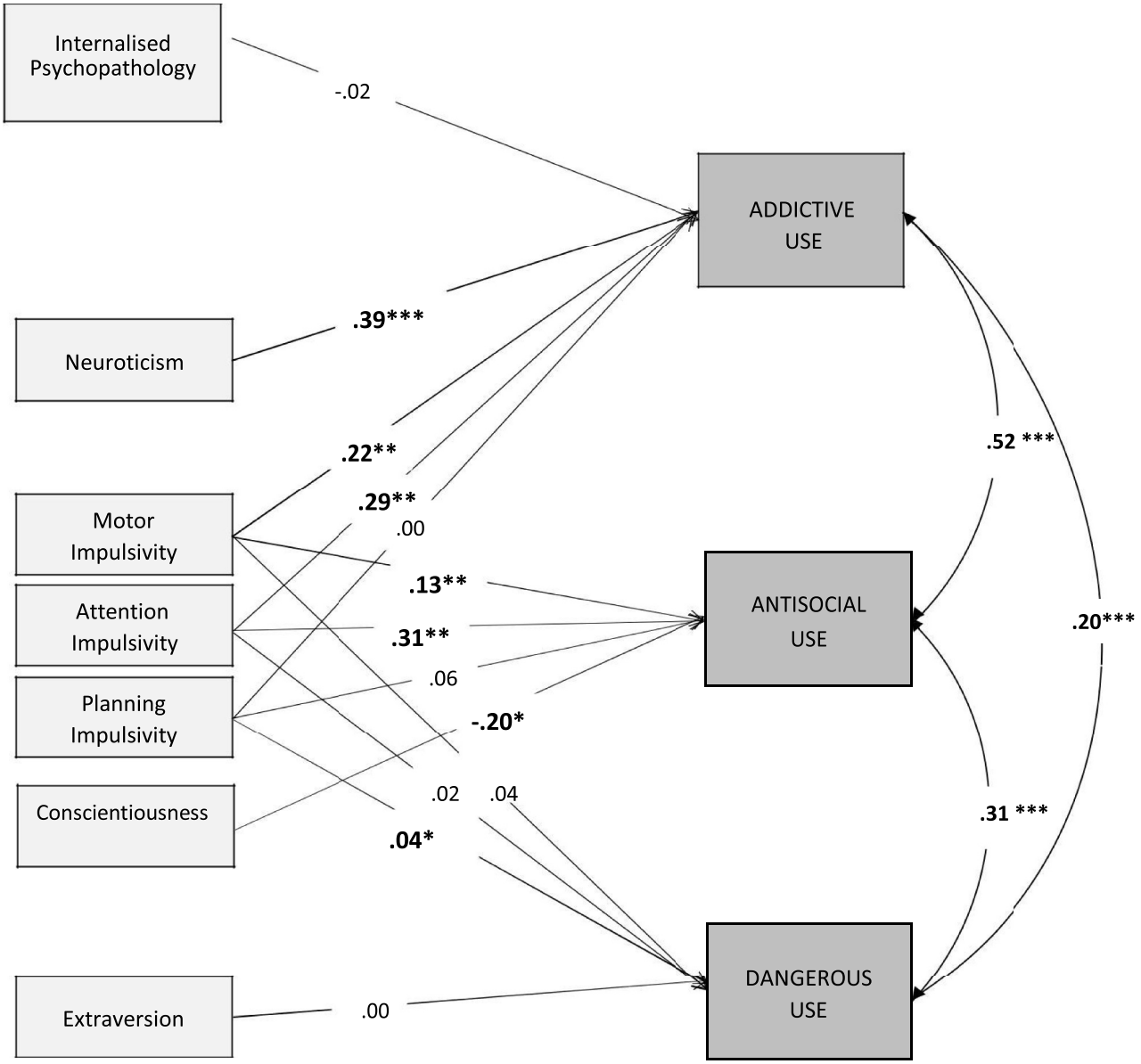
As depicted in Fig. 1, starting from the theoretical model proposed by Billieux et al. (2015), the authors provided a parsimonious explanation of PSPU by conceptualising the phenomenon under consideration within three main patterns of use: (1) *addictive use*, (2) *antisocial use* and (3) d*angerous use*. The variations between the tested models were due to the differential relationships between the variables considered. From this perspective, two alternative pathways models were implemented and tested to empirically explore the phenomenon in the different facets identified to date and to assess the relative importance of different causal paths to the endogenous variables under investigation (Garson, 2004):

Model 1: This model nested the relationships between variables as recommended by Billieux et al. (2015) and in relation to our a priori hypotheses (see Fig. 2) Accordingly, the predictor variables of impulsivity impacted all the three pathways. There were three pathways to problematic smartphone use: (1) internalised psychopathology, neuroticism and impulsivity (motor, attention, and planning) which impacted on *addictive use*; (2) as reported in Model 1, impulsivity (motor, attention, planning) and conscientiousness impacted on *antisocial use*; and (3) extraversion and impulsivity (motor, attention, and planning) impacted on *dangerous use*. Additionally, a co-varying relationship among the three patterns of Problematic Smartphone Use was specified, as the outcome variables of the three pathways were not considered as mutually exclusive (Billieux et al., 2015).

Model 2. The second model was designed as an alternative model to be compared with the hypothesized model. The psychological factors in each pathway, regarded as predictor variables, independently impacted on one outcome variable corresponding to a different pattern of use: (1) internalised psychopathology and neuroticism impacted on *addictive use*; (2) impulsivity, in all its facets, namely motor, attention and planning, and conscientiousness impacted on *antisocial use*; and (3) extraversion impacted on *dangerous use*. This model was designed as an alternative model to be compared with the hypothesized model. The statistical computations were performed in the R 3.4.4 package "Lavaan" as it provides a wide variety of useful tools for the analysis of latent variable models, including path analysis (Rosseel, 2012). To gain a precise understanding of the fit of the models to the data, models were compared to threshold fit indices suggested by Hu and Bentler (1999). A model showing good fit to the data was expected to report CFI > .93, TLI > 0.93, RMSEA 0.05 < x < 0.08 for good fit, SRMR < 0.05. Regression estimates for each path and covariance estimates were calculated.

4. Results

Correlations between the variables were explored to examine the proposed relationships between the variables. As documented in the methods section, there was indication of possible multicollinearity between the internalised psychopathology measures, and therefore we combined the scale scores to produce one overarching measure of internalised psychopathology. All other correlations were acceptable, and therefore model analysis proceeded. Table 4 demonstrates the



Note. B = standardized regression coefficient; *SE* = standard error; Significance Codes in comparison with models: *p < .05. **p < .01. ***p < .001. Values are reported to two decimal points.

Fig. 2. A Pathway Model of Problematic Smartphone Use. *Note.* B = standardized regression coefficient; Significance Codes in comparison with models: $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Values are reported to two decimal points.

correlations between predictors in this analysis (see Table 5).

The model evaluation section is divided into two parts. In order to define the best-fitting model, a Satorra-Bentler calculation was conducted to compare the fit of the hypothesized model to the alternative non-nested model (Satorra & Bentler, 2001). Model 1 (χ^2 (8) = 28.88, $p < .01$) was compared to Model 2 (χ^2 (14) = 68.12, $p < .001$), and the comparison between the two models showed significant values (χ^2 (6) = 34.84, $p < .001$).

Model 1 and Model 2 were both compared to the Null Model (χ^2 (21) = 120.54, $p < .001$). As expected, the reported values from the statistical computations for the Null Model showed the poorest model fit. Thus, the proposed models predicted the variations in scores more adequately than no model. Furthermore, comparisons of the model fit indices showed an overall better goodness of fit for Model 1 compared with Model 2. The Comparative Fit Index value of Model 1 (0.93) was higher than CFI value for Model 2 (0.83) and only for Model 1 did this figure suggest adequate model fit. The Tucker-Lewis Index value of Model 1 (0.8) was higher than TLI value of Model 2 (0.71), although both values fell outside of the ideal threshold for model fit in this statistic. Model 1 Root Mean Squared Error of Approximation was equal to 0.07 (90% C.I. = 0.05–0.1), and it indicated a fit close to good to the analysed data of the model. The calculated value for the Standardized Root Mean Square Residual (0.02) demonstrated excellent fit of Model 1. To sum up, these data confirmed that Model 1 reported the best goodness of fit. This supports the notion that the hypothesized nested Model 1 was preferable to the alternative non-nested Model 2.

The regression estimates of the hypothesized Model 1 largely reflected the expected directional relationships between predictor variables within each pathway, as demonstrated in Table 6. Regarding addictive mobile phone use, higher neuroticism scores predicted greater smartphone addiction scores ($r = 0.39$, $p < .001$). Additionally, there were significant positive relationships between two

Table 4
Means, standard deviations and correlations of model variables with confidence intervals.

Var.	M	SD	1	2	3	4	5	6	7	8	9
1. Intern Psychopat	14.72	11.54									
2. Extrav	6.40	2.03	-.14** [-.23,-.06]								
3. Consc	6.70	1.74	-.19** [-.27,-.10]	.02 [-.07,.10]							
4. Neurot	6.38	2.11	.49** [.42,.56]	-.26** [-.34,-.17]	-.16** [-.24,-.07]						
5. Motor Imp	10.60	3.05	.26** [.18,.34]	.30** [.22, .38]	-.24** [-.32,-.15]	.02 [-.07,.11]					
6. Non planning Imp	11.79	3.44	.10* [.01,.19]	.14** [.05,.22]	-.37** [-.44,-.29]	.00 [-.09,.09]	.26** [.17,.34]				
7. Att Imp	10.69	2.79	.32** [.24,.40]	.07 [-.02,.15]	-.34** [-.42,-.26]	.27** [.18,.35]	.32** [.24,.40]	.25** [.16,.33]			
8. Dangerous Use	2.87	1.27	.00 [-.08,.09]	.08 [-.01,.17]	-.04 -.13,.04]	-.14** [-.23,-.06]	.14** [.06,.23]	.14** [.05,.23]	.10* [.02,.19]		
9. Antisoc Use	14.63	3.85	.17** [.09,.25]	.14** [.05,.22]	-.24** [-.32,-.16]	.10* [.01,.19]	.24** [.15,.32]	.18** [.09,.26]	.31** [.23,.39]	.34** [.26,.41]	
10. Addict Use	**18.42**	**4.59**	**.16** [.07,.24]**	**[-.02,.16]**	**-.18** [-.26,-.09]**	**.20** [.12,.29]**	**.19** [.10,.27]**	**.08 [-.01,.16]**	**.25** [.17,.33]**	**[.10,.27]**	**.55** [.48,.61]**

Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation. Significance Codes in comparison with models: $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Values are reported to two decimal points.

Table 5
Comparison of model fit statistics for model 1, model 2 and the null model.

Model	Df	χ^2	p	CFI	TLI	RMSEA	SRMR
Null Model	21	120.54	$< .001^{***}$	.68	.64	.10	.10
Model 1	8	28.88	$< .01^{**}$	.93	.8	.07	.02
Model 2	14	68.12	$< .001^{***}$	.83	.71	.09	.07

Note. χ2 = Chi-Square value, CFI = Comparative Fit Index, TLI = Tucker–Lewis Index, RMSEA = Root Mean Squared Error of Approximation, SRMR = Standardized Root Mean Square Residual. Significance Codes in comparison with models: $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Values are reported to two decimal points.

Table 6
Correlation coefficients among the variables and covariances between pathways of model 1.

Path	B	*SE*	p
Regression estimates for each path			
Addictive Use			
~ Internalised Psychopathology	-.02	.02	.3
~ Attention Impulsivity	.29	.08	$< .001^{**}$
~ Motor Impulsivity	.22	.07	$.01^{**}$
~ Planning Impulsivity	.00	.06	.95
~ Neuroticism	.39	.1	$< .001^{***}$
Antisocial Use			
~ Attention Impulsivity	.31	.07	$< .001^{***}$
~ Motor Impulsivity	.13	.06	$.01^{**}$
~ Planning Impulsivity	.06	.06	.25
~ Conscientiousness	-.20	.09	$.02^{*}$
Dangerous Use	.00	.03	.94
~ Extraversion			
~ Attention Impulsivity	.02	.02	.31
~ Motor Impulsivity	.04	.02	.07
~ Planning Impulsivity	.04	.02	$.05^{*}$
Covariance estimates			
Addictive Use			
~ ~ Antisocial Use	.52	.86	$< .001^{***}$
~ ~ Dangerous Use	.20	.27	$< .001^{***}$
Antisocial Use			
~ ~ Dangerous Use	.31	.24	$< .001^{***}$

Note. B = standardized regression coefficient; *SE* = standard error; Significance Codes in comparison with models: $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Values are reported to two decimal points.

facets of impulsivity (motor impulsivity $r = .22$, $p < .01$, attention impulsivity $r = .29$, $p < .001$). Unexpectedly, the global internalised psychopathology of the participants had no significant impact on smartphone addiction. For the antisocial mobile phone use pathway, there were positive significant relationships with impulsivity, both in the attention facet ($r = 0.31$, $p < .001$) and in the motor dimension ($r = 0.13, p < .01$). Moreover, analyses showed a negative relationship with conscientiousness, indicating that as participants showed lower conscientiousness, they demonstrated more antisocial smartphone behaviours ($r = -.2$, $p = .02$). For both the dependent and antisocial pathways, non-planning impulsivity was not a significant predictor. However, for the dangerous smartphone use pathway, the only marginally significant predictor was the planning facet of impulsivity ($r = 0.04$, $p = .05$). Contrary to expectations, there was no significant association between extraversion and dangerous use. Finally, R-square calculations revealed that the hypothesized Model 1 showed relatively low predictive power for the variance in scores in each pathway, explaining 10% of the scores in the addictive use pathway, 13% of the scores in the antisocial use pathway, and 3% of the scores in the dangerous use pathway.

5. Discussion

The main objective of the present research was to empirically test a

theory-driven empirical model for PSPU according to the theoretical framework proposed by Billieux et al. (2015). Path analysis revealed information regarding the three main postulated pathways leading to PSPU (addictive use, antisocial use and dangerous use), contributing to expand the scientific knowledge on this phenomenon. This preliminary step of providing empirical support for the pathway model of PSPU is important for further research; it sheds lights on different factors and relationships that constitute PSPU by supplying data collected from a population of smartphone users. Providing empirical evidence that supports the conceptualisation of PSPU allows determining which predictors of perceived mobile phone overuse are relevant to the identification of the phenomenon. Indeed, the possibility to define criteria that are specific to this condition is still hindered by a lack of empirical data in the field (Billieux et al., 2015); the present study addresses this limitation and it provides valuable insights for a valid conceptualisation of problematic smartphone use.

In line with the current worldwide statistic on the amount of time spent on daily smartphone usage (Statista, 2018), participants confirmed the prominent role that these devices are assuming in their lives. More than half of the respondents (65.1%) estimated to spend at least 3 h on their smartphone every day, with a considerable proportion of participants (22.3%) reporting between five and 10 h or more spent using their smartphone. Taken together, these results confirm the increasing usage of smartphones as reported by national surveys (Ofcom, 2017). Moreover, the findings reinforce the significance of investigating the relationship between specific individual conditions (e.g., chronic stress and low emotional stability) and inappropriate smartphone use for a better understanding of potentially detrimental effects (Augner & Hacker, 2012).

With regards to the PSPU pathways tested, the current research revealed a positive association between neuroticism and addictive smartphone use, confirming previous findings (Pearson & Hussain, 2015; Takao, 2014). According to Ehrenberg et al., (2008), individuals high in neuroticism, who reported high instant messaging use, may be guided either by the need to stay more frequently in communication with others or, alternatively, by the need to have more time to revise the message content before sending it. In line with these stronger mobile phone tendencies, a study by Lane and Manner (2011) evidenced that neurotic people send a high number of emails via smartphones.

Altogether, these findings may be better understood within the framework of the excessive reassurance pathway originally postulated by Billieux et al. (2015), according to which individuals may develop addiction-like symptoms due to their smartphone use as a consequence of the perceived need to maintain interpersonal relationships and be constantly reassured by others. From an ecological perspective (Bronfenbrenner, 1994), it could be speculated that neurotic individuals may be particularly prone to seek and establish interactions with other people in the immediate environment of their microsystems, such as family members or workplace colleagues, to gain the beneficial effects of social support, in the case of the current study, via smartphones. To corroborate this hypothesis, Hardie and Tee (2007) found that neuroticism and perceived online social support were significant predictors of excessive Internet use.

Contrary to expectations, anchored to prior research that evidenced a positive association between problematic smartphone use and internalised psychopathology, including stress (Chiu, 2014; Thomée et al., 2011), anxiety (Lepp et al., 2014) and depression (Demirci, Akgönül, & Akpinar, 2015; Elhai et al., 2017), the present research did not unveil this relationship. Internalised psychopathology was not found to exert a significant influence on the average smartphone user's behaviour. This result could be due to the fact that our study comprises a community sample displaying low levels of internalised symptoms. Another potential explanation is the scale we used focuses on types of smartphone use rather than the negative consequences of use. In other words, this absence of relationships calls for future studies conducted on persons reporting concrete negative consequences or functional impairment related to smartphone use. At this point, it is worth noting that in the current research, only a small amount of variance was explained by the variables measured, as shown by the R-squared values, highlighting the opportunity to add to and update the model with the integration of emerging different constructs.

Furthermore, in line with our predictions, based on several earlier studies conducted by Billieux et al. (2008; 2010; 2012), the construct of impulsivity showed the expected correlations with all PSPU uses. Specifically, among the three dimensions assessed using the BIS-15, attention impulsivity was reported to have the highest correlation both with addictive use and antisocial use. This finding is consistent with the work of Roberts, Pullig and Manolis (2015), which linked attention impulsivity to a lack of perseverance, a dimension previously reported to be related to perceived mobile phone dependence (Billieux, Van der Linden, d'Acremont, Ceschi, & Zermatten, 2007). Attention impulsivity refers to the inability of individuals to concentrate their attention on a task, leading them to look for distractions (Patton et al., 1995; Spinella, 2007).Roberts et al. (2015) conjectured that when people are frustrated or bored, they may turn to smartphones in order to entertain themselves with a wide range of available activities. This explanation is pertinent both to addictive use, as it is characterised by the difficulty to disengage from smartphones in order to manage emotional issues, and to antisocial use, entailing the tendency to turn to the devices even in inappropriate situations. For instance, during social interactions, individuals who are not stimulated by the conversation may repeatedly check their smartphones, triggering feelings of discomfort or rejection in others (Kuss et al., 2018). Alternatively, it can be hypothesized that individuals may also enact such behaviours in the case that the conversation is perceived as excessively activating, trying to find comfort in smartphones in order to avoid intimate emotional contact. These behaviours are further supported by a second component of impulsivity, motor impulsivity, which has also been found to correlate with addictive use and antisocial use in the present study. Motor impulsivity refers to the proneness to act spontaneously and rashly, without enough deliberation (Patton et al., 1995). This latter result can be linked with previous findings having linked excessive and addictive smartphone use with poor inhibitory control assessed by a laboratory Go/No-go task (Chen, Liang, Mai, Zhong, & Qu, 2016). Overusing personal smartphones to fulfil personal needs without evaluating the appropriateness of this behaviour, appears to be associated to the two pathways under investigation. Moreover, as far as antisocial use is concerned, its negative association with conscientiousness found in the present study contributes to corroborate the idea underlying this PSPU dimension. Indeed, Costa and McCrae (1992) depicted conscientious individuals as careful people capable of monitoring their behaviours with a good level of self-control and discipline. It should not be surprising, therefore, that this personality trait was reported to be inversely associated with impulsivity (Roccas, Sagiv, Schwartz, & Knafo, 2002). Specifically,Roberts et al. (2015) suggested attention impulsivity to be the mediating factor between conscientiousness and smartphone addiction, stressing the need for additional research to ascertain this pathway. Furthermore, with regards to conscientiousness, lower levels were also found to be consistently associated with the broad construct of Internet addiction in previous studies (Gnisci, Perugini, Pedone, & Di Conza, 2011; Kuss et al., 2013). Adding credence to our supposition, the negative relationship between conscientiousness and Internet use was explained in terms of reduced impulse control (Stavropoulos et al., 2016).

The third component of impulsivity assessed in the present study was planning impulsivity. As opposed to attention and motor impulsivity, planning impulsivity appeared to be exclusively predictive of dangerous smartphone use. This is an interesting finding because it suggests that dangerous use has to be considered a distinct category when analysing smartphone use. To support this hypothesis, it has also to be noticed that dangerous use was found to weakly correlate with addictive use and antisocial use. Moreover, planning impulsivity was also found to characterise young individuals displaying risky driving

behaviours, such as speed limit violation in a previous study (O'Brien & Gormley, 2013). Given that planning impulsivity entails the inability to carefully think before acting, this dimension appears to be reasonably associated with the *lack of premeditation* facet of impulsivity as defined by Whiteside and Lynam (2001). Therefore, our results are consistent with those of Billieux et al. (2008), showing that low levels of premeditation predicted dangerous use of the phone. Indeed, individuals who frequently use their smartphones while driving may be particularly prone to disregard the potential negative consequences of their behaviours in favour of the "need to be connected" (Lantz & Loeb, 2013).

The inclination to take risks and to constantly seek out social stimulation constitutes core elements of extraversion (Eysenck & Eysenck, 1991). Thus, in line with the previous conceptualisations of Bianchi and Phillips (2005) and of Billieux et al. (2015), the authors of the present paper hypothesized extraversion to be predictive of dangerous use; as people may not desist from the desire to communicate with others via smartphones even while driving. However, contrarily to our expectations, extraversion was not a factor explaining self-reported dangerous use of the smartphone as measured by higher scores on the PMPU-Q. A possible explanation for this finding could be attributed to the characteristics of the sample, since 35% of participants reported not to have driving experience. It is also possible that the study sample contained participants who were not particularly motivated to use their smartphones in risky situations. Another explanation is that dangerous use is specifically related to sensation seeking, as previously found by Billieux et al. (2008), but not necessary to the more over-arching construct of extraversion.

The present testing of the PMPU pathway model showed an overall reasonable model fit when incorporating the addictive, antisocial and dangerous pathways by using empirical data. This model fit was adequate on most fit indices, but could be stronger according to Brown's (2006) recommended model fit cut-offs. For instance, the Tucker-Lewis Index value, although reported as high, was still not ideal. This is unsurprising as the theoretical model was conceptualised before the development of smartphones to their current levels of use and functionality. The current results suggest that the factors measured in the current study are especially relevant to measure addictive use of smartphones. Indeed, the psychological factors incorporated in the study were less useful in predicting the antisocial pathway. These findings, along with the relatively modest variance explained by the model, call for further research conducted with additional or different constructs. Typically, specific personality traits (such as antisocial or psychopathic traits) can be useful in predicting antisocial use, whereas sensation seeking would be more appropriate than extraversion in predicting dangerous use. For instance, as far as the dangerous pathway is concerned, it can be conjectured that there may be other factors contributing to determining this problematic use, such as the "fear of missing out" (FoMO; Przybylski, Murayama, DeHaan, & Gladwell, 2013). This newer personality construct refers to a "pervasive apprehension that others might be having rewarding experiences from which one is absent" and it appears to be a significant predictor of maladaptive smartphone use (Elhai, Levine, Dvorak, & Hall, 2016; Przybylski et al., 2013, p. 1841). With regards to risky behaviours, the desire to be constantly connected to other people's lives has been related to an increased level of distraction particularly in young drivers (Przybylski et al., 2013). Furthermore, as FoMO has been linked to insecure attachment attitudes and preoccupation with relationships (Schimmenti, Passanisi, Gervasi, Manzella, & Famà, 2014), which characterise the former *excessive reassurance pathway* (Billieux et al., 2015), it could also be considered as a potential predictor of addictive use. Indeed, individuals who are particularly concerned with their affective relationships may be more at risk to develop fears and worries of not being sufficiently in touch with the people they care about. Increasing their habitual checking behaviours via smartphones, the overall usage of this device may rise (Oulasvirta et al., 2012). Additionally, given the role of emotion-laden impulsivity (the "urgency" trait, see Cyders & Smith, 2008) in PSPU, further research should capitalize on using the UPPS Impulsivity model (Whiteside & Lynam, 2001) rather than Barratt's impulsivity scale (Patton et al., 1995; Spinella, 2007), which does not specifically measure this crucial component, although being a suitable and widely used tool. Considering that the UPPS Impulsive Behaviour Scale (Whiteside & Lynam, 2001) was largely adopted in previous studies on impulsivity and PMPU (Billieux et al., 2007; 2008; 2010), comparisons between findings would have been more accurate if this instrument had replaced the BIS-15 (Spinella, 2007).

To satisfy the need of closeness to others (Deci & Ryan, 1985), social media use, specifically that of online Social Networking Sites (SNSs), provides a good opportunity to be constantly updated on what other people are doing (Kuss & Griffiths, 2017). It should not be surprising, therefore, that previous research evidenced a direct association between FoMO and excessive SNS use, especially Facebook (Alt, 2015; Gil, Oberst, Del Valle & Chamarro, 2015). These findings become particularly relevant to the current study as it was found that the most frequent use of smartphones was social networking. As some researchers warned, individuals displaying compulsive and uncontrolled SNS-related behaviours can develop symptoms of addiction (Andreassen, 2015; Salehan & Negahban, 2013). Considering that 80% of social media use occurs via smartphones (Marketing Land, 2016), with Facebook being the most popular SNS used worldwide (Statista, 2018), we suggest that future research on PSPU pathways should include SNSs and the construct of FoMO, as potentially crucial variables within the investigation of different dysfunctional uses, given their strong association to the use of smartphones (Fuster, Chamarro, & Oberst, 2017). According to researchers, the "fear of missing out" (FoMO; Przybylski et al., 2013) is predictive of maladaptive social media engagement and psychopathology (Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017). Additionally, for a more comprehensive assessment of PSPU, we recommend to investigate the construct of nomophobia, a neologism combining "no mobile phone" and "phobia", entailing the anxiousness and discomfort triggered by the thought of being out of contact with these devices (Bragazzi & Del Puente, 2014). Indeed, as highlighted by Kuss and Griffiths (2017), nomophobia is intrinsically related to a fear of not being able to maintain social connections mainly via SNSs.

Moreover, as Marino et al. (2018) argued in a study conducted on problematic Facebook use, future attention should also be focused on the cumulative exposure to technology and SNSs, since their association with maladaptive consequences may increase over time. Currently, further understanding of the relationship between SNSs and smartphone addiction is limited by the lack of longitudinal studies conducted on PSPU and research in neuroscience exploring the constructs of Cyberpsychology (Norman, 2017), such as social media use, is still in its infancy (Meshi, Tamir, & Heekeren, 2015).

6. Limitations

Although the present research provided useful preliminary empirical support to the Pathway Model of PSPU, some limitations should be considered. One of the limitations is the nature of the sampling methodology adopted and the characteristics of the sample, since this included a non-representative Internet-based convenience sample, principally constituted of adults studying or working in higher education institutions. Moreover, the fact that participants were primarily females from the United Kingdom with higher education restricts the overall generalizability of the findings to other populations. To increase external validity, future research should investigate the phenomenon by including a more selected representative sample with a calibrated proportion between both genders. Additionally, the higher number of female participants may have contributed to partially influencing the results, since women's problematic smartphone use, linked to a heavier SNSs use, has been found to be greater than men's (Carbonell, Chamarro, Oberst, Rodrigo, & Prades, 2018).

Another limitation of the current research is the methodology of data collection, as this was based on self-report assessment questionnaires. On the one hand, an online survey can promote the willingness of individuals to participate because of their familiarity with the Internet environment, facilitating sincere self-disclosure (Kuss & Griffiths, 2017). On the other hand, the self-report methodology may have provided limited results, as it required respondents to have a good capacity for self-reflection (Dunning, Heath, & Suls, 2004). Moreover, this study provided indications of the strength and directions of pathways leading to potentially problematic smartphone behaviours, but it should be recognised that the nature of the path analysis could not account for subscale measurement variance. That is, there may have been differing variation in participant scores from each items to subscales, contributing to an overall influence on the scores. For a study testing an a priori stipulated model, this method of analysis was suitable. However, future research conducted on larger samples should reproduce these findings using latent variables instead of observed scores.

Finally, In order to enhance the reliability of the findings, a better integration of quantitative psychometric inquiries with qualitative data from structured clinical interviews or focus groups should be encouraged, as in the case of mixed method approaches (Kuss & Griffiths, 2017), because this strategy allows for a more comprehensive and precise understanding of personal experience.

7. Conclusion

Having provided the initial empirical test of the pathway model of PSPU appears to be a fundamental step in the study of this phenomenon. Although the current results have to be confirmed in a larger and more representative sample, they constitute a unique and valid contribution to the debated field of technology-mediated addictive and excessive behaviours (Pinna et al., 2015; Potenza, 2014). The findings of the present study not only offer new empirical evidence on the mechanisms underlying PSPU, but they also enrich the understanding of this multi-faceted phenomenon by adding the analysis of the correlates of two other dysfunctional outcomes, antisocial and dangerous. The present work is timely as the WHO has published a report stating that dysfunctional and excessive use of electronic devices constitutes an internationally relevant public health issue (2015), supporting the need to provide scientific evidence on the individual factors implicated in its onset and maintenance.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2019.06.013.

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