Unraveling problematic smartphone use

The good and the bad through longitudinal, qualitative and psychometric perspectives

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Unraveling Problematic Smartphone Use:
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Contents

CHAPTER 1

General Introduction

Meet Amanda, an 18-year-old freshman who recently relocated to a city 1000 kilometers away from home to obtain her bachelor's degree. In her daily life, Amanda's smartphone serves as her trusted companion. She relies on it for navigation, discovering new restaurants, staying connected with her family and friends back home, building new friendships, coordinating her class schedule, collaborating on group projects with her classmates, and managing appointments. Amanda's smartphone has undoubtedly enriched her life, bringing an abundance of ease and convenience. At times, she thinks about how challenging life might be without this invaluable tool.

However, Amanda's smartphone use has also caused her some problems. She often checks her smartphone when she is with friends, which annoys them. The library, originally intended for focused study, often becomes a place where her smartphone constantly distracts her. Procrastination is another hurdle she struggles with, mostly because she often loses track of time engrossed in video feeds and messages within chat groups. This has led to several missed assignment deadlines, even resulting in her failing two courses. On one particularly alarming occasion, she almost got hit by a car while crossing the street because she was checking an incoming message on her smartphone.

Amanda's story illustrates the inherent dichotomy of smartphone use. On one hand, smartphones offer convenience, connectivity, and avenues for self-expression. On the other hand, they present challenges related to screen time management, distractions, and privacy. This narrative effectively underscores the reality that smartphones have become an integral part of daily life, posing both advantages and disadvantages. In this dissertation, I aim to understand better how individuals navigate between these advantages and disadvantages and how it relates to problematic smartphone use.

With the relentless march of technological advancements, smartphones have emerged as transformative devices, bringing both benefits and drawbacks. A smartphone is defined as "a mobile phone capable of running general-purpose computer applications, now typically with a touch-screen interface, camera, and internet access" (Oxford English Dictionary, 2023). As we look ahead to 2028, the number of smartphone users worldwide is estimated to reach a staggering 7,743.6 million, which is more than double in comparison with 2016 (O'Dea, 2023). The multifaceted capabilities of smartphones empower users with easy access to abundant functions. In some cases, smartphone users may develop profound attachment to these smartphone affordances (e.g., Fullwood et al., 2017). Since their inception, smartphones have thoroughly reshaped human beings' daily lives, and the smartphone's positive and negative impacts have become the focal point of

investigation across diverse academic disciplines (Coyne et al., 2023; Torous et al., 2020; Yu et al., 2023).

Background and Context of This Dissertation

The aim of the present dissertation is to comprehensively investigate and gain insights into problematic smartphone use (PSU). Effectively navigating this complex landscape demands clear boundaries between normal smartphone use and problematic smartphone use. To reach the objectives of this dissertation, it is crucial to consider both the benefits and risks associated with smartphone use. On such basis, the primary aim is to uncover the potential factors and etiology contributing to PSU and discern the potential similarities and differences between PSU and the established addiction criteria.

The potential positive consequences and conveniences of smartphone use

Fulfilling various roles, smartphones can serve as communication hubs, study and workstations, sources of information, and entertainment centers, offering convenience and efficiency (Fullwood et al., 2017; Harkin & Kuss, 2021; Li & Lin, 2019; Yang et al., 2019). More notably, smartphones can play a pivotal and transformative role in promoting health behaviors.

Smartphones can provide an ideal platform for delivering health-related interventions, offering users easy access to support and guidance in managing behaviors like alcohol use, tobacco smoking, recreational screen time, physical activity, diet, and sleep (e.g., Champion et al., 2023). Smartphones also integrate a variety of sensors (e.g., light sensor, accelerometer, microphone, etc.) and data collection applications (Alamoudi et al., 2023; Harari et al., 2016), enabling the early detection of both physical (e.g., Parkinson's disease; Adams et al., 2023) and mental issues (e.g., Koinis et al., 2022). For instance, individuals and researchers can monitor and analyze online activities, track objective measures of physical activities like step count, and even access physiological data like heart rate variability (Koinis et al., 2022).

These comprehensive applications of smartphones not only enable proactive health management but also empower the possibility of a healthcare revolution, although the efficiency of healthcare apps on smartphones still requires further evaluations (e.g., Llorens-Vernet & Miró, 2020). Nevertheless, the advantages of smartphones are also accompanied by potential drawbacks.

The potential negative consequences of smartphone use and the emerging concern of problematic smartphone use

A growing body of research has underscored the potentially detrimental effects of excessive smartphone use on various aspects, including physical health, mental health, social well-being, and economic well-being (Elhai et al., 2017; Jannusch et al., 2021; Olson et al., 2022). Various terms have been used to describe the problems and disruptions in everyday life experienced from excessive smartphone use, including "problematic smartphone use" (PSU; e.g., Arrivillaga et al., 2023; X. Wang et al., 2023), "smartphone addiction"(e.g., Elhai et al., 2019; Luk et al., 2018), "smartphone use disorder" (e.g., Elhai et al., 2019), "smartphone dependence" (e.g., Hu et al., 2017), and "excessive smartphone use" (e.g., Matthes et al., 2021; Weinstein & Siste, 2022). Moreover, compared to the term "excessive smartphone use", PSU may better reflect potential problems that may not fully be explained by the frequency of use. It is estimated that 10-30% of children and youth (mainly aged 10 to 35 years) year olds experience PSU (for a review see, S. Sohn et al., 2019). As can be seen in Figure 1.1, there has been a worldwide increase in PSU among individuals aged 15 to 35 years over the past decade (Olson et al., 2022).

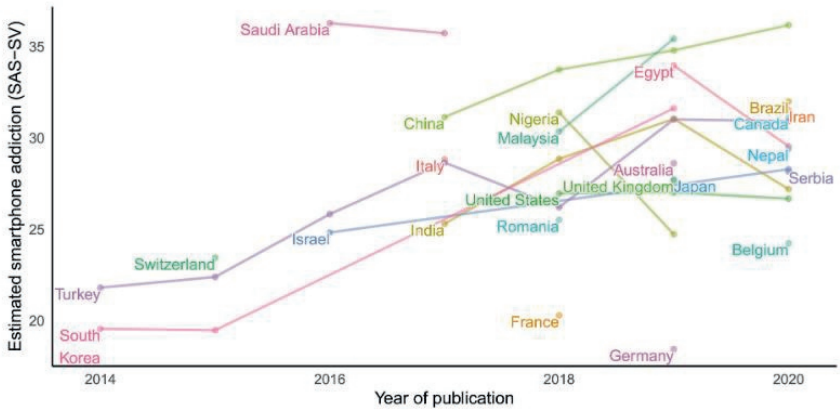

Figure 1.1 Estimated regional levels of problematic smartphone use between 2014-2020 as measured by the short version of smartphone addiction scale (SAS-SV; Kwon, Kim, et al., 2013).

Note. Dots represented pooled means from studies included in the meta-analysis conducted by Olson et al (2022). Figure reprinted with permission from Olson et al (2022).

Previous studies have investigated the association between PSU and specific adverse health outcomes. Concerning mental health problems, PSU has been positively correlated with depression, anxiety, loneliness, eating disorder, and perceived stress (Alzhrani et al., 2023; for a review see, S. Sohn et al., 2019; J. Wang et al., 2023). PSU has also been related to compromised physical health states, such as increased neck problems (AlAbdulwahab et al., 2017), poorer sleep quality

(Demirci et al., 2015; Hasan et al., 2023; S. Y. Sohn et al., 2021), and impaired cognitive functioning (for a review see, Wilmer et al., 2017). While many of those studies are cross-sectional and observational, lacking direct evidence of temporal relationships between PSU and the other correlates, they do offer preliminary evidence for the potential negative consequences related to PSU. Given the growing need for a smartphone to function in everyday life, it is essential to acknowledge that discontinuing smartphone use is not a viable solution to problematic use. In fact, studies have shown that individuals who do not regularly use a smartphone show worse physical and mental health than regular smartphone users (Pedrero-Pérez et al., 2019; Studer et al., 2022). In today's society, smartphone use can facilitate social connections and enhance well-being, benefits that were highlighted during the most recent COVID-19 pandemic when offline interactions may be limited (e.g., David & Roberts, 2021). This paradox underscores the importance of delineating the boundaries between normal and problematic smartphone use.

The Evolution of Problematic Smartphone Use: Theoretical Perspectives

An ongoing debate persists concerning the concept of "problematic smartphone use" (e.g., Billieux, Philippot, et al., 2015; Weinstein & Siste, 2022), particularly about whether PSU should be categorized as a form of behavioral addiction (e.g., Panova & Carbonell, 2018). To facilitate the understandings on such debate, I will first review the discussions on behavioral addictions, including other problematic online behaviors.

The evolution of behavioral addictions, including other problematic online behaviors

Behavioral addictions have been argued to involve persistent engagement in specific behaviors that impact psychosocial and brain functioning similar to established substance use disorders, including symptoms like persistence of use despite negative consequences and impaired controls over such behaviors (e.g., Grant et al., 2010; Karim & Chaudhri, 2012). Pathological gambling was the first recognized behavioral addiction (Fauth-Bühler & Mann, 2017). While **Pathological Gambling** was first mentioned under "Disorders of Impulse Control Not Elsewhere Classified" in the DSM-III (American Psychiatric Association, 1980) and later formally included under "Habit and Impulse Disorders" in the ICD-10 (World Health Organization, 1992). More recently, "Gambling Disorder" has been categorized in both the ICD-11 (World Health Organization, 2019) and the DSM-5 (American Psychiatric Association, 2013) with substance use disorders, under the categories of "Disorders Due to Addictive Behaviors" and "Non-Substance-Related Disorders", respectively. However, the definition and diagnostic criteria of behavioral addictions

are still a topic of debate (Brand & Potenza, 2023; Gullo et al., 2022; Kardefelt-Winther et al., 2017).

With technological advancement, problematic online behaviors have garnered increasing attention, giving rise to concepts such as "internet addiction" (for a review see, Lozano-Blasco et al., 2022), "internet gaming addiction" (for a review see, Rosendo-Rios et al., 2022), and "social media addiction" (for a review see, C. Cheng et al., 2021), all of which have been discussed extensively in the literature. Nevertheless, the classification of these problematic online behaviors as an "addiction" remains a subject of ongoing controversy with some researchers being cautious about labeling certain behaviors as addictive (e.g., Kardefelt-Winther et al., 2017). Notably, **Internet Gaming Disorder** stands out as the sole problematic online behavior included under "Disorders Due to Addictive Behaviors" in the ICD-11 (World Health Organization, 2019) and is considered as a potential mental disorder in the DSM-5 (American Psychiatric Association, 2013), although its inclusion continues to be a topic of discussion (e.g., Aarseth et al., 2017).

The evolution of problematic smartphone use as another variant of problematic online behavior

PSU, as another variant of problematic online behavior, possesses unique conceptual traits due to the high "habit-forming" nature of smartphones, marked by their portability and easy access to the Internet (Oulasvirta et al., 2012). Certain parallels between PSU and other addictions have been observed (e.g., Haug, Paz Castro, et al., 2015; Lin et al., 2014; Weinstein & Siste, 2022). For example, clinical evidence, such as a case report of an excessive smartphone user, suggested that symptoms associated with PSU aligned with the criteria of behavioral addiction and gambling disorder in the DSM-5 (American Psychiatric Association, 2013; Goodman, 1990; Griffiths, 2000, 2005; Körmendi et al., 2016). Moreover, neuroimaging studies on problematic smartphone users suggested compromised brain structure and function of areas often implicated in substance use disorders and recognized behavioral addictions. For example, problematic smartphone users displayed smaller gray matter volume in the right lateral orbitofrontal cortex (OFC) (Lee et al., 2019), left anterior insula, inferior temporal and parahippocampal cortex relative to a control group (Horvath et al., 2020). Moreover, problematic smartphone users exhibited lower rest-state activity in the right anterior cingulate cortex (ACC) (Horvath et al., 2020), decreased activation of the prefrontal cortex during presentations of 10-second oddball movies as distractors in the rapid serial visual presentations (RSVP) of digits (Han & Kim, 2022). Furthermore, they displayed heightened resting-state functional connectivity within the salience network and between the salience and default mode network, coupled with decreased functional connectivity between the

salience and central executive network (Ahn et al., 2021). It is important to note that these studies have primarily established their findings by cross-sectionally comparing individuals with and without PSU, preventing us from making causal inferences. These observed differences and parallels with substance use disorders might serve as either risk factors or potential negative consequences for PSU, or they could serve both roles (c.f., Verdejo-García et al., 2008).

The skepticism surrounding the classification of problematic smartphone use

The skepticism surrounding the classification of PSU as an addiction is grounded in several key arguments. First, the longitudinal stability of PSU has been relatively underexplored, given that most studies on this topic are correlational and cross-sectional (Panova & Carbonell, 2018). Second, studies on PSU often lack direct illustrations of addiction-like symptoms (Billieux, Maurage, et al., 2015), such as significant functional impairment, severe physical consequences, tolerance, and withdrawal (Panova & Carbonell, 2018). Third, the approach to defining and measuring PSU tends to be primarily confirmatory, atheoretical, and general (Billieux, Maurage, et al., 2015; Panova & Carbonell, 2018). Finally, some researchers contend that the focus should shift from labeling the smartphone itself as an object of addiction to pinpointing specific activities like gaming and social networking on the smartphone as addictive elements (Körmendi et al., 2016; Panova & Carbonell, 2018). Such perspective aligns with earlier discussions on "internet addiction", which is also considered as a broad category by many researchers (e.g., Musetti et al., 2016).

In this dissertation, I choose to employ the term PSU because it is still debated whether PSU should be classified as a behavioral addiction (e.g., Panova & Carbonell, 2018). I will strive to address these key arguments mentioned in last paragraph throughout this dissertation. I contend that smartphone use is both advantageous whilst also holds the potential of becoming problematic.

Other relevant theories related to the possible etiology of problematic smartphone use

In this dissertation, I aim to explore additional theories relevant to the etiology of PSU. Based on the Self-Determination Theory (Ryan & Deci, 2017; Vasconcellos et al., 2020), individuals may seek to fulfill their basic need for relatedness through smartphone use. Moreover, by drawing on the Uses and Gratifications Theory (Blumler, 1979) and Motivational Theory (Brand et al., 2016), Individuals perhaps initially use their smartphones based on their unique needs and motives. However, there may be both intended (e.g., connecting with others on smartphone) and unintended (e.g., disruptions related to smartphone use when communicating with

others) consequences for the users after their various needs are met with their smartphone use. Chapter 2 will delve into the Self-Determination Theory (Ryan & Deci, 2017; Vasconcellos et al., 2020), investigating the relationships between online peer engagement and PSU. Chapter 3 will examine the Uses and Gratifications theory (Blumler, 1979) and Motivational Theory (Brand et al., 2016), exploring the motives for smartphone use and the positive and negative consequences of smartphone use.

The Measurement of Problematic Smartphone Use

Various scales have been developed to measure PSU (see Table S4.1), including the Mobile Phone Problem Use Scale (MPPUS; Bianchi & Phillips, 2005), the Problematic Mobile Phone Use Questionnaire (PMPUQ; Billieux et al., 2008), the smartphone addiction scale (SAS; Kwon, Lee, et al., 2013) and the already mentioned short version (SAS-SV; Kwon, Kim, et al., 2013), the Smartphone Addiction Inventory (SPAI; Lin et al., 2014) and its short form (SPAI-SF; Lin et al., 2017). While these existing scales have offered valuable insights, there is room for improvement in terms of their contemporary and theoretical applicability. For instance, MPPUS and PMPUQ were established relatively early after the more widespread smartphone adoption, potentially affecting their relevance nowadays. The SAS-SV scale may overestimate the prevalence of PSU, especially when employing the thresholds of 31 for males and 33 for females (Kwon, Kim, et al., 2013). That is, a recent meta-analysis reported an average SAS-SV score of 28.78 (*SD* = 4.16) among all the included studies that used the SAS-SV (Olson et al., 2022). Furthermore, many existing PSU measurement scales have been developed based on the existing "addiction", specifically "substance addiction" criteria without comprehensively covering the newly identified PSU features and consequences. These updated PSU features and consequences may include distracted driving, traffic accidents, impaired productivity, compromised relationships, and cognitive impairments (Ding & Li, 2017; Fitch et al., 2015; Gutiérrez et al., 2016; Oviedo-Trespalacios et al., 2016; Wilmer et al., 2017). To address these gaps, this dissertation will employ an in-depth qualitative study that integrates existing "addiction" criteria, relevant scales and recent research on (problematic) smartphone use (Chapter 3). Building upon qualitative findings, a novel questionnaire-the Smartphone Use Problems Identification Questionnaire (SUPIQ), will be developed (Chapter 4).

Problem Statement and Research Objectives

This dissertation aims to address several research gaps, adopting a mixed-method approach to investigate benefits and disadvantages of smartphone use. First, it will

fill a gap by conducting comprehensive longitudinal studies to explore environmental factors (i.e., peer engagement) contributing to problematic smartphone use (PSU) among adolescents. In this study, I will examine bidirectional relationships between PSU and the quantity and quality of peer engagement **(Chapter 2).** Second, it will contribute to the literature by conducting in-depth qualitative research to comprehensively examine PSU and distinguish it from excessive/frequent use and the existing addictions, emphasizing the etiology of PSU, including motives for smartphone use and perceived social norms. This approach helps avoid unwarranted stigmatization for regular smartphone use **(Chapter 3).** Lastly, the dissertation will address the need for more relevant and accurate PSU measures due to the lack of updated findings on PSU in existing scales and relatively lenient criteria for PSU. It aims to develop a comprehensive PSU assessment applicable to both the university community and general populations-the Smartphone Use Problems Identification Questionnaire-SUPIQ **(Chapter 4).** To articulate the specific goals of each chapter, further details are presented below.

Chapter 2: Problematic smartphone use and the quantity and quality of peer engagement among adolescents: A longitudinal study

The principal aim of Chapter 2 was to disentangle the dynamic interplay between PSU and the various facets of peer engagement over time. The bidirectional associations between PSU and the quantity and quality of peer engagement among adolescents were examined, employing a cross-lagged panel design. This investigation on peer engagement encompassed active and passive social media messaging on smartphone, the intensity of face-to-face meeting with friends, and perceived competence in close friendships. To reach the research goals, three measurement waves with a large sample of adolescents (N=2100) aged 10 to 16 years were utilized.

Chapter 3: The good and the bad: A qualitative investigation of students' perspectives on their problematic smartphone use

The main goal of Chapter 3 was to explore the participants' PSU-related experiences, antecedents, and consequences. To reach this goal, I employed a qualitative methodology to gain a deeper understanding of PSU from the perspectives of university students who were identified as problematic smartphone users (N=28) according to their SAS-SV scores. Both deductive and inductive thematic analyses were conducted. This qualitative investigation expanded beyond the existing addition-like criteria to uncover commonalities and distinctions in comparison with the established addiction symptoms in the DSM-5 and the ICD-11. Key themes

relating to PSU etiology were identified and assessed, ultimately leading to the development of a preliminary theoretical framework for the etiology of PSU.

Chapter 4: From Everyday Life to Measurable Problematic Smartphone Use: The Development and Validation of The Smartphone Use Problems Identification Questionnaire (SUPIQ)

In Chapter 4, my primary objective was to create a comprehensive tool for PSU that can be applied across diverse populations. Building upon insights from the qualitative study, I focused on the development and validation of the Smartphone Use Problems Identification Questionnaire (SUPIQ). First, exploratory factor analysis (EFA) was conducted with a university community sample (N=292) to uncover the latent factor structure of the SUPIQ. Subsequently, the same factor structure was used in a confirmatory factor analysis (CFA) in a general population sample (N=397). Additionally, this study addressed the convergent validity, illustrating correlations between the SUPIQ total score, the SUPIQ factor scores, the SAS-SV, and indicators of mental health. Partial correlation network analysis was employed to visually explore the relationships between various SUPIQ factors, indices of smartphone use, and mental health. Finally, measurement invariance was tested across the samples and multivariate regressions were used to examine the explanatory power of the SUPIQ on mental health problems, being compared to the short version of the smartphone addiction scale (SAS-SV) in both samples.

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CHAPTER 2

Problematic smartphone use and the quantity and quality of peer engagement among adolescents: A longitudinal study

This chapter is adapted from the published article:

Su, S., Larsen, H., Cousijn, J., Wiers, R. W. H. J., & Van den Eijnden, R. J. J. M. (2022). Problematic smartphone use and the quantity and quality of peer engagement among adolescents: A longitudinal study. *Computers in Human Behavior*, *126*, [107025]. https://doi.org/10.1016/j.chb.2021.107025

Abstract

Problematic smartphone use (PSU) has recently attracted a lot of attention, especially among adolescents. The knowledge about the role peer engagement might play in the development of PSU is still limited. We aimed to investigate the bidirectional relationships between PSU, the quantity of online (i.e., passive and active social media messaging on smartphone) and offline peer engagement (i.e., intensity of face-to-face meeting with friends) and the quality of peer engagement (i.e., perceived competence in close friendships) among adolescents. Data from a three-wave longitudinal study among 2100 Dutch high school students (56.7% boys) was used. Cross-lagged models indicated that: (1) perceived competence in close friendships at T1 negatively predicted PSU at T2 and PSU at T2 negatively predicted perceived competence in close friendships at T3; (2) there were positive and reciprocal cross-lagged correlations between PSU and passive social media messaging on smartphone; (3) there were positive and reciprocal cross-lagged correlations between intensity of face-to-face meeting with friends and active social media messaging on smartphone. This implies that adolescents who perceive a low competence in close friendships and/or intensively check their smartphone for messages from their peers may be particularly vulnerable to developing problematic smartphone use over time.

Keywords: problematic smartphone use; peer engagement; social media messaging on smartphone; cross-lagged analysis

Introduction

During the past decade, smartphone use has strongly increased and is considered a necessary element of everyday life (Y. Kim et al., 2016; Kuss et al., 2018; Recio-Rodriguez et al., 2019). In parallel, problems related to smartphone use have increasingly been reported. There is increasing evidence that excessive smartphone use can negatively affect mental (e.g., higher levels of depression and anxiety; Elhai et al., 2018, 2019) and physical health (e.g., neck problems, poor sleep quality; AlAbdulwahab et al., 2017; Demirci et al., 2015). In previous studies, problematic smartphone use (PSU) has been defined as a persistent and excessive pattern of smartphone use accompanied by significant impairments in daily-life functioning, and the impairments could include daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance (Kardefelt-Winther et al., 2017; Kwon, Lee, et al., 2013). We used this proposed definition in the current study and the most popular instrument measuring PSU-the short version of smartphone addiction scale (SAS-SV) was developed for adolescents based on such a definition, which has been validated across different countries (Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Luk et al., 2018). Note that the symptoms of PSU proposed in previous research are similar to the established criteria of substance use disorders in DSM-5 (APA, 2013; Kwon, Lee, et al., 2013; Lin et al., 2016), and the question whether PSU should be considered as a behavioral addiction is still heavily debated (Elhai & Contractor, 2018; Horvath et al., 2020; Körmendi et al., 2016; Panova & Carbonell, 2018). Adolescents are thought to be particularly susceptible to develop PSU (Fischer-Grote et al., 2019; Sohn et al., 2019) because of their suboptimal self-regulation and lack of control competencies (Fischer-Grote et al., 2019; H. J. Kim et al., 2018). Hence, it is vital to explore the underlying pathways of adolescents' problematic smartphone use (PSU).

Based on previous studies, PSU has been associated with adolescents' personality characteristics (Cocoradă et al., 2018), relatively poor self-control (H. J. Kim et al., 2018), and to mental health (Seung. Gon. Kim et al., 2019). Regarding environmental factors, PSU has been related to parental factors (Bae, 2015; Sun et al., 2019) and peer factors (Y. Wang et al., 2017). Both peers and parents play an important role in the socialization process of adolescents (Lakon et al., 2015). Nevertheless, peer may be a more salient factor since the effects of parents gradually decrease during adolescence (Huang et al., 2014). Besides, autonomy, competence, and relatedness are the basic needs for adolescents according to self-determination theory (Ryan & Deci, 2017; Vasconcellos et al., 2020). Their need for relatedness could be fulfilled by smartphone use and peer engagement, which also makes it necessary to investigate the effects of peer engagement on PSU (Ryan & Deci, 2017; Vasconcellos et al., 2020). The term peer engagement refers to social interactions

with peers, including the investment in peer interaction, as well as the formation, maintenance of peer relationships (Scanlon et al., 2020; M. T. Wang & Hofkens, 2020). Peer engagement plays a complex but important role in adolescents' development of other problematic behaviors like the use of cigarettes, alcohol (Huang et al., 2014; Van Ryzin et al., 2012). Only limited studies have investigated the potential role of peer engagement in the development of PSU and longitudinal studies are still missing. Given the popularity of social media messaging among adolescents (Dolev-Cohen & Barak, 2013; Huang et al., 2014), the crucial role it nowadays plays in the maintenance of social relationships (Spies Shapiro & Margolin, 2014), and the influences of choosing online social media messaging as a preferred communication way (Caplan, 2003), it is important to consider the role of online peer engagement as well as offline peer engagement, both in quantity and quality.

In terms of online peer engagement, social media messaging is now the main tool for adolescents to contact with their peers with the technology development (Dolev-Cohen & Barak, 2013). The relationship between social media messaging on smartphone and PSU could be bidirectional based on existing findings (Haug et al., 2015; Rozgonjuk, Saal, et al., 2018; Van Deursen et al., 2015), while the strengths of the relationships may differ between PSU and active (e.g., sending pictures or messages) and passive (e.g., checking pictures or messages) social media messaging based on the evidence from previous studies (Allegrante & Sigfusdottir, 2019; Kross et al., 2013; Verduyn et al., 2017). For example, Allegrante and Sigfusdottir (2019) found that active (e.g., posting pictures, sending messages, etc.) and passive (e.g., scrolling profiles, checking messages, etc.) social media use were highly related, but higher frequency of active social media use was related to lower emotional distress (i.e., symptoms of anxiety and depressed mood) and higher frequency of passive social media use was related to higher emotional distress among adolescents. Based on existing findings, we propose Hypothesis 1 (H1): there are bidirectional positive associations between PSU and both active and passive social media messaging on smartphone, and the relationship between PSU and passive social media messaging on smartphone is stronger than the relationship between PSU and active social media messaging on smartphone.

Regarding real-life, offline peer engagement, the relationship between the quantity of offline peer engagement (i.e., intensity of face-to-face meeting with friends) and PSU is currently unclear. There is a possibility that adolescents' PSU might positively relate to intensity of face-to-face meeting with friends, since adolescents might use smartphones to gain peer acceptance and peer conformity when they meet with their friends who use smartphones excessively (Lee & Lee, 2017). However, it is hard to speculate the strength of this pathway because of

prevalence of smartphone use problems differs from 5% to 50% among children and adolescents (Fischer-Grote et al., 2019). In contrast, adolescents' PSU could also negatively relate to intensity of face-to-face meeting with friends, as intensity of face-to-face meeting with friends might be an indirect protective factor for PSU (Caplan, 2003; M. T. Wang & Hofkens, 2020). Based on the two different rationales and limited evidence, we do not formulate specific hypotheses on the direction of the relationship between intensity of face-to-face meeting with friends and adolescents' PSU though we think the association exists.

An important indicator for quality of peer engagement is perceived competence in close friendships (Scanlon et al., 2020; M. T. Wang & Hofkens, 2020; Yoder et al., 2019). Perceived competence in close friendships refers to the capabilities to develop and sustain close friendships, which is significant for adolescents' socioemotional adjustment (Bornstein et al., 2010; Buhrmester, 1990). It pertains to both online and offline peer engagement. In previous studies, poor social competence has been found to be a risk factor for the development of many problem behaviors like pathological gaming (Lemmens et al., 2011; Peeters et al., 2018). Adolescents who perceive low social competence would use online interactions as alternatives for face-to-face interaction. Their preferences for online interactions might lead to more problematic smartphone use (Caplan, 2003). Not only can competence in close friendships negatively predict PSU, PSU could also negatively impact adolescents' perceived competence in close friendships since excessive smartphone use may interfere with in-person social interactions, thereby creating a negative downward spiral (Przybylski & Weinstein, 2013; Rotondi et al., 2017). Thus, we posit Hypothesis 2 (H2): there is a bidirectional negative association between perceived competence in close friendships and PSU.

Adolescents tend to use social media messaging on their smartphone to also promote and strengthen connections with their friends (Davies, 2014; Davis, 2012; Nesi et al., 2018). For instance, instant messaging has been demonstrated to be positively linked to adolescents' perceived quality of peer interactions (Floros et al., 2015). Social media messaging also provides meeting opportunities when in-person meetings are not feasible, which could, in turn, facilitate the quality of in-person offline relationships (Davies, 2014). Social media messaging on smartphone during in-person social interactions, however, could also be intrusive, impairing friendship quality (Hales et al., 2018; Noë et al., 2019; Przybylski & Weinstein, 2013; Rotondi et al., 2017). Social media messaging on smartphones might therefore both disturb or facilitate adolescents' social interactions (Allen et al., 2014). Therefore, the relationships between online (i.e. active and passive social media messaging) and offline peer engagement (i.e., intensity of face-to-face meeting with friends) and the

quality of peer engagement (i.e., perceived competence in closed friendships) were also tested in current study.

This Study

Previous studies suggest an important, but complex relationship between quantity and quality of peer engagement and PSU. Little is still known about their relationship over time, taking bidirectional relationships into account. The goal of the current study, therefore, was to investigate the bidirectional associations between the quantity and quality of peer engagement and PSU over time, in which we considered active and passive social media messaging on smartphone, intensity of face-to-face meeting with friends and perceived competence in close friendships. We investigated the longitudinal bidirectional associations with 3 measurement waves in a large sample of adolescents between 10 and 16 years old.

Structural equation modeling (SEM) with three-wave longitudinal data was applied to estimate the cross-lagged models. This study will also test the possible confounding roles of several covariates. According to Social Learning Theory (Bandura & Walters, 1977), children may learn from parents through observing and imitating parental behavior. Regarding the possible intergenerational transmission of parents' smartphone use on adolescents' PSU (C. Kim & Kang, 2020; Lian et al., 2016), the role of parents' smartphone use should be considered. In addition, gender could be another confounding factor since some research found that girls might be more vulnerable to PSU (Lee & Lee, 2017). Therefore, along with demographics such as age at survey onset and education category, we also included parental smartphone use and adolescents' gender as covariates.

Methods

Procedure

The study procedures were carried out in accordance with the Declaration of Helsinki and were approved by the board of ethics of the Faculty of Social Sciences at Utrecht University (FETC16-076 Eijnden). Data for this study were collected annually between 2016 and 2018 (T1-T3) based on convenience sampling, as a part of the Digital Youth Project (Boer et al., 2020). In addition, the short version of smartphone addiction scale and smartphone use of parents started being measured from T2. A passive consent procedure was used: all students in the participating schools were given an information sheet about the study to bring home to their parents, and all students whose parents did not object to participation were included in the study. Participants filled out the survey anonymously in the classroom (with unique ID for the longitudinal tracing). Participation was voluntary and no incentives were given.

Participants

Regarding the longitudinal data, 2100 Dutch secondary school students participated in the survey of T1, 1750 participants completed the surveys for T1 and T2, and 919 participants completed all surveys for T1-T3. At T1, boys and girls were equally distributed (56.7% boys) and the mean age was 13.310 (*SD* = 0.914). Most of the students were born in the Netherlands (96.0%), and the distribution of students' education category is: 50.9% VMBO, 17.9% VMBO/HAVO, 7.8% HAVO, 19.3% HAVO/VWO, 4.0% VWO. VMBO refers to pre-vocational education, HAVO to intermediate education, VWO to pre-university education. VMBO/HAVO or HAVO/VWO reflect the combination of multiple education categories in the same class. Pre-university education was relatively underrepresented based on the statistics of Dutch adolescent population (Boer et al., 2021; Statistics Netherlands, 2019).

Measurements

The short version of *smartphone addiction scale* (SAS-SV) developed by Kwon, Kim, Cho and Yang (Kwon, Kim, et al., 2013) was used to assess the extent to which the adolescents were "addicted" to their smartphones. It contains 10 items which were rated from 1 (completely disagree) to 5 (completely agree). We translated and adapted the original SAS-SV from English to Dutch with several rounds of double-checks, in which covariances among items 1–3 and items 4–7 were added based on the suggestions from previous studies (Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Luk et al., 2018). The results of CFA (confirmatory factor analysis) are as follows: CFI= 0.910, TLI= 0.884, RMSEA= 0.087, indicating an acceptable model fit. We adopted the SAS-SV in the measurements of T2 and T3, the Cronbach's α of the two waves showed good internal reliabilities (T2: .894; T3: .886).

Active social media messaging on smartphone was evaluated by asking participants about the frequency they send a message, photo or video via their smartphones per day. It was recorded from 1 (Less than once a day) to 7 (More than 80 times). The scoring was based on a small pilot study and the previous work investigating social media use intensity (Boer et al., 2021).

Passive social media messaging on smartphone was assessed by asking participants about the frequency they look on their smartphones to see if a message, photo or video has arrived per day. It was recorded from 1 (Less than once a day) to 7 (More than 80 times). The scoring was also based on the same pilot study and the previous work as active social media messaging on smartphone (Boer et al., 2021).

Intensity of face-to-face meeting with friends was measured with a 4-item scale aimed at estimating the frequency of participants meeting with their friends in person across different situations (e.g., out of school, at home and so on) with a 6-

point Likert scale ranging from 1 (never) to 6 (very often). The Cronbach's α of the three waves showed good internal reliabilities (T1: .849; T2: .863; T3: .854) across the three waves' data collection.

Perceived competence in close friendships is a Dutch scale to assess adolescents' abilities to develop and sustain their friendships (Harter, 1988; Treffers et al., 2002). The scale included 5 items with answers ranging from 1 (completely disagree) to 5 (completely agree). The Cronbach's α of the three waves showed to be relatively low, but acceptable (T1: .648; T2: .656; T3: .663). Although the coefficients of Cronbach's α were relatively low, we have found that all item-total correlations were over .350.

Perceived smartphone use of parents was estimated at T2 by asking adolescents to report the frequency their parents use smartphones or tablets under various conditions (e.g., dinner, conversations and so on) with four questions. Participants gauged their parents' smartphone use frequency from 1 (never) to 6 (very often). The Cronbach's α showed satisfactory internal reliabilities (T2: .799; T3: .785) across the two waves' data collection.

Demographic information including age at survey onset, gender, and education category of each participant were also collected in our survey.

Statistical analysis

Cross-lagged panel analysis was applied to investigate the stability and relationships between the study variables over the course of the three measurement waves in order to identify how variables impact each other (Kearney, 2017). For each research question, four nested models (Model 0 to Model 3) were tested to compare which model provided the best fit to the data. For example, to explore whether active and passive social media messaging on smartphone showed a reciprocal relationship, Model 0, the baseline model, assumed significant auto-regressive relationships and within-time correlations for active and passive social media messaging but no lagged effects. Model 1 and Model 2 assumed directional lagged associations between active and passive social media messaging. Model 1 assumed that active social media messaging affected passive social media messaging, while Model 2 assumed that passive social media messaging impacted active social media messaging. Model 3 assumed reciprocal relationships, with both active and passive social media messaging having cross-lagged effects on each other. Chi-square difference tests were used to compare the models for each proposed research question. We expected that Model 3 (i.e., the reciprocal model) would show a better fit compared to the other models (i.e. Model 0-Model 2). In addition, measurement invariance (MI) analyses were conducted to confirm all constructs were measured in the same way at different time points prior to the cross-lagged analyses (Meredith,

1993). For the sensitivity analyses, the confounding factors (i.e., age at survey onset, gender, education category and smartphone use of parents at T2) were explored.

SPSS 26.0 (George & Mallery, 2019; Pallant, 2020) was used for descriptive analyses. We used Mplus 8.3 (Muthén & Muthén, 2017) to do the multi-group confirmatory factor analysis, cross-lagged panel analyses and exploratory analyses (e.g., mediation analyses).

Results

Measurement invariance (MI) and descriptive statistics

The results of measurement invariance analyses are shown in Table 2.1. According to the criteria of changed CFI (increase of ≥ .01) and RMSEA (decrease of ≥ .015), the unconstrained models did not fit better than the constrained models (Boer et al., 2020; van de Schoot et al., 2012). Measurement invariances were therefore established over time, indicating that we could continue to test the longitudinal associations.

The descriptive and correlation analyses can be found in Table 2.2.

Model comparisons

Bidirectional relationships between active and passive social media messaging on smartphone among adolescents

According to the model fits shown in Table 2.3, Model 2 fitted the data significantly better than Model 0 ($\Delta\chi^2$= 195.849, $p < .001$) and the chi-square difference between Model 2 and Model 3 was significant ($\Delta\chi^2$= 60.030, $p < .001$), indicating that Model 3 significantly improved the model specification. Thus, Model 3 provided the best fit to the data, indicating positive cross-lagged associations between active and passive social media messaging on smartphone.

Bidirectional relationships between online (i.e., active and passive social media messaging on smartphone) and offline quantity of peer engagement (i.e., intensity of face-to-face meeting with friends) among adolescents

Based on the results from the previous step, M0-M3 were developed (i.e., the established cross-lagged effects were added). According to the model fits shown in Table 2.4, Model 1 fitted the data significantly better than Model 0 ($\Delta\chi^2$= 70.945, $p < .001$) and the chi-square difference between Model 1 and Model 3 was significant ($\Delta\chi^2$= 42.704, $p < .001$), indicating that Model 3 significantly improved the model specification. Thus, Model 3 provided the best fit to the data, indicating positive cross-lagged associations between online and offline quantity of peer engagement.

Bidirectional relationships between the quantity (i.e., online and offline) and quality of peer engagement among adolescents

Based on the results from the previous steps, M0-M3 were developed (i.e., the established cross-lagged effects were added). According to the model fits shown in Table 2.5, Model 1 fitted the data significantly better than Model 0 ($\Delta\chi^2$= 97.235, p < .001) and the chi-square difference between Model 1 and Model 3 was significant ($\Delta\chi^2$=15.247, p < .05), indicating that Model 3 significantly improved the model specification. Thus, Model 3 provided the best fit to the data, indicating that the quantity (i.e., online and offline) and quality of peer engagement have cross-lagged effects on each other.

Bidirectional relationships between the quantity (i.e., online and offline) and quality of peer engagement and problematic smartphone use

Based on the results from the previous steps, M0-M3 were developed (i.e., the established cross-lagged effects were added). According to the model fits shown in Table 2.6, Model 2 fitted the data significantly better than Model 0 ($\Delta\chi^2$= 41.030, p < .001) and the chi-square difference between Model 2 and Model 3 was significant ($\Delta\chi^2$= 23.133, p < .001), indicating that Model 3 significantly improved the model specification. Thus, Model 3 provided the best fit to the data, indicating that the quantity (i.e., online and offline) and quality of peer engagement and PSU have cross-lagged effects on each other.

The final cross-lagged model including problematic smartphone use, active social media messaging on smartphone, passive social media messaging on smartphone, intensity of face-to-face meeting with friends and perceived competence in close friendship

The final cross-lagged model could be regarded as two parts: a. auto-regressive relationships and within-time correlations for problematic smartphone use, active social media messaging, passive social media messaging, intensity of face-to-face meeting with friends and perceived competence in close friendship; b. the cross-lagged associations between problematic smartphone use, active social media messaging, passive social media messaging, intensity of face-to-face meeting with friends and perceived competence in close friendship.

The auto-regressive relationships and within-time correlations for problematic smartphone use, active social media messaging, passive social media messaging, intensity of face-to-face meeting with friends and perceived competence in close friendship, the standardized coefficients of the auto-regressive relationships and within-time correlations are depicted in Fig.2.1.

The cross-lagged effects among problematic smartphone use, active social media messaging, passive social media messaging, intensity of face-to-face meeting with friends and perceived competence in close friendship, and the standardized coefficients of cross-lagged effects are illustrated in Fig.2.2.

The results indicated a bidirectional association between problematic smartphone use and active social media messaging: active social media messaging at T1 positively predicted problematic smartphone use at T2 and problematic smartphone use at T2 positively predicted active social media messaging at T3. The results also indicated a reciprocal cross-lagged association between problematic smartphone use and passive social media messaging: passive social media messaging at T1 and T2 positively predicted problematic smartphone use at T2 and T3 separately, and problematic smartphone use at T2 positively predicted passive social media messaging at T3. There were no associations between problematic smartphone use and intensity of face-to-face meeting with friends over time while the associations between problematic smartphone use and perceived competence in close friendship were bidirectional: perceived competence in close friendship at T1 negatively predicted problematic smartphone use at T2 and problematic smartphone use at T2 negatively predicted perceived competence in close friendship at T3.

The results also showed that the associations between active social media messaging and intensity of face-to-face meeting with friends were reciprocal: active social media messaging at T1 positively predicted intensity of face-to-face meeting with friends at T2 and intensity of face-to-face meeting with friends at T1 also positively predicted active social media messaging at T2, and their associations from T2 to T3 were the same. The associations between active social media messaging and perceived competence in close friendship were bidirectional: perceived competence in close friendship at T1 positively predicted active social media messaging at T2 and active social media messaging at T2 positively predicted perceived competence in close friendship at T3.

Additional exploratory analysis: the mediating effect of problematic smartphone use T2 in the relationship between perceived competence in close friendship T1 and T3

As problematic smartphone use at T2 was significantly related to perceived competence in close friendship at T1 and T3, we were interested in the possible mediating role of problematic smartphone use at T2 in the relationship between perceived competence in close friendship at T1 and T3. Thus, this mediation effect was estimated in the final model (Fig.2.3).

When both problematic smartphone use at T2 and perceived competence in close friendship at T1 were included in the model, the association of problematic smartphone use at T2 with perceived competence in close friendship at T3 remained significant. The bias-corrected bootstrap 95% indicated that the indirect effect through problematic smartphone use at T2 was significant ([0.002, 0.02]), showing

that problematic smartphone use at T2 mediated the negative relationship between perceived competence in close friendship at T1 and T3.

Sensitivity analyses: sex, age, education category, perceived parental smartphone use

The possible confounding factors included gender, age at survey onset, education category and smartphone use of parents at T2 were investigated. Based on the results of sensitivity analyses, none of the factors significantly improved the model specification, thus, the cross-lagged model without any confounders was maintained.

Discussion

Though some studies have explored the relationships between adolescents' PSU and quantity and quality of peer engagement, longitudinal results are still limited. In the present study, we investigated the cross-lagged relationships between PSU and quantity and quality of peer engagement including online peer engagement (i.e., passive and active social media messaging on smartphone), offline peer engagement (i.e., intensity of face-to-face meeting with friends), and perceived competence in close friendships with a three-wave longitudinal survey. We found that the associations between PSU and adolescents' offline and online peer engagement and perceived competence in close friendships were bidirectional, and that the associations between offline and online peer engagement, and perceived competence in close friendships were also bidirectional.

Our first hypothesis was about the bidirectional positive associations between PSU and both active and passive social media messaging on smartphone. In line with our hypothesis, we found that higher intensity of active and passive social media messaging on smartphone were positively associated with adolescents' PSU. As for the directionality, the associations between passive social media messaging and PSU were reciprocally cross lagged while the associations between active social media messaging and PSU were not completely bidirectional (i.e. active social media messaging at T2 didn't predict PSU at T3), indicating that passive social media messaging better predicted adolescents' PSU than active social media messaging. The results are consistent with the findings that passive social media messaging is more strongly related to negative outcomes like PSU in comparison to active social media messaging (Allegrante & Sigfusdottir, 2019; Ding et al., 2017; Hu & Liu, 2020; J. L. Wang et al., 2018).

Regarding the quantity of offline peer engagement, there were basically no significant associations between intensity of face-to-face meeting with friends and adolescents' PSU, except for the positive correlation between PSU at T2 and intensity of face-to-face meeting with friends at T2. This finding is to some extent in

line with the results from a recent study, in which face-to-face contacts with friends were not related to adolescent's social media use problems (Boer et al., 2021). The possible reason could be the protective effect of intensity of face-to-face meeting with friends on PSU is kind of indirect and thus insignificant (Caplan, 2003; M. T. Wang & Hofkens, 2020).

Our second research hypothesis was on the bidirectional negative relationship between PSU and the quality of peer engagement. Consistent with our hypothesis, lower perceived competence in close friendships was positively associated with adolescents' higher PSU, which is consistent with previous studies (Kwak et al., 2018; Lee & Lee, 2017; Y. Wang et al., 2017). For example, adolescent's PSU related positively to relational maladjustment with peers in school (Kwak et al., 2018), and negatively associated with the quality of student-student relationship at school (Y. Wang et al., 2017). In contrast, PSU could also negatively influence adolescents' perceived competence in close friendships. This is supported by the found mediating role of PSU at T2 in the relationship between perceived competence in close friendships at T1 and T3, and consistent with studies showing that the intrusive effects of smartphone on communication in real life could do harm to adolescents' close relationships (Hales et al., 2018; Noë et al., 2019; Przybylski & Weinstein, 2013; Rotondi et al., 2017). The negative relationship between PSU and perceived competence in close friendship is similar to the found downward spiral relationship between internet gaming disorder (IGD) and perceived social competence (Peeters et al., 2018; Van Den Eijnden et al., 2018). Adolescents with low perceived competence in close friendships seem more vulnerable to PSU since they might tend to use their smartphone more excessively to compensate for lack in social connection with their peers. In turn, excessive smartphone use could disturb interactions with peers and could thereby lead to even lower perceived competence in close friendships (Van Den Eijnden et al., 2018). This pattern also aligns with the poor-get-poorer hypothesis, although we have to note it would also be necessary to confirm whether adolescents have succeeded or not in enhancing their connections with peers via smartphone (Snodgrass et al., 2018). In addition, lower perceived social competence in the context of PSU could also reflect be a criterion for PSU as a possible behavioral addiction (Kardefelt-Winther et al., 2017; Van Den Eijnden et al., 2018).

We have also tested the bidirectional relationships between the quantity of online peer engagement (i.e., active and passive social media messaging on smartphone) and offline peer engagement (i.e., intensity of face-to-face meeting with friends) and the quality of peer engagement (i.e., perceived competence in close friendships) over time. In terms of active social media messaging, we found that there were positive and reciprocal cross-lagged correlations between active social

media messaging on smartphone and intensity of face-to-face meeting with friends over time, which means that adolescents would meet with their friends in person more frequently when they are texting or sharing photo and videos actively, rather than just receiving the messages passively via social media. This intuitively makes sense, since adolescents could maintain contacts with their friends by actively interacting with others through social media, creating more possibilities to meet in person (Davies, 2014; Davis, 2012; Nesi et al., 2018). Meanwhile, meeting friends in real life would conversely promote active social media messaging, suggesting that adolescents tend to interact with the friends they already know and interact with in-person (Davies, 2014; Floros et al., 2015). Within-time correlations were found between perceived competence in close friendships at T1 and active social media messaging at T1 in current study. In addition, perceived competence in close friendships at T1 predicted active social media messaging at T2 and active social media messaging at T2 predicted perceived competence in close friendships at T3. These results are consistent with the transformation theory, suggesting that adolescents could have more opportunities to actively exert their abilities of developing and sustaining close friendships, and that frequent communications with peers via social media could further foster perceived competence in close friendships (Allegrante & Sigfusdottir, 2019; Nesi et al., 2018).

As for passive social media messaging on smartphone, only intensity of face-to-face meeting with friends predicted adolescents' passive social media messaging, not vice versa, meaning that adolescents tend to passively check the messages from the people they would meet in person while the passive checking has no effects on possibilities of meeting with friends. There were no associations between passive social media messaging and perceived competence in close friendships. The difference between active and passive social media messaging' associations with perceived competence in close friendships is compatible with the previous study (Allegrante & Sigfusdottir, 2019; Escobar-Viera et al., 2018), indicating that active social media messaging on smartphone is more closely related to the quality of peer engagement.

Limitations and future directions

A strength of the current study is the longitudinal investigation of the mechanisms of adolescents' PSU in terms of both quantity and quality of peer engagement. However, there are also several limitations that need to be addressed in future studies.

Firstly, participants were followed over the three waves and PSU was measured twice. Longer studies with more waves may identify more comprehensive

dynamic models on relationships between the quantity and quality of peer engagement and PSU. Especially, the mediating effect of PSU in our study implicates that the possible developmental cascade effects between PSU and perceived competence in close friendships should be further investigated with longer intervals (Blandon et al., 2010; Bornstein et al., 2010).

Secondly, we have used four variables to gauge the quantity and quality of peer engagement among adolescents, while other indicators like friends selection, numbers of friends, and peer influences online and offline also need to be considered when testing the associations between PSU and adolescents' peer engagement (Davies, 2014; Huang et al., 2014; Smahel et al., 2012). Moreover, though we have found that active and passive social media messaging function differently, future work is needed to determine the underlying mechanism and more validated measures for active and passive social media use, not just social media messaging should be applied (Gerson et al., 2017; Trifiro & Gerson, 2019). Besides, the scale of perceived competence in close friendships has shown relatively low internal consistencies in present study. Therefore, other scales assessing social competence with better internal consistency (Harter, 2012) could be used in further studies. Apart from that, future work could even detect adolescents' friendship via the co-locations of their smartphones (Malik et al., 2020).

Thirdly, the debate surrounding PSU, including the similarities with behavioral addictions and the role of the activities on the smartphone, rather than the smartphone itself, needs to be addressed in future research (Elhai & Contractor, 2018; Horvath et al., 2020; Körmendi et al., 2016; Panova & Carbonell, 2018). As a first step, we mainly focused on the role of peer engagement in the development of PSU, in which we used social media messaging as an indicator of online peer engagement. It has been suggested that the activities on the phone, like general social media use (Noë et al., 2019; Rozgonjuk, Kattago, et al., 2018) and gaming (Liu et al., 2016) drive PSU. This means that to understand PSU, it is important to focus on the specific activities, rather than the smartphone itself (Panova & Carbonell, 2018). In addition, objective measures on adolescents' and their parents' smartphone and social media use should be applied (Ryding & Kuss, 2020) since the self-reported measures were found to be only moderately correlated to the objective logs (Parry et al., 2021). Person-centered qualitative studies should be further applied to answer the question whether PSU is really a behavioral addiction without pathologizing normal smartphone use (Kardefelt-Winther et al., 2017).

The present study makes several notable contributions. At first, we found that passive social media messaging on smartphone and perceived competence in close friendship are two salient factors that could influence adolescents' PSU, which

should be included when designing the protocols for smartphone use interventions. As for the promotion of adolescents' social competence (Stichter et al., 2016), the importance of active interactions online for meetings with friends in-person, as well as the detrimental influences of problematic smartphone use on the quality of relationships should be emphasized. Besides, the different effects of active and passive social media messaging found here should also be noted in both practical and theoretical research in the area. For instance, a balance of active and passive social media messaging could be a viable point to reach the goal of "digital well-being" (Vanden Abeele, 2020).

Conclusion

To conclude, the current study provides longitudinal evidence, showing that adolescents who perceive a low competence in close friendships and frequently check messages from their peers on smartphone would have a higher risk to develop problematic smartphone use over time. Our findings also suggest that the balance between active and passive social media messaging should be attained to benefit adolescents' well-being.

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Appendix A: Figures

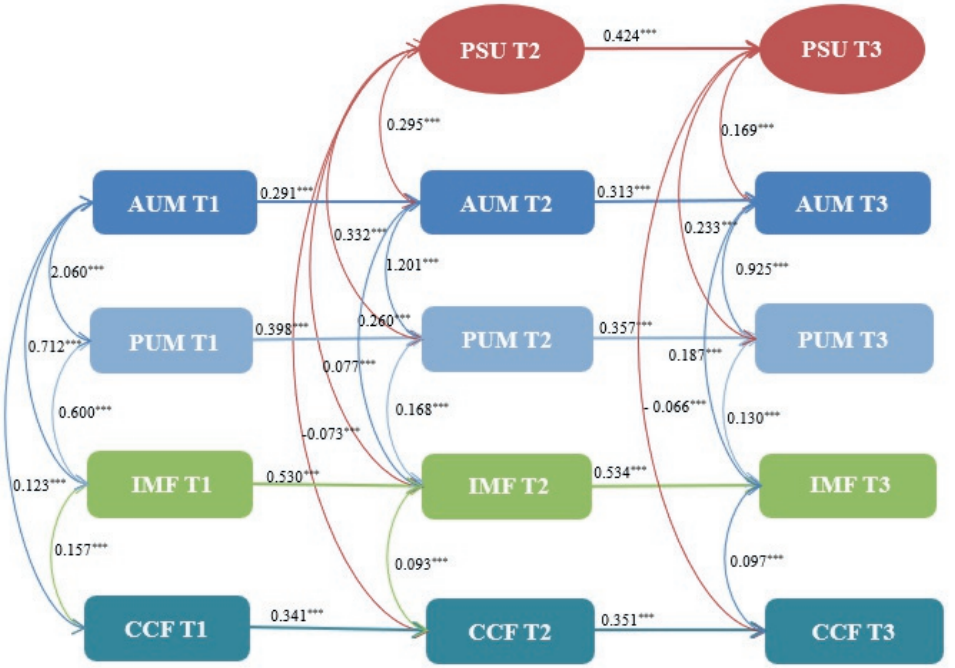

Figure.2.1. The standardized coefficients of the auto-regressive and within-time effects in the final model.

Note. PSU = problematic smartphone use, AUM = active social media messaging on smartphone, PUM = passive social media messaging on smartphone, CCF = perceived competence in close friendships, IMF = intensity of face-to-face meeting with friends; T1 = Time 1, T2 = Time 2, T3 = Time 3. Only the significant paths are showed in the figure, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

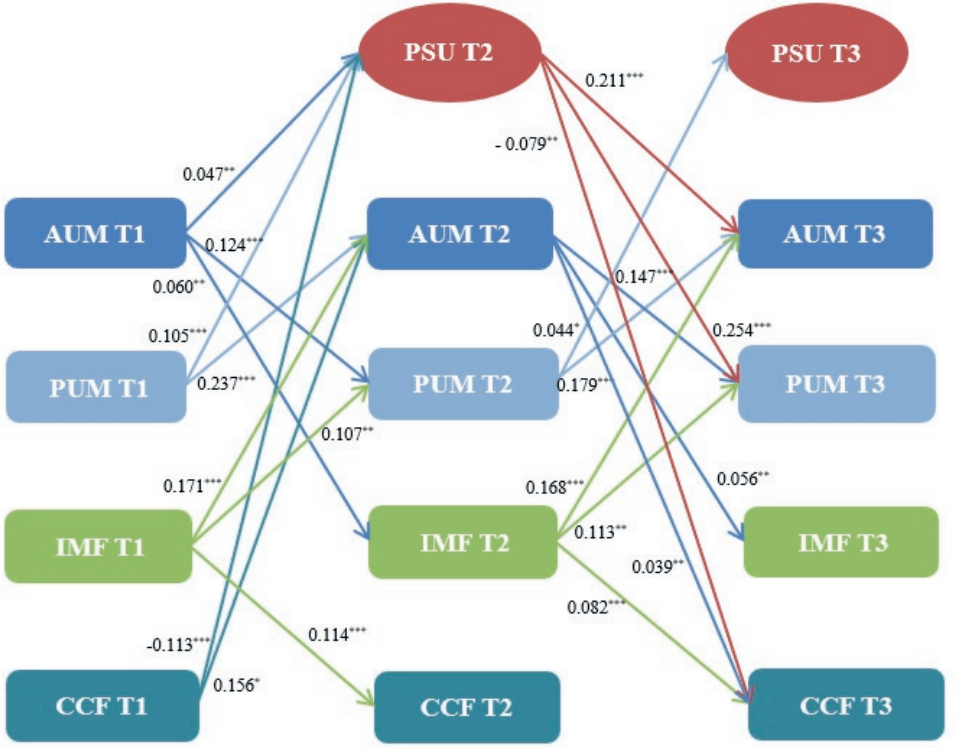

Figure.2.2. The standardized coefficients of cross-lagged effects in the final model.

Note. PSU = problematic smartphone use, AUM = active social media messaging on smartphone, PUM = passive social media messaging on smartphone, CCF = perceived competence in close friendships, IMF = intensity of face-to-face meeting with friends; T1 = Time 1, T2 = Time 2, T3 = Time 3. Only the significant paths are showed in the figure, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

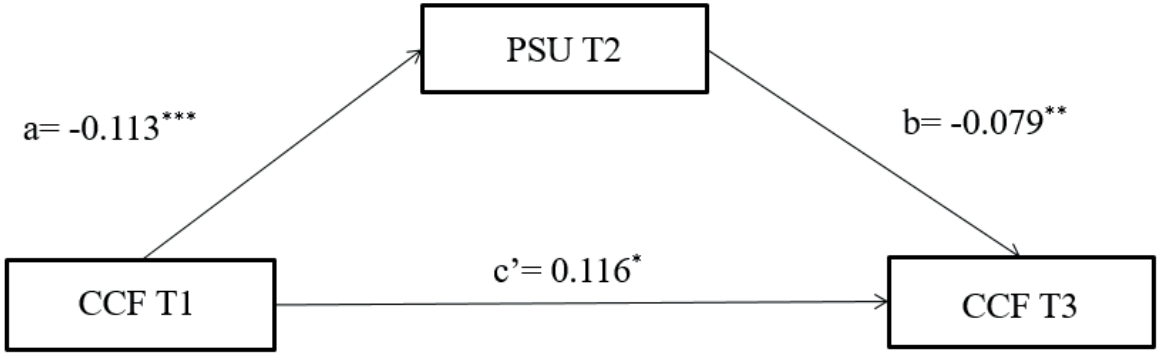

Figure.2.3. The mediation effect of problematic smartphone use at T2 on the relationship between perceived competence in close friendship s at T1 and T3

Note. a, b and c' are expressed as the standardized regression coefficients. CCF T1=perceived competence in close friendships at Time 1; CCF T3=perceived competence in close friendships at Time 3; PSU T2=problematic smartphone use at Time 2; $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Appendix B: Tables

Table 2.1 Measurement Invariance Analysis: Multi-group CFA

	Overall model fit constrained model			Changes in model fit	
	CFI	TLI	RMSEA	ΔCFI	ΔRMSEA
PSU	.911	.893	.052	.004	.002
IMF	.987	.983	.027	.009	-.010
CCF	.935	.923	.030	.003	.002

Note. PSU = problematic smartphone use, CCF = perceived competence in close friendships, IMF = intensity of face-to-face meeting with friends; CFA = confirmatory factor analysis, CFI = comparative fit index, TLI = Tucker–Lewis index, RMSEA = root mean square error of approximation; changes in model fit were the results from the comparisons between the unconstrained model (i.e., the factor loadings and item intercepts were free over time) and constrained model (i.e., the factor loadings and item intercepts were the same over time).

Table 2.2 Means, standard deviations and correlations of problematic smartphone use, active and passive social media messaging on smartphone, intensity of face-to-face meeting with friends, and perceived competence in close friendships over the three-wave measurements

Variables	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.PSU T2	2.148	0.799	1													
2. PSU T3	2.131	0.759	.499***	1												
3.AUM T1	4.270	1.815	.220***	.161***	1											
4.AUM T2	4.280	1.763	.337***	.260***	.482***	1										
5.AUM T3	4.020	1.670	.311***	.331***	.440***	.522***	1									
6.PUM T1	4.310	1.628	.255***	.174***	.692***	.450***	.434***	1								
7.PUM T2	4.510	1.586	.407***	.303***	.444***	.711***	.481***	.516***	1							
8.PUM T3	4.390	1.545	.358***	.423***	.415***	.501***	.673***	.536***	.559***	1						

9. IMF T1	3.492	1.085	.061*	.039	.359***	.280***	.254***	.339***	.261***	.245***	1					
10. IMF T2	3.393	1.118	.143***	.113***	.288***	.344***	.283***	.249***	.284***	.255***	.545***	1				
11. IMF T3	3.376	1.065	.084**	.111***	.273***	.314***	.323***	.271***	.283***	.289***	.500***	.585***	1			
12. CCF T1	4.325	0.702	-.087**	-.148***	.092***	.099***	.080*	.039	.052	.031	.198***	.125***	.162***	1		
13. CCF T2	4.317	0.702	-.150***	-.096***	.102***	.113***	.065*	.050	.074***	.058*	.217***	.273***	.184***	.355***	1	
14. CCF T3	4.325	0.695	-.117***	-.166***	.103**	.131***	.088***	.076*	.084**	.034	.162***	.243***	.286***	.309***	.414***	1

Note. PSU = problematic smartphone use, AUM = active social media messaging on smartphone, PUM = passive social media messaging on smartphone, IMF = intensity of face-to-face meeting with friends, CCF = perceived competence in close friendships; T1 = Time 1, T2 = Time 2, T3 = Time 3; $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 2.3 Fit statistics for the nested models on the cross-lagged relationships between active and passive social media messaging on smartphone.

Model	AIC	χ^2	*df*	CFI	TLI	RMSEA
Model 0	45801.178	315.242	8	.907	.837	.101
Model 1	45606.080	141.836	6	.959	.904	.078
Model 2	45576.640	119.393	6	.966	.920	.071
Model 3	45512.440	59.363	4	.983	.941	.061

Note. Model 0: auto-regressive relationships and within-time correlations for active and passive social media messaging on smartphone but no lagged effects; Model 1: active social media messaging on smartphone has a directional lagged effect on passive social media messaging on smartphone; Model 2: passive social media messaging on smartphone has a directional lagged effect on active social media messaging on smartphone; Model 3: active and passive social media messaging on smartphone have cross-lagged effects on each other.

Table 2.4 Fit statistics for the nested models on the cross-lagged relationships between offline and online peer engagement.

Model	AIC	χ^2	*df*	CFI	TLI	RMSEA
Model 0	63743.273	201.686	17	. 959	.921	.053
Model 1	63667.006	130.741	13	.974	.934	.049
Model 2	63686.319	142.151	13	.971	.927	.051
Model 3	63629.189	88.037	9	.982	.936	.048

Note. Model 0: auto-regressive relationships and within-time correlations for online and offline peer engagement but no lagged effects; Model 1: online peer engagement has a directional lagged effect on offline peer engagement; Model 2: offline peer engagement has a directional lagged effect on online peer engagement; Model 3: online and offline peer engagement have cross-lagged effects on each other.

Table 2.5 Fit statistics for the nested models on the cross-lagged relationships between the quantity and quality of peer engagement.

Model	AIC	χ^2	*df*	CFI	TLI	RMSEA
Model 0	76947.375	220.387	28	.965	.925	.043
Model 1	76850.409	123.152	22	.982	.950	.035
Model 2	76938.854	197.402	22	.968	.913	.046
Model 3	76849.667	107.905	16	.983	.937	.039

Note. Model 0: auto-regressive relationships and within-time correlations for the quantity and quality of peer engagement but no lagged effects; Model 1: the quantity of peer engagement has a directional lagged effect on the quality of peer engagement; Model 2: the quality of peer engagement has a directional lagged effect on the quantity of peer engagement; Model 3: the quantity and quality of peer engagement have cross-lagged effects on each other.

Table 2.6 Fit statistics for the nested models on the cross-lagged relationships between the quantity and quality of peer engagement and PSU.

Model	AIC	χ^2	*df*	CFI	TLI	RMSEA
Model 0	86001.174	171.663	28	.977	.934	.037
Model 1	85968.403	137.270	24	.982	.938	.035
Model 2	85958.688	130.633	24	.983	.943	.034
Model 3	85939.364	107.500	20	.986	.942	.034

Note. Model 0: auto-regressive relationships and within-time correlations for the quantity and quality of peer engagement and PSU; Model 1: the quantity and quality of peer engagement have a directional lagged effect on PSU; Model 2: PSU has a directional lagged effect on the quantity and quality of peer engagement; Model 3: the quantity and quality of peer engagement and PSU have cross-lagged effects on each other.

CHAPTER 3

The good and the bad: A qualitative investigation of students' perspectives on their problematic smartphone use

This chapter is adapted from a manuscript in submission:

Su, S., Cousijn, J., Wiers, R. W., Murray, H., Schoenmakers, T. M., & Larsen, H. (*in submission*). The good and the bad: A qualitative investigation of students' perspectives on their problematic smartphone use.

Abstract

Background and Aims: Problematic smartphone use (PSU) has recently attracted attention and its characteristics continue to be debated. To advance our understanding of PSU, we explored PSU-related experiences, antecedents, and consequences in students who reported their smartphone use as significantly problematic. We aimed to uncover both similarities and differences with the established addiction symptoms (i.e., DSM-5 and ICD-11) and identify central themes relating to PSU etiology. **Design:** Qualitative study using semi-structured interviews. **Setting:** University of Amsterdam, The Netherlands. **Participants:** Twenty-eight European university students with problematic smartphone use, as indicated by a score above 33 on the Short Version of Smartphone Addiction Scale (SAS-SV). **Measurements:** Semi-structured interview focusing on the perceptions of PSU. Deductive and inductive analyses were applied, and the data were thematically coded. **Findings:** Overall, participants experienced addiction-like symptoms including craving, salience and preoccupation, negative consequences, loss of control, coping, and tolerance-like and withdrawal-like symptoms. Results also emphasized the vital roles of the smartphone, habitual smartphone use, and smartphones as disruptive distractions. However, all participants mentioned substantial positive consequences resulting from smartphone use that surpassed negative consequences. The central role of the "trade-off process" between positive and negative consequences as well as the motives, and perceived social norms for smartphone use emerged as key factors in PSU etiology. **Conclusions:** To better define and understand PSU, future research should examine the trade-off between positive and negative consequences, the motives, and perceived social norms for smartphone use, moving beyond existing "addiction" criteria and measures.

Keywords: Problematic smartphone use, qualitative study, university students, addiction

Introduction

The ubiquitous nature of smartphones in daily life has facilitated communication, entertainment, and even health management (Kim et al., 2016; Kuss et al., 2018; Recio-Rodriguez et al., 2019), with the number of global smartphone users estimated to be 6.841 billion in 2023 (O'Dea, 2023). However, excessive smartphone use has raised concerns regarding its potential psychological and physical consequences (AlAbdulwahab et al., 2017; Clayton et al., 2015; Demirci et al., 2015). The prevalence of problematic smartphone use (PSU) among children and youth was estimated to be between 10% and 30% (Sohn et al., 2019), with a global increase observed among youth aged 15 to 35 years (Olson et al., 2022). However, it should be noted that the classification and definition of PSU as an "addiction" remains controversial (Billieux, Maurage, et al., 2015; Panova & Carbonell, 2018; Weinstein & Siste, 2022). This controversy arises because many studies have relied on broad screening methods that lack evidence for the presence of severe addiction-like symptoms as defined in established diagnostic manuals like the DSM-5 or ICD-11 (American Psychiatric Association, 2013; Panova & Carbonell, 2018; World Health Organization, 2019). PSU has been proposed as a potential behavioral addiction (Haug et al., 2015; Lin et al., 2014), however, its definition varies across studies and disciplines. Some researchers have adopted the DSM-5 framework, including six symptom criteria (e.g., withdrawal), four functional impairment criteria (e.g., physical problems), and one exclusion criterion (i.e., the symptoms are not caused by other disorders) (Lin et al., 2016). Alternatively, other established scales on PSU have emphasized dimensions such as daily-life disturbance, leading to the high prevalence of PSU based on such criteria (Akın et al., 2014; Khalily et al., 2019; Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Lopez-Fernandez, 2017; Luk et al., 2018; Olson et al., 2022).

Qualitative research methods offer a valuable approach to exploring in-depth subjective experiences of problematic smartphone users. Based on semi-structured interviews with Indian university students and young Chinese workers, problematic smartphone users seemed to experience symptoms like withdrawal, salience and preoccupation, and conflict that align with the existing addiction criteria (Jameel et al., 2019; Li & Lin, 2019a). Additionally, phantom phone signals may be a potential unique symptom of PSU (Li & Lin, 2019a). With open-ended questions, negative consequences of PSU have also been reported by British undergraduate students (Yang et al., 2019). In terms of the possible etiology, qualitative researchers have explored several antecedents of PSU, including personality traits, poor self-regulation, and boredom (Li & Lin, 2019b; Yang et al., 2019).

Despite these significant contributions, some important aspects have not yet been studied in depth. For example, impaired cognitive abilities (Wilmer et al., 2017) and physical dangers related to PSU (Gutiérrez et al., 2016), are akin to established symptoms of substance use-related disorders in the DSM-5. Furthermore, the unique anthropomorphic characteristics of the smartphone require future investigations among individuals with PSU (Fullwood et al., 2017; Harkin & Kuss, 2021). Given the many benefits smartphones can offer in daily life, the emerging imbalance between positive (i.e., the multifunctionality of smartphone use) and negative (i.e., substantial impairments in daily-life functioning caused by PSU) consequences has been proposed as a salient factor in PSU etiology (Harkin & Kuss, 2021; Kardefelt-Winther et al., 2017; Panova & Carbonell, 2018; Yang et al., 2019). Additionally, the motives and perceived social norms for smartphone use also play an important role in PSU (Chotpitayasunondh & Douglas, 2016; Fullwood et al., 2017; Harkin & Kuss, 2021; Hong et al., 2021). Without a proper understanding of the multifaceted positive and negative nature of smartphone use as well as the motives and perceived social norms for smartphone use, the current labeling of individuals as having "smartphone use problems" or even "smartphone addiction" may be premature (Billieux, Maurage, et al., 2015; Kardefelt-Winther et al., 2017), potentially resulting in over pathologizing or stigmatizing smartphone users (Billieux, Maurage, et al., 2015; Billieux, Schimmenti, et al., 2015; Kardefelt-Winther, 2015; Kardefelt-Winther et al., 2017).

Therefore, to advance our understanding of PSU, we investigated the perceived PSU-related experiences, antecedents, and consequences in European university students who reported their smartphone use as significantly problematic. Going beyond phenomena resembling addiction, our goal was to systematically identify both commonalities and differences through deductive and inductive approaches in comparison to established addiction symptoms (i.e., DSM-5 and ICD-11). Finally, central themes relating to PSU etiology were identified and evaluated.

Methods

Sample and procedure

Thirty European students were recruited via an online research platform from the University of Amsterdam. Inclusion criteria were (1) age 18-25 years; (2) at least one European nationality; (3) a score higher than 31 for males or 33 for females on the short version of smartphone addiction scale (SAS-SV) based on the proposed SAS-SV cut-off scores for PSU (Kwon, Kim, et al., 2013).

Two participants withdrew for personal reasons resulting in a final sample of 28 (n=24 males; n=26 Bachelor students; n=2 Master students) aged between 18-24 years (M=20.29, *SD*=1.61). The average SAS-SV score of these participants was

46.82 (*SD*=3.22) and the average number of years that they had used their smartphones was 7.39 (*SD*=1.47). Participants were from 17 different European countries of which six had dual nationality.

A semi-structured interview protocol was developed, using the following sources: a protocol of a cross-cultural qualitative study on problematic internet use (Dreier et al., 2012); DSM-5 (American Psychiatric Association, 2013) and ICD-11 (World Health Organization, 2019); existing questionnaires and recent studies on PSU, problematic internet use, social media use and gaming (Cho & Lee, 2015; Fisher et al., 2015; Kwon, Lee, et al., 2013; Stavrinos et al., 2018; Van Rooij et al., 2011); pilot interviews with two co-authors, two colleagues, and two pilot participants. The final interview protocol (see Supplementary protocol S3.1) started with questions about how the smartphone was used in daily life (e.g., frequency, duration, setting, social/non-social goals), followed by questions on the positive and negative consequences of use. These were followed by questions about specific PSU symptoms proposed in previous studies, DSM-5 [13] and ICD-11 [14] (e.g., withdrawal, negative effects, etc.), motives and perceived social norms for smartphone use, and potential changes in use. Open-ended questions were employed to encourage participants to provide detailed narratives. Follow-up prompts were used to facilitate further elaborations on those questions. The interviews were conducted in English, the second language of all interviewees and the interviewer, and minorly revised during the interview process.

At the university, participants first received the informed consent form and filled out the socio-demographic questionnaire. The interviewer (i.e., the first author, female) audio-recorded all interviews. The average duration of the interviews was 71.68 minutes (*SD*=12.33). Upon completion, participants were given the choice between receiving 10 euros or earning 1 research credit. Ethical approval was obtained from the Ethical Review Board of the Faculty of Social Sciences, University of Amsterdam (ERB number 2018-DP-9789).

Data analysis

After all interviews were transcribed verbatim, the data were coded with MAXQDA2022 (VERBI Software, 2021) and systematically analyzed, via multiple rounds of coding: first, open coding was conducted; second, the important themes were developed; third, deductive analysis was used to validate the pre-existing theory-based criteria from DSM-5 and ICD-11 based on the open codes; finally, inductive analysis was used to identify emerging unique themes (e.g., experiences and antecedents) related to PSU and the central themes relating to PSU etiology and an explanatory theoretical model was developed (Braun & Clarke, 2006). For the first round of open coding, the first author and a research assistant coded 3

transcripts independently, after which discrepancies between coding were discussed. When agreement was reached between the two researchers (average agreements of the codes were 92.5%), the first author open-coded the remaining 25 transcripts. After several rounds of discussion among the two researchers, the analysis was further reviewed and discussed with the other five co-authors. Upon analyzing the data from 26 participants, data saturation was achieved, indicating no new themes emerged from subsequent participants. To provide a comprehensive overview of the findings, a frequency table was constructed for each theme, showing the underlying sub-themes and the distribution of the participants who reported them (see Table 3.1). The codebook is shown in Supplementary Table S3.2.

Results

Themes of PSU symptoms in the light of DSM-5 and ICD-11 addiction criteria

Our analyses revealed several themes that align with almost all of the DSM-5 and ICD-11 addiction criteria, including craving, salience and preoccupation, negative effects of smartphone use, loss of control, coping, tolerance-like, and withdrawal-like symptoms.

Urges to be always on one's smartphone: craving

Most participants frequently expressed a strong desire for continuous smartphone use. Even when they were not using their smartphones, they would contemplate various smartphone activities. They experienced intense urges to frequently check their smartphones and stay connected. This intense craving, characterized by a subjective sensation of desiring or longing for smartphone use (Tiffany & Wray, 2012), was perceived as highly potent among participants.

If my phone dies, and then I want to listen to music, then the entire time I'm thinking about it. And sometimes, I think of something that I want to message someone and then I don't have internet and then I'm thinking about my phone like: Oh, I can't wait until I get internet. (S09, Pos. 484)

Salience and preoccupation

Most participants exhibited significant preoccupation with their smartphones, particularly demonstrating constant alertness for incoming notifications, which had been described as perceptual illusions (e.g., sound, light, vibration, etc.) of new notifications.

Sometimes I think that it vibrated, but it didn't, it is in silence mode most of the time and I feel like it's vibrating. (S20, Pos. 618)

Many participants acknowledged using their smartphones in prohibited settings such as during conferences, cycling, and driving. Notably, smartphone use during cycling and driving is illegal in the Netherlands. Engaging with their

smartphone led to a swift immersion into this behavior, which in turn resulted in adverse outcomes like potential dangers when moving (i.e., walking, cycling, and driving) and missing important travel information.

I am walking somewhere and I'm on my phone and I don't notice where someone is going, so I have like confrontation, and we follow each other. Or I get lost because I was looking at my phone or when are we going somewhere, I forget to leave the tram because I was on my phone. (S17, Pos. 470)

Over half of the participants noted that they constantly paid attention to their smartphones even when not actively using them. Several participants revealed smartphones were their default choice when having nothing to do, engaging in the virtual world via smartphones rather than the real world, and some even reported dreams involving smartphone-related content.

Negative consequences of smartphone use on daily life

Participants reported negative consequences of smartphone use on various aspects of participants' daily lives. In-person relationships with their family and friends were jeopardized, marked by conflicts, concealment, and dishonesty about their smartphone use. Furthermore, participants highlighted the detrimental effects of their smartphones on their study efficiency and academic performance. Concerning mental health risks, participants mentioned suffering from stress and pressure related to instant messaging, negative feelings stemming from their excessive smartphone use, and a sense of detachment from the real world.

Interviewer: So how does it negatively influence your health?

Interviewee: I get impatient with myself. I get mad at myself for not getting things done. And I get stressed. Stressing causes me to now feel physical problems from stress like stomach ulcers, stress out, stress eating, binge eating, just like drinking caffeine, over caffeine, anything serious. I get aggressive with other people for nothing because I couldn't do some stuff. (S10, Pos. 330)

Participants also disclosed cognitive problems with attention, memory, and problem-solving abilities. Physical health risks associated with smartphone use were widely reported, with participants describing discomfort in their hands, back, neck, and eyes. Moreover, smartphone use had negative effects on participants' eating and sleep quality and they reported reduced physical activity.

Maybe late at night when I'm checking some things, and I just don't feel sleepy. I don't want to go to bed because I'm too focused on what I'm doing. So, procrastination is like 5 a.m. And I'm like, what is happening? (S20, Pos. 290)

Several participants have (almost) encountered traffic accidents, attributing these incidents to their habit of using their smartphones while walking, cycling, and

driving. Participants regarded this behavior as “pervasive” and were cognizant of the associated risks.

Everybody was using it. And because in the Netherlands we bike a lot. So, it's really dangerous to bike and use your phone at the same time. And one time I did hit the car. But I was using my phone a lot. So that's why I bumped into a car. (S07, Pos. 750)

Loss of control

Participants predominantly described two primary categories of loss of control regarding their smartphone use: (1) exceeding self-imposed smartphone use limits, which resulted in diminished time for other activities like studying and sleeping; (2) failing to restrict their smartphone use despite recognizing its negative effects.

Although you're setting your conscious to reminding yourself that you want to stop, want to end it after a certain point. You are already so in-depth into the task on smartphone that you feel that you cannot stop now. You have to first finish it, and then go to, then move on to the other things that you have to do. Then at the end, you are getting continuous stops and not concentrated enough to see stuff. (S31, Pos. 874-878)

Coping

Most participants used their smartphones to cope with negative emotions by using some functions of their smartphones. They could escape or get distracted by using their smartphone instead of confronting such emotions. However, they also report actively seeking social support to reduce their negative emotions, which might reflect a healthier way to cope with negative emotions:

If I'm anxious, I text a lot of my friends to like, get rid of that anxiousness and tell them what I'm feeling. And then they can get like, give their opinion about that. (S04, Pos. 364)

Tolerance-like symptoms

Regarding tolerance-like symptoms, participants did not explicitly mention an increased need for usage time. However, they acknowledged spending more time on their smartphones than before. A prevalent description of tolerance was the feelings of emptiness and neutrality after spending a significant amount of time on their smartphones. A less common manifestation of tolerance was a reduced patience for “boring” real-life situations, leading to highlighted susceptibility to boredom without their smartphones.

Withdrawal-like symptoms

Regarding withdrawal-like symptoms, all participants described having negative emotional states and behavioral responses when unable to use their smartphones

under different conditions, such as being out of battery, internet issues, or interruptions. The reported negative emotions mainly included frustration, anger, and annoyance when their smartphone use was impeded. Notably, all of them actively tried to resolve these impediments, even though they acknowledged that there might not be any urgent or important content on their smartphone. Furthermore, most of the participants expressed a profound sense of happiness upon regaining access to their smartphones after a period of deprivation. Some participants even reported a tendency to engage in excessive smartphone use upon regaining access.

Interviewer: How would you feel after being connected again?

Interviewee: I would feel like I would need to spend a lot of time to be known to people again. (S10, Pos. 684-686)

Emerging themes related to PSU beyond DSM-5 and ICD-11 addiction criteria

Vital roles of the smartphone in daily life

When asking the participants about the roles of their smartphones in their lives, smartphones were attributed to anthropomorphic qualities, such as "a best friend", reflecting their emotional attachment to their smartphones. Smartphones were also regarded as an extension of the self (e.g., *It's always in the pocket or somewhere or in my hand. It's like part of me.* S20, Pos. 1134). The multi-functionality of smartphones making life easier was also mentioned, with participants emphasizing smartphones as useful tools: *It's a super, super useful tool. I can kind of physically imagine my life without it, but my life would be so much more complicated.* (S23, Pos. 280). The role of smartphones was therefore intricately tied to the underlying motives driving participants' smartphone use patterns.

Habitual smartphone use

Most participants described habitual smartphone use patterns, characterized by checking their smartphones and apps automatically. They used terms like "automatic", "unconscious", "reflexive", "natural", and "habitual", indicating a lack of conscious deliberation during the process. Habitual smartphone use was reported to occur in the absence of specific goals, as exemplified by participants who reported engaging with their smartphones under various situations, including moments of social awkwardness or when preoccupied with demanding tasks.

I can just read a book and then stop at one point and even not realize it. I would take off my smartphone. And I start scrolling down the feed or whatever. (S23, Pos. 48)

Two participants acknowledged their inability to exert control over these habitual behaviors, suggesting underlying control issues.

Sometimes I just open it and look at it for a few seconds. And then I close it. I may do it again, like, five minutes later. (S27, Pos. 422-424)

Participants consistently experienced distractions caused by their smartphones in various situations of daily life, such as during lectures, conversations, and engagement in hobbies. Particularly noteworthy was one's smartphone as a major distractor while studying. The endless and abundant content on the smartphone would frequently divert their attention, resulting in unintended and prolonged disengagement from daily life tasks. Consequently, this distraction was perceived as having detrimental effects of inducing procrastination and a perceived loss of ability to regulate their smartphone use, which would lead to the sense of wasting time.

On my free days when I have laid in bed too long. When I use my phone long, then I check the time. Oh, it's already like, 11 o'clock or 12 o'clock. I'm wasting my time. That's when I noticed, I use my phone too much, I think it's a waste of my time. (S07, Pos. 498)

Central emerging themes related to PSU etiology

Motives for smartphone use and restrictive motives

Three primary motives driving their smartphone use were mentioned by all participants: social, informational, and emotional. For social motives, participants emphasized the importance of using their smartphones to connect with their family and friends, with communication emerging as the central benefit of smartphone use. For informational motives, participants highlighted the convenience of smartphones in providing easy access to information, which significantly contributed to their daily lives. For emotional motives, participants mentioned smartphones were used for entertainment (mainly listening to music), coping with negative feelings (e.g., boredom, sadness, stress, etc.), sharing aspects of their lives with others online (e.g., social media), and so on.

In addition to the aforementioned motives for smartphone use, participants have also expressed motives to restrict their smartphone use. These motives arose when participants recognized the negative consequences related to smartphone use on communication/relationships, study/work, cognition, hobbies, and physical and mental health.

Positive consequences of smartphone use on daily life

All participants acknowledged that smartphones have positive consequences on their daily lives as they consistently mentioned it helped in meeting their social, emotional, and informational needs. Participants highlighted their smartphone's instrumental role in facilitating communication, memory, and problem-solving processes, as well as new hobby development. Despite the descriptions of one's

smartphone as a major distractor, participants acknowledged the benefits and necessity of smartphones for their study.

If I need to look up something, and I am not on my laptop, I can do that quickly. For example, if I don't know a place, or I don't know the definition, I can look that up quickly. And I always get notifications of an online student portal, for example. So, I'm always up to date on that. Same with emails. (S11, Pos. 196)

The trade-off process for smartphone use

In addition to the identified themes, we also found a dynamic trade-off between the pros and cons of smartphone use. Despite acknowledging the negative impact of smartphones on their daily life, most participants were unwilling to give up their smartphones. They identified their smartphone as predominantly positive and useful, perceiving that the advantages outweighed the disadvantages. This evaluation of smartphones appeared to dynamically impact their patterns of PSU. Notably, the context played an important role in this trade-off process, as participants reported both positive and negative effects of their smartphones within the same daily activities (e.g., study, communication, etc.).

Interviewer summarizing and reflecting: You think your smartphone may have some negative influences on your life, but you will still use it, why?

Interviewee: I think that overall positive influences are way more than negative influences. (S25, Pos. 376)

Furthermore, despite being aware of the negative consequences of their smartphones, some participants chose not to restrict their use. They attributed this decision to the positive effects they experienced, making it more challenging to change their smartphone use.

I'm aware of all the negative sides of it. It's like the advantages that I gained from it still overweight its disadvantages. So, I think I wouldn't be able to give up my smartphone use. (S23, Pos. 982)

Perceived social norms

Others' evaluations of one's smartphone use. Based on participants' descriptions, most of them had received feedback from their family, partner, and friends indicating concerns about their smartphone use, often characterized as "you are addicted to your smartphone" and "you use your smartphone too much". However, it is worth noting that some participants mentioned receiving feedback from others that their smartphone use was acceptable, primarily based on opinions from their friends. Interestingly, participants' friends appeared to be more tolerant of their smartphone use compared to their family members.

One's evaluation of their smartphone use. In contrast to others' evaluations, most participants perceived their smartphone use time as either on par with or even lower than the average smartphone use time, especially within their age group. Only a small part of the participants perceived their smartphone use to exceed the average use time of the older generation, especially their parents' age group. This disparity in self-perception of smartphone use may contribute to the manifestation of PSU among our participants, as indicated by their relatively high SAS-SV scores.

I think most people use it too much. So, I think I'm quite average. But I still think that I use it too much. Because in general, people use it too much these days, including me. (S32, Pos. 650)

A preliminary theoretical framework for the etiology of PSU

Figure 3.1 summarizes the primary experiences, antecedents, and consequences of PSU, as well as the intricate interconnections elucidated in this study. Participants' smartphone use was driven by social, informational, and emotional motives, resulting in different types of smartphone use. Consequently, their smartphone use manifested both positive and negative consequences in their daily lives, a dynamic process within the context of a trade-off framework. As the negative consequences began to outweigh the positive consequences, participants exhibited addiction-like symptoms, which manifested into significant functional impairments. To mitigate the negative consequences, participants may restrict their smartphone use. Conversely, when the positive consequences outweigh the negative consequences, participants will be more inclined to use smartphones or not to change their use. Throughout this whole process, the perceived social norms emerged as a prominent factor, exerting a notable impact on each stage.

Discussion

The primary novel insight of this study is that problematic smartphone use may best be considered as a trade-off process between the negative consequences of smartphone use that outweigh the perceived positive consequences. This highlights the limitation of relying on scores solely gauging addiction-like symptoms for understanding problematic smartphone use. Additionally, our participants (i.e., European students with scores higher than 33 on the SAV-SV) demonstrated a functional ability to manage their daily responsibilities and exhibited a reluctance to completely give up smartphone use, which is understandable from the perspective of the trade-off process.

Our exploration of PSU etiology extends beyond the trade-off process, encompassing two important factors: "motives for smartphone use" and "perceived social norms". We have expanded the scope of the motives for smartphone use by highlighting informational motives, which have received less attention in previous

research (Chen et al., 2017; Haug et al., 2015). In line with previous studies, the multifunctionality and self-extension roles of smartphones suggest that the diverse functions offered by smartphones may contribute to PSU (Fullwood et al., 2017; Harkin & Kuss, 2021). Additionally, the social and emotional motives, along with the anthropomorphic roles of smartphones, align with previous findings on emotional attachment to smartphones (Trub & Barbot, 2016). These results aligned with the established theories like Rational Addiction Theory (Becker & Murphy, 1988), Uses and Gratifications Theory (Blumler, 1979), and Motivational Theory (Brand et al., 2016; Cooper et al., 1995; Köpetz et al., 2013; Kuss et al., 2012). In accordance with the Rational Addiction Theory, smartphone users seek to maximize the utility of smartphones to attain positive consequences (Becker & Murphy, 1988; Köpetz et al., 2013). They use their smartphone to satisfy diverse needs and motives, in line with the Uses and Gratifications Theory (Blumler, 1979) and Motivational Theory (Brand et al., 2016; Cooper et al., 1995; Köpetz et al., 2013; Kuss et al., 2012). This underscores the importance of considering specific motives for smartphone use and goal-directed behaviors when identifying individuals with severe smartphone use problems (Everitt & Robbins, 2005; Hogarth, 2020). In line with Hogarth's model, our findings demonstrated that excessive smartphone use may result in conflicts with other goals (e.g. academic achievement, work), yet this behavior persists due to the continued pursuit of the positive consequences associated with smartphone use (Hogarth, 2020). Additionally, the contrast between subjective and external evaluations of smartphone use highlights discrepancies (Parry et al., 2021), a trend congruent with the previous studies on social norms within PSU (Hong et al., 2021; McAlaney et al., 2020). This phenomenon parallels the function of social norms observed in various substance use scenarios like alcohol consumption (Vallentin-Holbech et al., 2017; Wood et al., 2012).

In the context of the described trade-off process in problematic smartphone use, while considering motives and perceived social norms for smartphone use, we have identified "addiction-like" symptoms. These include craving, salience and preoccupation, negative consequences of smartphone use, loss of control, and coping, as well as tolerance-like and withdrawal-like symptoms. These symptoms align with the criteria outlined in DSM-5 and ICD-11, as well as the previous questionnaires and criteria on PSU (American Psychiatric Association, 2013; Kwon, Lee, et al., 2013; Lin et al., 2014, 2016; World Health Organization, 2019), while also expanding upon these conceptualizations. To illustrate, our investigation has further extended the view on "tolerance" in PSU, encapsulating not only diminished excitement after long smartphone use but also reduced tolerance for boredom without smartphones. Furthermore, our study has identified unique symptoms of PSU that went beyond the DSM-5 and ICD-11 addiction criteria. These include the

themes of “special roles of the smartphone”, “habitual smartphone use” and “disruptive distractions from everyday life”. These findings are consistent with previous investigations into smartphone use, highlighting the attachment to smartphones (Fullwood et al., 2017; Trub & Barbot, 2016), smartphones as an extension of oneself (Harkin & Kuss, 2021), habitual smartphone use (Van Deursen et al., 2015; Wilmer et al., 2017), and smartphones as major distractions (Mendoza et al., 2018; Roberts & David, 2016). However, whether those symptoms should be formally incorporated into the criteria for diagnosing PSU warrants further investigation. It is also noteworthy that our participants’ portrayal of “habitual smartphone use” was presented descriptively, reflecting the frequency and automatic nature of such behaviors, rather than being laden with technical explanations (De Houwer, 2019; Everitt & Robbins, 2005).

Expanding on our current findings, we aimed to formulate a preliminary framework illustrating the connections between the identified themes, providing a foundational step toward understanding PSU etiology. We encourage further research to differentiate trade-off processes between non-problematic and problematic smartphone users related to daily functioning, and consider co-occurrence with other mental health problems (Hogarth, 2020). The outlined theoretical framework including the trade-off process underscores intervention potential to address PSU by increasing the awareness of adverse PSU outcomes (Carlson & Larkin, 2009), aiding in reducing problematic smartphone use. Interventions should avoid advocating the elimination of smartphones, recognizing their integral role in achieving “digital well-being” (Pedrero-Pérez et al., 2019; Vanden Abeele, 2020). Moreover, interventions targeting perceived social norms may offer a promising strategy to help problematic users.

This study has not only demonstrated the multifactorial nature of PSU, but also sheds light on unexplored facets. However, it is important to acknowledge the limitations of this study. First, the generalizability of our findings is limited due to the specific focus on university students. Further research could include clinical samples, involving the problematic smartphone users identified by clinicians or psychotherapists (Körmendi et al., 2016). It is crucial to acknowledge that while the symptoms of PSU we identified align with existing “addiction” criteria, using the term “smartphone addiction” may contribute to stigma and misunderstandings about typical smartphone use (Kardefelt-Winther et al., 2017; Wiers & Verschure, 2021). Therefore, a cautious approach is necessary when applying professional terminology like “addiction” solely based on our participants’ descriptions, especially when appropriate terminology is lacking in certain contexts.

Conclusion

Our study underscores the significance of the trade-off process as well as the motives and perceived social norms for smartphone use in understanding problematic smartphone use, transcending a mere tallying of addiction criteria and reliance solely on psychometric measures. Future research should distinguish distinct patterns between non-problematic and problematic use within this proposed framework.

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Appendix A: Table

Table 3.1 The underlying sub-themes of each theme and the reporting frequency of the sub-themes

Theme	Subtheme	Definition	n	Frequency (%)
Urges to be always on one's smartphone: craving	Think about things on smartphone when not using	-	22	78.6
	Want to use smartphones when not using	-	26	92.9
Salience and preoccupation	Illusions of new messages or notifications on smartphone	-	25	89.3
	Ignore the regulations that one is not allowed to use smartphones under some specific situations	The situations include conferences, driving a car, cycling, and so on	27	96.4
	Get immersed when using smartphones	-	24	85.7
	Living in the virtual world on smartphone instead of the real world	Participants feel they have paid more attention to the virtual world on smartphone	5	17.9

	Dreams about smartphones	Having dreams about smartphones or activities related to smartphone	8	28.6
Negative consequences of smartphone use on daily life	Negative effects on real-life relationships	-	23	82.1
	Negative effects on cognitive process	The negative effects of smartphone use on participants' attention span, problem-solving abilities, memory, and general thinking abilities	23	82.1
	Negative effects on study	The negative effects of smartphone use on lectures, study efficiency (e.g., less time for study, less concentration during study, procrastination, etc.), academic performance, and so on	28	100
	Mental health risks	The negative feelings and pressure related to smartphone use	23	82.1
	Physical health risks	The physical health risks include physical complaints, traffic accidents, and bad eating and sleeping habits	28	100
	Negative effects on hobbies	Spend less or no time on hobbies because of smartphone use	14	50.0
Loss of control	Use smartphones longer than intended	-	27	96.4
	Failures of control	Participants feel they could not control their smartphone use	4	14.3
Coping	Reduce the negative feelings with smartphones	To actively make themselves feel better by using smartphone functions (e.g., watching videos, listening to music, etc.)	27	96.4
	Get distracted/escape with smartphones when having negative feelings	Get distracted or escape hard situations or negative feelings by using smartphones	12	42.9
	Seek social connections or support via smartphone when having negative feelings	To make themselves feel better by contacting their family or friends	10	35.7
Tolerance-like symptoms	Can't get bored anymore with the smartphone	-	1	3.6
	Get bored easily since one has used the smartphone a lot	-	2	7.1
	No excitement about smartphone use	Feeling empty or neutral after spending much time on their smartphones	21	75.0
	Use smartphones more than before	-	19	67.9
Withdrawal-like symptoms	Withdrawal-like feelings when one cannot get access to smartphones	-	28	100
	Attempts to avoid/fix the problem when one cannot access smartphones	-	28	100
	Positive feelings when getting smartphones back	-	27	96.4
	Excessive use when getting	-	5	17.9

	smartphones back			
Vital roles of the smartphone in daily life	Important role	Stress the importance of smartphones	28	100
	Emotional attachment role	Emotional attachment to smartphones	9	32.1
	Self-extension role	Smartphone as a part or an extension of the user	16	57.1
	Functional role	Stress the multiple and versatile functions that can make life easier	19	67.9
Habitual smartphone use	Habitual smartphone use	Get smartphones automatically/subconsciously	27	96.4
	Habitual App use	Open smartphone Apps automatically/subconsciously	27	96.4
	Control issues related to such habitual use	Inability to control such habitual behaviors	2	7.1
Disruptive distractions from daily life	General distractions from everyday life	Smartphone as a general distractor	16	57.1
	Distractions from social settings	Smartphone as a distractor when communicating/interacting with others offline	6	21.4
	Distractions from study	Smartphone as a distractor during study	28	100
Motives for smartphone use and restrictive motives	Social motives	Connect and communicate with the participant's family and friends	28	100
	Informational motives	Easy access to information for everyday life	28	100
	Emotional motives	Entertainment (mainly listening to music), coping with negative feelings (e.g., boredom, sadness, stress, etc.), sharing their life with others online (e.g., social media), enhancing positive and negative feelings	28	100
	Restrictive motives	Want to restrict one's smartphone use when realizing the negative consequences of smartphone use on communication/relationships, study/work, cognition, hobbies, physical and mental health	20	71.4
Positive consequences of smartphone use on daily life	Positive effects on communication/relationships	The benefits their smartphone could bring to participants' communication and relationships	28	100
	Positive effects on cognitive processes	The positive effects of smartphone use on participants' memory, problem-solving, and general thinking	26	92.9
	Positive effects on study	The benefits and facilities smartphone use could bring to participants' study	25	89.3
	Positive effects on mental health	The positive effects of smartphone use on participants' perceived mental health	15	53.6
	Positive effects on physical health	The positive effects of smartphone use on participants' perceived physical health	18	64.3
	Positive effects on hobbies	Smartphones could facilitate the execution and development of participants' hobbies	8	28.6

The trade-off process for smartphone use	I can control my smartphone use when I realize its negative effects	-	8	28.6
	I don't restrict my smartphone use though I'm aware of its negative effects	-	5	17.9
	I don't think my smartphone has negative effects on me	-	4	14.3
	I can't give up my smartphone completely	-	21	75.0
	My smartphone is generally positive	-	16	57.1
	My smartphone has more positive than negative effects	-	11	39.3
Perceived social norms:	Others said I'm "addicted" to my smartphone	-	21	75.0
Others' evaluations of one's smartphone use	Others think I use my smartphone too much	-	27	96.4
	Others, mainly my friends think my smartphone use is okay	-	20	71.4
Perceived social norms:	I don't use my smartphone more than the average	-	10	35.7
One's evaluation of their smartphone use	I use my smartphone as much as the average	-	12	42.9
	I use my smartphone more than the average	-	10	35.7
	I use my smartphone less than the average	-	4	14.3

Appendix B: Figure

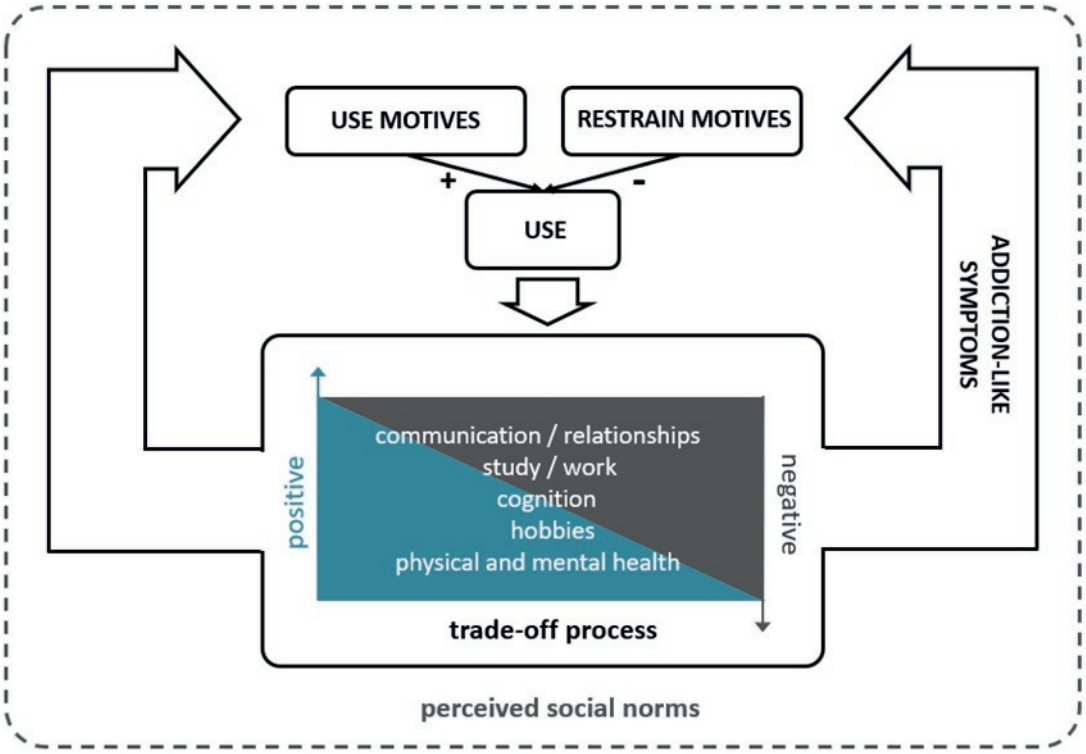

Figure 3.1. A preliminary theoretical framework for the etiology of Problematic Smartphone Use based on the findings from this study

CHAPTER 4

From Everyday Life to Measurable Problematic Smartphone Use: The Development and Validation of The Smartphone Use Problems Identification Questionnaire (SUPIQ)

This chapter is adapted from the published article:

Su, S., Cousijn, J., Molenaar, D., Freichel, R., Larsen, H., & Wiers, R. W. (2024). From everyday life to measurable problematic smartphone use: The development and validation of the Smartphone Use Problems Identification Questionnaire (SUPIQ). *Journal of Behavioral Addictions*. Advance online publication. https://doi.org/10.1556/2006.2024.00010

Abstract

Background and aims: Problematic smartphone use (PSU) has gained attention, but its definition remains debated. This study aimed to develop and validate a new scale measuring PSU-the Smartphone Use Problems Identification Questionnaire (SUPIQ). **Methods:** Using two separate samples, a university community sample (N=292) and a general population sample (N=397), we investigated: (1) the construct validity of the SUPIQ through exploratory and confirmatory factor analyses; (2) the convergent validity of the SUPIQ with correlation analyses and the visualized partial correlation network analyses; (3) the psychometric equivalence of the SUPIQ across two samples through multigroup confirmatory factor analyses; (4) the explanatory power of the SUPIQ over the Short Version of Smartphone Addiction Scale (SAS-SV) with hierarchical multiple regressions. **Results:** The results showed that the SUPIQ included 26 items and 7 factors (i.e., Craving, Coping, Habitual Use, Social Conflicts, Risky Use, Withdrawal, and Tolerance), with good construct and convergent validity. The configural measurement invariance across samples was established. The SUPIQ also explained more variances in mental health problems than the SAS-SV. **Discussion and conclusions:** The findings suggest that the SUPIQ shows promise as a tool for assessing PSU. Further research is needed to enhance and refine the SUPIQ as well as to investigate its clinical utility.

Keywords: Problematic smartphone use, Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), partial correlation network analysis, SUPIQ

Introduction

The global smartphone user population has nearly doubled in 7 years, reaching an estimated 6,841 million in 2023 (O'Dea, 2023), raising concerns about the potential health, social, and economic impacts of excessive smartphone use (Elhai et al., 2017; Jannusch et al., 2021; Olson et al., 2022). "Problematic smartphone use (PSU)" describes the persistent and excessive smartphone use patterns related to daily-life malfunctioning (e.g., Elhai & Contractor, 2018; Kardefelt-Winther et al., 2017). PSU shares features with addictive disorders (Haug et al., 2015; Lin et al., 2014), but the concept of "smartphone addiction" remains debated (e.g., Horvath et al., 2020; Larsen et al., 2022). This study aimed to develop and validate a new PSU questionnaire.

PSU is typically assessed with various scales, including the Mobile Phone Problem Use Scale (MPPUS; Bianchi & Phillips, 2005), the Problematic Mobile Phone Use Questionnaire (PMPUQ; Billieux et al., 2008), the Smartphone Addiction Scale (SAS; Kwon, Lee, et al., 2013), the Short Version of Smartphone Addiction Scale (SAS-SV; Kwon, Kim, et al., 2013), the Smartphone Addiction Inventory (SPAI; Lin et al., 2014) and the Short-Form of Smartphone Addiction Inventory (SPAI-SF; Lin et al., 2017), which measure factors like tolerance, withdrawal, overuse, loss of control and dangerous/prohibited use. While cross-cultural validation studies have shown satisfactory psychometric properties for these scales (e.g., Agus et al., 2022; Andrade et al., 2022; Khoury et al., 2017; Lopez-Fernandez et al., 2014, 2018; Sfendla et al., 2018; Wang et al., 2020; Zhao et al., 2022), we would argue that there is room for improvement.

While previous scales were developed based on existing "addiction" criteria (see Supplementary Table S4.1), they may not fully capture the current problems people face in relation to PSU (see a review, Nawaz, 2023), particularly issues specific to smartphone use like distracted driving and impaired productivity (e.g., D. Ding & Li, 2017; Fitch et al., 2015; Jannusch et al., 2021; Oviedo-Trespalacios et al., 2016). They also may not address general addiction-like features like compromised relationships and cognitive impairments (e.g., D. Ding & Li, 2017; Gutiérrez et al., 2016; Wilmer et al., 2017). Therefore, PSU measurement should consider the everyday smartphone use experiences to avoid over-pathologizing normal behaviors.

To optimize PSU assessment, person-centered and process-based qualitative research can provide valuable insights into individuals experiencing functional impairment and emotional distress due to smartphone use (Billieux, Maurage, et al., 2015; Billieux, Philippot, et al., 2015; Billieux, Schimmenti, et al.,

2015; Flayelle et al., 2022; Kardefelt-Winther et al., 2017). However, few in-depth qualitative studies (see Supplementary Table S4.1) have been conducted to identify PSU assessment themes (e.g., Yildirim & Correia, 2015). Instead, several studies used relatively informal interviews to generate scale items, without formal coding and analyses (e.g., Cho & Lee, 2015; J. E. Ding et al., 2019; Lee et al., 2017; Merlo et al., 2013). A thorough qualitative approach with deductive and inductive thematic analyses can offer a richer understanding of PSU-related experiences in everyday life, leading to more accurate and valid measurements.

In this study, we have developed the Smartphone Use Problems Identification Questionnaire (SUPIQ) based on an in-depth semi-structured interview protocol (Su et al., 2023) that incorporated DSM-5 (American Psychiatric Association, 2013a) and ICD-11 (World Health Organization, 2019) "addiction" criteria, existing PSU scales (e.g., SAS, Kwon, Lee, et al., 2013; SPAI, Lin et al., 2014) and the recent research (e.g., D. Ding & Li, 2017; Fitch et al., 2015; Gutiérrez et al., 2016; Jannusch et al., 2021; Oviedo-Trespalacios et al., 2016; Wilmer et al., 2017). Our primary aim is to assess the SUPIQ's reliability and validity in measuring PSU, beginning with examining its construct validity. We will also evaluate its convergent validity by exploring the associations between SUPIQ scores and mental health problems. High levels of PSU have been related to higher levels of mental health and cognitive problems like depression and anxiety (e.g., Elhai et al., 2017, 2020; Jin et al., 2021; Kim et al., 2019), personality disorders (e.g., Pearson & Hussain, 2016), sleep problems (e.g., Cheung et al., 2019; S. Y. Sohn et al., 2021), somatic symptoms (e.g., Winkler et al., 2020), suicidal ideation (e.g., Arrivillaga et al., 2020), memory problems (e.g., Madore et al., 2020), and repetitive thoughts and behaviors (e.g., Brailovskaia et al., 2021). To assess convergent validity, we also include the Short Version of Smartphone Addiction Scale (SAS-SV; Kwon, Kim, et al., 2013), frequently used to assess PSU (e.g., Khalily et al., 2019; Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Luk et al., 2018; Zhao et al., 2022).

Besides mental health problems, we will explore how smartphone use frequency and duration relate to PSU (Harris et al., 2020; James et al., 2023; Parry et al., 2021), akin to other addictive behaviors like alcohol use (AUDIT; Mattiko et al., 2011; Saunders et al., 1993) and problematic social media use (Social Media Disorder Scale; Van Den Eijnden et al., 2016). To assess the relationships, we will differentiate between screen time and unlock frequency (Ryding & Kuss, 2020), social versus nonsocial screen time (Elhai et al., 2017, 2020), active (i.e., actively interacting with others via social media on smartphone) versus passive (i.e., passively scrolling and checking via social media on smartphone) social media use (Su et al., 2022). Partial correlations between the SUPIQ factors, smartphone use

statistics, and mental health problems will be tested and visualized with network analysis to further show the convergent validity. Additionally, we will compare the SUPIQ with the SAS-SV to assess its explanatory power in hierarchical multiple regression models (Kwon, Kim, et al., 2013; Olson et al., 2022). While prior PSU scale studies have primarily focused on student and adolescent populations (e.g., Andrade et al., 2022; Cheung et al., 2019; Khoury et al., 2017; Leung, 2008; Lin et al., 2014; Lopez-Fernandez et al., 2014; Pavia et al., 2016; Walsh et al., 2010; Wang et al., 2020; see Supplementary Table S4.1), leaving the applicability of these scales to the general population largely unexplored (e.g., Busch et al., 2021; Rosales & Fernández-Ardèvol, 2019). We will extend its applicability using two separate samples: one from the university community and a general population sample.

In summary, we aimed to develop a comprehensive and widely applicable PSU assessment tool, conducting an exploratory factor analysis (EFA), a confirmatory factor analysis (CFA), correlation analyses, and partial correlation network analyses, examining measurement invariance, and assessing explanatory power with hierarchical multiple regression models in two diverse samples.

Methods

Participants and Procedures

The study involved two samples: Sample 1 (university community sample) was comprised of 323 participants (Mean age=20.81, SD = 4.34, the range = 18-66 years; 72.76% females), recruited through the university's internal study platform, primarily composed of university students. However, note that other volunteers could also sign up through the University's recruitment platform, therefore it is not exclusively a student sample. Sample 2 (the general population sample) included 618 participants (Mean age=28.47, SD = 7.39, the range is 18-75 years, 43.85% females), recruited via snowball sampling on social media including LinkedIn, X (Twitter), and Facebook as well as through posters. The survey was administered online using Qualtrics XM software (Qualtrics, 2021). The general population sample had a 1 in 20 chance of winning a 20-euro gift card by providing their email, while the university community sample could earn 0.50 psychology research credits in addition to the lottery. Data collection took place from March 20 to April 12 spanned 3.5 weeks period in 2021. The survey, mainly conducted in the Netherlands, used English as the primary language. Participants confirmed their English proficiency in the consent form. Table 4.1 displays participants' country of residence and nationality distribution.

Measures

The Quality Control Questions To ensure the quality of online responses, three quality control measures were implemented (DeSimone et al., 2015): (1), participants were instructed to select "always" from the response options "never" to "always" for the indication question; (2) they were supposed to select "false" for the statement of "I have never used a smartphone" in the bogus question; (3) participants rated their survey effort and attention on a scale of 0 to 100 at the survey's end.

The Smartphone Use Problems Identification Questionnaire (SUPIQ). The initial items of the first version of the Smartphone Use Problems Identification Questionnaire (SUPIQ) were developed from a separated qualitative study among 28 university students with smartphone use problems (Su et al., 2023). The inclusion criteria for participant recruitment were university students between 18 and 25 years old, possessed at least one European nationality, and scored above 31 (males) or 33 (females) on the Short Version of the Smartphone Addiction Scale (SAS-SV; Kwon, Kim, et al., 2013). These cut-off scores were determined based on the established thresholds for identifying PSU. The ultimate qualitative sample, consisting of 28 participants (24 males, 26 Bachelor students, 2 Master students), demonstrated an average SAS-SV score of 46.82 (SD=3.22). The participants, with an average of 7.39 years of smartphone usage (SD=1.47), originated from 17 distinct European countries, with six individuals holding dual nationality. The first author conducted interviews, recording, transcriptions, and coding, with the results discussed among the research team. Based on the qualitative results, the first author drafted a preliminary questionnaire comprising 126 items. This draft was then thoroughly deliberated upon with the entire research team. Based on the discussions, the initial version of SUPIQ contained 57 items (see Supplementary Table S4.2), including 2 negatively worded items. The SUPIQ aimed to capture 8 theory-derived factors related to PSU according to DSM-5 (American Psychiatric Association, 2013a) and ICD-11 (World Health Organization, 2019): (1) Impaired Control, (2) Preoccupation, (3) Craving, (4) Escapism/Relief/Coping, (5) Negative effects/Consequences/Risks, (6) Ignorance of Negative Effects/Consequences/Risks, (7) Tolerance, and (8) Withdrawal. Participants rated their smartphone use during the past 12 months, using a 5-point Likert scale (1 = never to 5 = always).

Mental Health Problems: DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure-Adult. The DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure was used to assess participants' mental health problems over the past 12 months instead of the original 2-week version (American Psychiatric Association, 2013b). It consists of 20 questions on a 5-point Likert scale (0=Never to 4=Always) measuring

depression, anxiety, personality functioning, sleep, somatic symptoms, suicidal ideation, memory, repetitive thoughts and behaviors, mania, psychosis, and dissociation. The total score ranges from 0 to 80, with higher scores indicating more mental health problems. See Table 4.3 for means, standard deviations, and internal consistencies including Cronbach's α and McDonald's ω values of the DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure.

Smartphone Use Statistics

The amount of smartphone use. Participants reported total screen time, social screen time, and unlock frequency in the past 7 days using the Digital Wellbeing (Android) or Screen Time (iPhone) application on their smartphones. If participants were unable to access the data directly on their phones, they were asked to estimate these indicators to the best of their ability.

Active and passive social media use frequency on smartphone. Participants were asked to estimate the frequency of their past 7-day social media use with 6 questions. Active social media use involved active interactions with others by sending, posting, liking, and commenting on the social media apps (e.g., Estimate how many times in 7 days you send a text, message, photo or video via the social media apps (e.g., Instagram, Facebook, iMessage, TikTok, WhatsApp, LinkedIn, etc.) on your smartphone?). Passive social media use included passive scrolling behaviors like reading and browsing on these social media apps (e.g., Estimate how many times in 7 days you read messages, photos or videos from others via the social media apps (e.g., Instagram, Facebook, TikTok, WhatsApp, LinkedIn, etc.) on your smartphone?).

App usage. Participants reported the three most frequently used social media apps and three most frequently used apps after they pick up their smartphones.

The Short Version of Smartphone Addiction Scale (SAS-SV). The short version of smartphone addiction scale (SAS-SV) was developed by Kwon, Kim, and colleagues (2013), which includes 10 items and measures problematic smartphone use (Khalily et al., 2019; Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Luk et al., 2018; Zhao et al., 2022). Participants were asked to rate their smartphone use in the past 12 months from 1 (strongly disagree) to 6 (strongly agree), on questions like: "I use my smartphone longer than I have intended". The means, standard deviations, and internal consistencies including Cronbach's α and McDonald's ω values of the SAS-SV were presented in Table 4.3.

Statistical analysis

The case-selection procedure with the Quality Control Questions and the descriptive analyses on demographic information of the two samples were performed with R (version 4.2.2; R Core Team, 2022) and RStudio (Allaire, 2022), using "janitor" (Mansley, 2021), "dplyr" (Wickham et al., 2020), "plyr" (Wickham & Wickham, 2020), "sjmisc" (Lüdecke, 2021a), and "sjPlot" (Lüdecke, 2021b) packages. The factor analyses were conducted using Mplus 8.3 (Muthén & Muthén, 2017) and the package "MplusAutomation" (Hallquist & Wiley, 2018).

To ensure data quality in both samples, participants were excluded if they spent less than 2 seconds per item, reported less than 50% effort/attention, or answered quality control questions incorrectly (DeSimone et al., 2015, see more detailed explanations in Measures) were excluded from analysis. To ensure the comparability of our previous study, participants from the university community were selected based on criteria (i.e., aged 18-24 years and had completed upper secondary or bachelor's level education) in the qualitative study (Su et al., 2023).

Construct validity of the SUPIQ: exploratory factor analysis (EFA). To examine the SUPIQ's factor structure, we conducted an EFA. Since the SUPIQ questionnaire uses 5-point Likert scales and the data deviated from the normal distribution, we employed weighted least squares estimation, accounting for the categorical and nonnormal data nature (DiStefano & Morgan, 2014; Holgado-Tello et al., 2010; Rhemtulla et al., 2012; Wu & Leung, 2017). To determine the number of factors underlying the data, we fitted a series of models that varied in the number of factors (starting with a one-factor model) model-based approach in which we fit a series of models that increase in their number of factors, but in which all items are allowed to load on all factors. This model-based approach is the default method in Mplus 8.3 (Muthén & Muthén, 2017). Such an approach is grounded in the benefits of a model-based strategy, which relies on an explicit statistical model instead of principal axis factoring (Brown, 2015). This approach enables a more comprehensive and objective selection of the best fitting model with diverse model fit indices: the root-mean-square-error of approximation (RMSEA), the standardized root mean square residual (SRMR), the comparative fit index (CFI), and the Tucker–Lewis index (TLI). Generally, good model fit is indicated by RMSEA < .05, SRMR < .08, and CFI/TLI > .95, while acceptable fit is indicated by RMSEA < .08, and CFI/TLI > .90 (see Brown, 2015; Goulter et al., 2022; Little, 2013). Within the best fitting model, we retained items based on criteria: 1) no cross-factor loadings (i.e., with two factors' loadings > .30; 2) factor loading > .50 and < 1 (William Jr, 2013); 3) alignment with the SUPIQ's intended factors according to our theoretical framework.

Construct validity of the SUPIQ and the SAS-SV: confirmatory factor analysis (CFA). To investigate whether the SUPIQ factor structure found using EFA replicated in the general population sample, we used CFA with weighted least squares estimation. For the factor structure (as established in the university sample) to be replicable, the fit of the CFA model should at least be acceptable in the general population sample. In addition, we have also used CFA to test the construct validity of the SAS-SV, with residual covariances added among items 1 to 3 and items 4 to 7 since they belonged to one factor in the original version of SAS-SV (Kwon, Kim, et al., 2013; Kwon, Lee, et al., 2013; Luk et al., 2018). To assess the fit of the confirmatory model, we relied on the same model fit statistics discussed above.

Psychometric equivalence analyses of the SUPIQ: measurement invariance test. To examine whether the SUPIQ factor structure remained invariant across the university community and the general population samples, we conducted multigroup confirmatory factor analyses (MG-CFA): Three models were employed: 1) a configural model (Model 1), fitting the same factor model to the two samples with all factor model parameters freely estimated; 2) a metric measurement invariance model (Model 2), restricting item loadings to be equal across the samples while allowing differences in the factor variances; 3) a scalar measurement invariance model (Model 3), with equal factor loadings and equal item threshold parameters while allowing differences in the factor means and variances. A decrease in CFI by more than .01 or an increase in RMSEA by more than .015 indicates that measurement invariance is not established (Chen, 2007).

The analyses on descriptive statistics, reliability, and convergent validity. The descriptive statistics were done after the final version of SUPIQ was determined. For the reliability test of the SUPIQ, both Cronbach's α and McDonald's ω values were reported since they represent mean test level and general factor saturation separately (Revelle & Condon, 2019). For the convergent validity analyses, the linear correlations and partial correlation network analyses were used. The linear correlations between the SUPIQ, the SAS-SV, mental health problems, and smartphone use statistics were calculated. Unreasonable smartphone use statistics, such as minutes exceeding 59 (as participants reported hours and minutes separately), reported screen time of 0, or nonsocial screen time less than 0, were treated as missing values and the missing values were dealt with pairwise deletion method. Partial correlation network analyses among the sum scores of different factors of the SUPIQ, mental health problems, and smartphone use statistics were performed using the packages "bootnet" (Epskamp & Fried, 2015, 2020), "qgraph" (Epskamp et al., 2020) packages. We mainly focused on visualizing network results, where nodes represented the variables including mental health problems, the

smartphone use statistics, and the SUPIQ factors. Edges depicted the connections between variables, with edge thickness and color saturation indicating association strength (Monteleone et al., 2022). With dealing with the missing values of the smartphone use statistics with pairwise deletion method, partial correlation networks were separately computed for the two samples (Borsboom et al., 2021; Epskamp & Fried, 2018). The stability of the edges in two networks was tested with bootstrapping (nboots=2000). We used the "EBICglasso" algorithm, which implements the least absolute shrinkage and selection operator (LASSO) regularization method to shrink estimates and remove false positive edges. A hyperparameter of 0.5 was used to remove nonsignificant edges from the network.

The explanatory power of the SUPIQ: hierarchical multiple regression. The multivariate stepwise regression analyses used the sum score of mental health problems as the outcome variable. The first step included the SAS-SV as a predicting variable. In the second step, the SUPIQ was added to assess its additional explanatory power compared to the SAS-SV. The hierarchical multiple regression analyses were done separately in the two samples. The standardized coefficients were estimated with package "lm. beta" (Behrendt, 2022). In addition, the relative importance of the SAS-SV and the SUPIQ were compared with package "relaimpo" (Groemping, 2021).

Ethics. Participants received an information letter before starting the questionnaire and the study protocol was approved by the Ethical Review Board (ERB ID # 2021-DP-13072).

Results

Demographic information for the final samples

The data screening process is shown in Supplementary Figure S4.3: the final university community sample consisted of 292 participants, and the final general population sample consisted of 397 participants. Demographic information for the two samples is shown in Table 4.1.

The construct validity results: exploratory factor analysis (EFA) for the SUPIQ

Based on the results of the EFA with the university community sample, we reached 24 items in a 7-factor version of the SUPIQ (see Supplementary Table S4.4). We restored 3 items since there were only two items for 3 of the 7 factors (i.e., craving, coping, and tolerance, see Supplementary Table S4.5). Item 26 was removed since the removal increased the Cronbach's α values of the corresponding subscale by .10 (see Supplementary Table S4.6 and Table S4.7; Cronbach's alpha of the full questionnaire increased by .01). The final version of the SUPIQ includes 26 items

with 7 factors (see Table 4.2). The 7 factors can be described as follows: Craving, Coping, Habitual Use, Social Conflicts, Risky Use, Withdrawal, Tolerance. The model fit indices showed a good fit: CFI = .993, TLI = .986, RMSEA = .030, SRMR = .031. The network analysis also showed the 7-factor structure well fitted the data (see Supplementary Figure S4.8), the centrality indices (e.g., closeness, strength, betweenness) of the network were shown in Supplementary Figure S4.9 and S4.10.

The construct validity results: confirmatory factor analysis (CFA) for the SUPIQ and the SAS-SV

Results of the CFA (CFI = .970, TLI = .965, RMSEA = .072, SRMR = .047) for the SUPIQ indicated that there is a residual covariance between item 1 (i.e., I think about my smartphone when I am not using it.) and item 15 (i.e., I continue using my smartphone after others ask me not to.) of the SUPIQ. After adding this covariance, the model fit indices of the CFA in the general population sample indicated an acceptable to good model fit (CFI = .971, TLI = .966, RMSEA = .070, SRMR = .047). The standardized factors loadings and correlations between factors of the SUPIQ based on the CFA were presented in Supplementary Table S4.11 and S4.12.

Results of the CFA of the SAS-SV in the two samples were as follows: CFI = .959, TLI = .932, RMSEA = .064, SRMR = .043 in the university community sample; CFI = .949, TLI = .915, RMSEA = .097, SRMR = .040 in the general population sample.

Psychometric equivalence of SUPIQ: measurement invariance test results

See Table 4.3 for the results concerning the measurement invariance analyses. The SUPIQ demonstrated configural invariance with acceptable model fit of Model 1. This indicated that the general structure of SUPIQ was consistent across the two samples. However, according to the criteria of changed CFI (decrease of $\geq .015$) and RMSEA (increase of $\geq .015$), both metric and scalar invariance were not tenable, as the model fit indices deteriorate, suggesting that some items' factor loadings and thresholds in the SUPIQ differed in the two samples (Chen, 2007). We consulted modification indices to see if there were some specific items responsible for the misfit. However, there was no clear source of misfit identifiable.

The descriptive statistics, reliability, and convergent validity results

The descriptive statistics including Means (*M*), Standard Deviations (*SD*), Range, and Reliability Coefficients including Cronbach's α and McDonald's ω values for mental health problems, the SAS-SV, the sum scores of SUPIQ, and its Seven Factors are shown in Table 4.4.

The descriptive statistics of the smartphone use statistics across two samples are presented in Table 4.5. The reliability coefficients indicated that SUPIQ has good reliability.

Regarding convergent validity results, the Correlation Coefficients for mental health problems, the smartphone use statistics, the SAS-SV, the SUPIQ, and its Seven Factors are displayed in Table 4.6. Based on the results, all the factors and scales were highly positively correlated with each other in the general population sample ($p < .001$). However, in the university community sample, Risky Use was not correlated with Craving and Coping, and the correlation coefficients between Risky Use and Habitual Use, Social Conflicts, Withdrawal, and Tolerance were relatively lower than those between other factors of the SUPIQ. The total scores of the SUPIQ were positively correlated with mental health problems, SAS-SV, active and passive social media use on smartphone in both samples. In the university community sample, the total score of the SUPIQ was positively correlated with non-social screen time per day. The results indicated that the SUPIQ has good convergent validity generally.

The partial correlation network with the university community sample demonstrated that Tolerance and Withdrawal were positively correlated with mental health problems (Figure 4.1). In addition, passive social media use was negatively associated with Social Conflicts while positively associated with Habitual Use. The correlation stability coefficient was .671, indicating sufficient stability (see Supplementary Figure S4.13 for bootstrapping results). The centrality indices of the network were shown in Supplementary Figure S4.14 and S4.15. The estimation of significant differences between edge weights and bootstrapped results were shown in Supplementary Figure S4.16.

The partial correlation network with the general population sample showed Craving, Social Conflicts, Risky Use, Tolerance, and Withdrawal were positively correlated with mental health problems (Figure 4.2). Active social media use was negatively associated with Habitual Use and positively associated with Social Conflicts. Moreover, passive social media use was positively associated with Habitual Use. The correlation stability coefficient was .751, indicating sufficient stability (see Supplementary Figure S4.17 for bootstrapping results). The centrality indices of the network were shown in Supplementary Figure S4.18 and S4.19. The estimation of significant differences between edge weights and bootstrapped results were shown in Supplementary Figure S4.20.

The explanatory power of the SUPIQ: hierarchical multiple regression results

Hierarchical multiple regression analyses showed that the SUPIQ generally outperformed the SAS-SV in the regression models of step 2 when the SUPIQ and the SAS-SV were added to the regression model as predictors for mental health problems at the same time (Table 4.7). Based on the results of relative importance analyses (Table 4.8), the SUPIQ played a more important role than the SAS-SV when explaining the variance of mental health problems with step 2 models.

Discussion

Derived from a qualitative study involving problematic smartphone users from diverse European countries, we have gained contemporary and comprehensive perspectives on PSU in everyday life, which moves beyond existing "addiction" criteria. Based on such perspectives, we developed and tested the comprehensive Smartphone Use Problems Identification Questionnaire (SUPIQ) to assess PSU. The SUPIQ exhibited good construct and convergent validity, reliability, and explanatory power in both samples. The initial version of the questionnaire comprised 8 factors and 57 items based on DSM-5 (American Psychiatric Association, 2013a) and ICD-11 (World Health Organization, 2019) criteria, after exploratory and confirmatory factor analyses, the final SUPIQ consists of 7 correlated factors: Craving, Coping, Habitual Use, Social Conflicts, Risky Use, Withdrawal, Tolerance. The final SUPIQ showed good construct validity and reliability, while the structure is different from the initial version.

The final inclusion of Craving and Coping factors aligns with the established scales like MPPUS (Bianchi & Phillips, 2005) and SPAI (Lin et al., 2014), with adaptions based on the descriptions from the qualitative study on problematic smartphone users. Impaired Control items were included in the Habitual Use factor. This aligns with previous studies (e.g., Van Deursen et al., 2015), indicating that Habitual Use may be a more critical factor than control-related problems in measuring PSU. This factor is distinctive compared to the existing questionnaires like MPPUS (Bianchi & Phillips, 2005), PMPUQ (Billieux et al., 2008), SAS (Kwon, Lee, et al., 2013), and SPAI (Lin et al., 2014), which emphasize control issues. In the SUPIQ, the Social Conflicts and Risky Use factors retained as the main negative consequences. Risky Use measurement has been expanded to include items on frequency of real-life accidents and reluctance to change after accidents, deviating from the Dangerous Use factor of PMPUQ (Billieux et al., 2008). The retainment of social and physical risks is different from other questionnaires that encompass broader negative consequences, including MPPUS (Bianchi & Phillips, 2005), PMPUQ (Billieux et al., 2008), SAS (Kwon, Lee, et al., 2013), and SPAI. This difference may imply the significance of the two aspects to differentiate PSU from normal smartphone use. However, it is worth noting that

Risky Use showed weaker correlations with other factors in the university community sample, similar to the findings in problematic cannabis use (see a review, Casajuana et al., 2016). This suggests that the Risky Use items may need optimization for different contexts, aligning with the findings related to problem drinking, where the specific scale has been designed for adolescents (White et al., 2005; White & Labouvie, 1989). While the inclusion of Tolerance and Withdrawal in defining behavioral addictions remains debated (e.g., Starcevic, 2016), both factors were incorporated in the final SUPIQ based on participants' everyday experiences. The inclusion of the two factors are consistent with the existing questionnaires (Bianchi & Phillips, 2005; Kwon, Lee, et al., 2013; Lin et al., 2014), expands their measurement. Tolerance of the SUPIQ involves feeling "empty" after spending much time on smartphones, while Withdrawal covers both issues with the internet connection and smartphone access. In terms of the covariances between item 1 and item 15, the correlation can be explained by the notion that individuals who genuinely contemplate and crave for their smartphones are more likely to overlook or disregard requests from others to stop using their smartphones.

While the configural invariance of the SUPIQ was established across the university community and general population samples, other forms of measurement invariances were not. As noted, it is not uncommon for addictive behaviors to show different indicators of problems at different ages (c.f., White & Labouvie, 1989). Results showed that the strength of the relationships between items and the underlying construct like the factor loadings of the SUPIQ, differed across the two samples.

Regarding convergent validity, the linear correlation analyses showed that the SUPIQ and its factors were positively correlated with mental health problems, the SAS-SV, indicating the good convergent validity of the SUPIQ. The partial correlation network analyses showed that mental health problems were positively correlated with Withdrawal and Tolerance in both samples and positively correlated with Coping, Social Conflicts, and Risky Use in the general population sample. Such results are consistent with previous studies (see a review, S. Sohn et al., 2019). These results suggest that Habitual Use and Craving might not be key factors in defining PSU or central symptoms of PSU (e.g., Fournier et al., 2023). Total screen time, nonsocial screen time, and pickup frequency were not correlated with the SUPIQ factors, contrary to prior research (see a review, Ryding & Kuss, 2020). This discrepancy may be due to our inclusion of mental health problems in the analyses, which was not common in previous studies (see a review, Ryding & Kuss, 2020). Active social media use was positively correlated with Social Conflicts in both samples and negatively correlated with Habitual Use in the general population sample. Passive social media use was positively correlated with Habitual Use in

both samples and negatively correlated with Social Conflicts in the university community sample. These results align with former studies (e.g., Su et al., 2022), suggesting different roles of active and passive social media use in relation to the PSU. Regarding explanatory power, the SUPIQ outperformed the SAS-SV in the regression models where the mental health problems were the outcome variables for both samples.

Limitations and future study directions

While our study provides valuable insights into the initial psychometric features of the SUPIQ, there is a need for further investigation to deepen our understanding of PSU. We comprehensively examined construct and convergent validity, reliability, measurement invariance, and explanatory power using samples primarily from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) countries. However, the volunteerism of participants and the focus on WEIRD countries with English as the primary survey language impacted the representativeness of the samples. To address this limitation, future research should target larger and more diverse samples, including clinical samples, while considering the different languages to assess the broader applicability of the SUPIQ globally (Billieux, Philippot, et al., 2015; Billieux, Schimmenti, et al., 2015; Flayelle et al., 2022; Lopez-Fernandez, 2017). Further refinements are warranted, particularly in the items of Craving, Coping, and Tolerance. The tailoring of the SUPIQ for different populations is crucial, and assessing the relative significance of different factors in defining PSU remains an important avenue for future research. Additionally, the test-retest reliability can also be further investigated with future studies and a short form of the SUPIQ should be generated to ensure the feasibility of usage and compare the short form with the SAS-SV in future studies (c.f. Kwon, Kim, et al., 2013).

In our study, we tested the SUPIQ's convergent validity with smartphone use statistics, mental health problems, and the SAS-SV. Future research could explore the overlap between the SUPIQ and other behavioral and substance-related addictions (e.g., Andrade et al., 2022; Kwon, Lee, et al., 2013) or the possible correlations between the SUPIQ and other variables like personality traits (Giustiniani et al., 2022) and childhood trauma (Fan et al., 2023). We have also tested the explanatory power of the SUPIQ in comparison to the SAS-SV (Kwon, Kim, et al., 2013), while future studies would benefit from employing the full versions of the PMPUQ (Billieux et al., 2008) and SAS (Kwon, Lee, et al., 2013) to confirm the predictive power of the complete SUPIQ. Additionally, individual differences in the SUPIQ warrant investigation through person-centered analyses, such as latent profile analysis with cross-sectional data (e.g., Yue et al., 2021) and

growth mixture modeling with longitudinal data (e.g., Lai et al., 2022), to identify the problematic subgroups.

Conclusion

To conclude, we tested the psychometric quality of a newly developed instrument to measure problematic smartphone use, namely the Smartphone Use Problems Identification Questionnaire (SUPIQ). Throughout this process, the SUPIQ underwent refinements in different aspects, including the adaptation of items within factors like Craving and Coping, identification of pivotal negative consequences related to Social Conflicts and Risky Use, expanded measurements for Risky Use, Withdrawal, and Tolerance factors, and the introduction of a novel factor-Habitual Use. The SUPIQ shows good reliability and validity, and it is a valuable tool for evaluating contemporary and severe smartphone use problems rooted in users' everyday behaviors. The SUPIQ stands as an updated and robust tool, aiming to contribute significantly to the nuanced assessment of problematic smartphone use.

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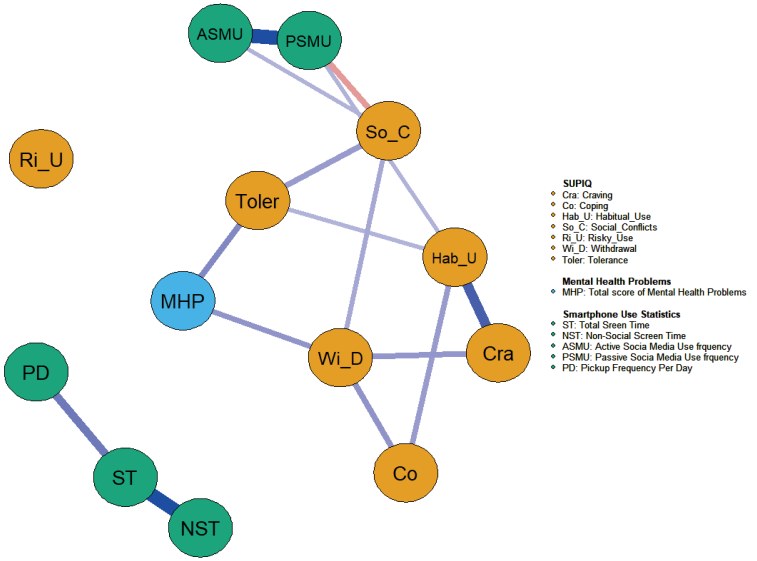
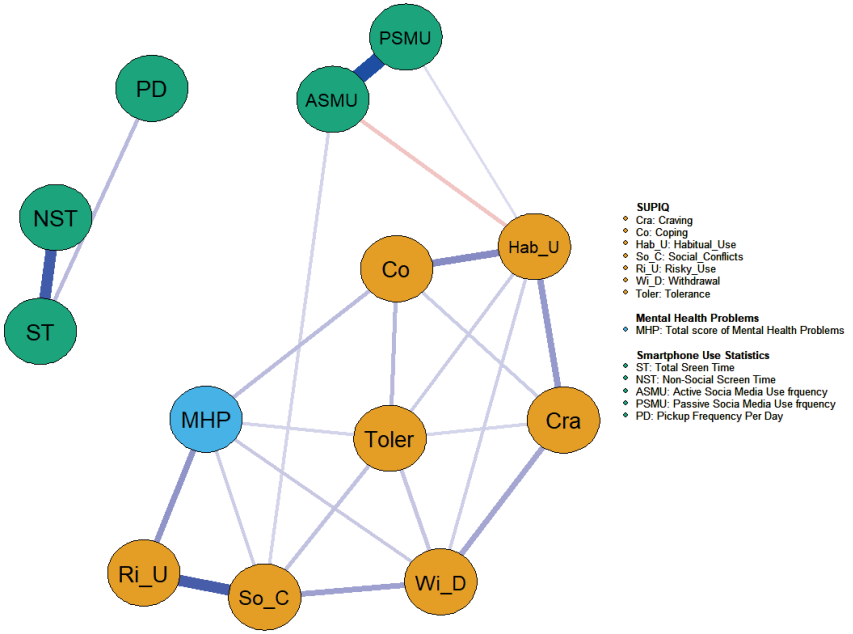
Appendix A: Figures

Figure 4.1. The network analysis including all the sum scores of the SUPIQ factors, mental health problems and all smartphone use indicators (regularized model) with the university community sample (N=292)



Note. The color (blue = positive, red = negative) and thickness of the edges indicate the strength of association. The nodes have been colored according to the domain that they belong to. SUPIQ=The Smartphone Use Problems Identification Questionnaire.

Figure 4.2. The network analysis including all the sum scores of the SUPIQ factors, mental health problems and all smartphone use indicators (regularized model) with the general population sample (N=397)



Note. The color (blue = positive, red = negative) and thickness of the edges indicate the strength of association. The nodes have been colored according to the domain that they belong to. SUPIQ=The Smartphone Use Problems Identification Questionnaire.

Appendix B: Tables

Table 4.1 The demographic information of the university community sample (N=292) and the general population sample (N=397), including the Number (n), Range, Means (M) and Standard Deviations (SD)

	University community sample			General population sample		
	n (%)	Range	*M* (*SD*)	n (%)	Range	*M* (*SD*)
Age		18-24	20 (1.48)		18-75	28.02 (7.66)
The onset age when starting to use smartphone		6-18	12.37 (1.73)		4-71	17.50 (7.44)
The years for smartphone use		3-13	7.64 (1.70)		3-33	10.49 (3.98)
Gender*						
Male	70 (23.97)			193 (48.61)		
Female	217 (74.32)			203 (51.13)		
Other	5 (1.71)			1 (0.25)		
Highest level of education						
Primary education	-			2 (0.50)		
Lower secondary education	-			3 (0.76)		
Upper secondary education	249 (85.28)			77 (19.40)		
Post-secondary non-tertiary education	12 (4.11)			19 (4.79)		
Short-cycle tertiary education	6 (2.05)			65 (16.37)		
Bachelor's or equivalent level	25 (8.56)			156 (39.29)		
Master's or equivalent level	-			64 (16.12)		
Doctoral or equivalent level	-			11 (2.77)		
The marital status						
Married	2 (0.68)				109 (27.46)	
Engaged	1 (0.34)				18 (4.53)	
Living together	14 (4.79)				45 (11.349)	
In a relationship/having a boyfriend/girlfriend	90 (30.82)				96 (24.18)	
Registered partnership	-				3 (0.76)	
Divorced	-				6 (1.51)	
Separated	-				5 (1.26)	

Single	185 (63.36)				115 (28.97)	
Country currently live in						
Netherlands	214 (73.29)			United States of America	289 (72.80)	
Germany	27 (9.25)			Netherlands	43 (10.83)	
Poland	4 (1.37)			Canada	20 (5.04)	
Other countries	47 (16.09)			Germany	12 (3.02)	
				Other countries	33 (8.31)	
Nationality						
Dutch	100 (34.25)			American	302 (76.07)	
German	73 (25.00)			English	32 (8.06)	
English	15 (5.14)			German	19 (4.79)	
American	12 (4.11)			Dutch	16 (4.03)	
Italian	11 (3.77)			Canadian	14 (3.53)	
Other nationalities	81 (27.74)			Italian	7 (1.76)	
				Other nationalities	39 (9.82)	
Whether live in home country or abroad						
At home	155 (53.08)			357 (89.92)		
Abroad	137 (46.92)			40 (10.08)		
The years of living abroad		0-18	2.21 (4.00)		0-21	4.85 (4.21)

Note. Here is one missing value with the general population sample in terms of "The onset age when starting to use smartphone" and "The years for smartphone use" because one participant's years for smartphone use is "-1".* Gender here implies the participants' self-identified gender.

Table 4.2 Factor Loadings of the final 26 items (adding three extra items, item) based on EFA with the university community sample (N=292)

Final order	Initial Order	Item	Factor 1- Craving	Factor 2- Tolerance	Factor 3- Social Conflicts	Factor 4- Withdrawal	Factor 5- Risky Use	Factor 6- Habitual Use	Factor 7- Coping
1	1	I think about my smartphone when I am not using it.	.624						
2	2	I feel a strong urge to check my smartphone.	.631						
3	3	I feel empty even when I spend a lot of time on my smartphone.		.867					
4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.					.858		

5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).				.721
6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.			.851	
7	**14**	**I need to spend more and more time on my smartphone to satisfy myself.**	**.346**	**.298**		
8	15	I continue using my smartphone after others ask me not to.		.541		
9	16	I tell lies about my smartphone use.		.864		
10	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.		.780		

11	**20**	**My smartphone is the solution to my boredom.**				**.316**	**.369**
12	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).		.812			
13	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).			.654		
14	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.		.745			
15	27	I feel unsatisfied even when I spend a lot of time on my smartphone.	.532				

16	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).			.798	
17	30	I automatically open apps on my smartphone.				.910
18	31	I automatically check my smartphone, even when I just checked it.				.686
19	**35**	**I feel a strong need to be available via my smartphone.**	**.275**	**.302**		**.287**
20	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.		.759		

21	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.					.645
22	46	I feel anxious/ nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).		.801			
23	48	I automatically unlock my smartphone.				.860	
24	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.			.906		
25	55	People around me tell me that I use my smartphone too much.	.674				

26	57	I check my smartphone when I am entertain ing myself in other ways (e.g., watching movies, TV series, reading, etc.).	.576

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire. This version contains 26 items, 7 factors. Applied rotation method is oblimin in EFA. Only factor loadings >= .250 were listed in the table. The model fits were good: CFI = .991, TLI = .983, RMSEA = .032, SRMR = .031. The three restored items were marked in bold.

Table 4.3 Measurement Invariance Analysis of the SUPIQ: Multi-group CFA.

	Overall model fit constrained model							Changes in model fit			
Model test	χ^2	*df*	BIC	CFI	TLI	RMSEA	SRMR	$\Delta\chi^2$	Δdf	ΔCFI	ΔRMSEA
Group equivalence	1,036.20	278	44,478.73	.923	.911	.063	.061	-	-	-	-
Configural (Model 1)	1,153.52	556	43,708.69	.932	.920	.056	.053	-	-	-	-
Metric (Model 2)	1,348.63	575	43,779.63	.912	.900	.062	.076	195.112***	19	-.020	.006
Scalar (Model 3)	1,723.33	594	44,030.16	.871	.859	.074	.082	374.699***	19	-.041	.012

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire; BIC = Bayesian information criterion; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation; Difference tests are displayed for configural versus metric and metric versus scalar, respectively. ***χ^2 test was statistically significant at $p < .001$ level.

Table 4.4 Summary of Means (M), Standard Deviations (SD), Range, and Reliability Coefficients for mental health problems, the SAS-SV, the SUPIQ and its Seven Factors in the university community sample (N=292) and general population sample (N=397).

	University community sample (N=292)					**General population sample (N=397)**				
	M (*SD*) Sum score	*M* (*SD*) Item average	Range Sum score	Cronbach's α	McDonald's ω	*M* (*SD*) Sum score	*M* (*SD*) Item average	Range Sum score	Cronbach's α	McDonald's ω
Mental health problems	18.70 (10.14)	0.94 (0.51)	0-55	.89	.90	25.83 (17.22)	1.29 (0.86)	0-63	.97	.97
SAS-SV	27.54 (8.06)	2.75 (0.81)	10-50	.83	.86	33.16 (10.32)	3.32 (1.03)	10-57	.91	.93
SUPIQ-Total	56.65 (13.21)	2.18 (0.51)	34-103	.90	.92	66.85 (18.30)	2.57 (0.70)	26-104	.94	.96
SUPIQ-Craving	8.09 (2.44)	2.70 (0.81)	3-14	.73	.77	8.93 (2.48)	2.98 (0.83)	3-15	.67	.68
SUPIQ-Coping	7.76 (2.31)	2.59 (0.77)	3-14	.68	.71	8.31 (2.54)	2.77 (0.85)	3-15	.69	.70
SUPIQ-Habitual Use	12.60 (3.68)	3.15 (0.92)	5-20	.85	.88	11.52 (3.22)	2.88 (0.80)	4-20	.75	.78
SUPIQ-Social Conflicts	7.98 (2.99)	1.33 (0.50)	6-25	.85	.90	13.47 (5.52)	2.25 (0.92)	6-26	.91	.94
SUPIQ-Risky Use	4.34 (1.70)	1.45 (0.57)	3-12	.76	.79	6.44 (2.94)	2.15 (0.98)	3-14	.83	.84
SUPIQ-Withdrawal	8.28 (3.41)	2.07 (0.85)	4-20	.83	.87	10.27 (3.41)	2.57 (0.85)	4-20	.81	.84
SUPIQ-Tolerance	7.59 (2.70)	2.53 (0.90)	3-15	.69	.70	7.91 (2.55)	2.64 (0.85)	3-14	.68	.68

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire, SAS-SV=the short version of smartphone addiction scale. For *t* values, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

Table 4.5 Summary of Means (M), Standard Deviations (SD) and Range for the smartphone use statistics in the university community sample (N=292) and the general population sample (N=397).

	University community sample (N=275/292)		**General population sample (N=315/397)**		***t***
	M (*SD*)	Range	*M* (*SD*)	Range	
Total screen time per day (hours)	4.72 (2.30)	0.43-11.88	7.19 (3.89)	0.08-19.36	-11.37***
Non-social screen time per day (hours)	2.24 (1.74)	0.06-10.55	3.14 (2.19)	0-12.62	-6.45***
Active social media use frequency per day	64.38 (49.50)	0-268.14	94.53 (72.49)	0-314.71	-7.03***
Passive social media use frequency per day	92.93 (71.13)	0-357.14	94.79(70.62)	0-361.71	-0.36
Pickup frequency per day	71.34 (40.94)	0.43-142.86	52.82 (28.44)	4.14-142.86	6.99***
Top 3 social media apps (frequency)	WhatsApp (51), Instagram (47), YouTube (16), SnapChat (13), Reddit (9), TikTok (6), Twitter (6)		Facebook (211), Instagram (206), TikTok (171), WhatsApp (125), LinkedIn (62), Twitter (30), YouTube (14), SnapChat (13), Messages (11), Spotify (8)		
Top 3 pickup apps (frequency)	WhatsApp (57), Instagram (34),YouTube (19), Chrome (17), SnapChat (12), Spotify (10)		Instagram (191), WhatsApp (150), Facebook (120), TikTok (92), Safari (75), Messages (25), LinkedIn (24), Spotify (16), Twitter (16), Chrome (14)		

Note. For the numeric data, the missing values have been considered. For the top 3 apps, we have used the whole samples to do the data analyses. For *t* values, * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4.6 Correlation Coefficients between Mental health problems, the SAS-SV, the SUPIQ and its Seven Factors, and smartphone use statistics in the university community sample (N=292) and the general population sample (N=397, in bold).

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Mental health problems	1	**.71*****	**.78*****	**.51*****	**.59*****	**.47*****	**.73*****	**.72*****	**.62*****	**.65*****	**-.04**	**.04**	**.22****	**.21****	**-.10**
2. SAS-SV	.46***	1	**.77*****	**.58*****	**.62*****	**.53*****	**.69*****	**.55*****	**.69*****	**.64*****	**-.03**	**.04**	**.19****	**.17***	**-.10**
3. SUPIQ-Total	.52***	.77***	1	**.74*****	**.77*****	**0.72*****	**.87*****	**.78*****	**.86*****	**.83*****	**-.10**	**.02**	**.22****	**.22****	**-.14**
4. SUPIQ-Craving	.33***	.67***	.78***	1	**.60*****	**.64*****	**.49*****	**.38*****	**.63*****	**.58*****	**-.13**	**-.06**	**.12**	**.14**	**-.08**
5. SUPIQ-Coping	.39***	.48***	.67***	.49***	1	**.66*****	**.55*****	**.44*****	**.61*****	**.64*****	**-.11**	**.02**	**.15**	**.18***	**-.04**
6. SUPIQ-Habitual Use	.30***	.60***	.78***	.64***	.49***	1	**.41*****	**.37*****	**.57*****	**.57*****	**-.05**	**.02**	**-.01**	**.09**	**-.12**
7. SUPIQ-Social Conflicts	.31***	.53***	.66***	.39***	.25***	.31***	1	**.82*****	**.71*****	**.68*****	**-.09**	**.04**	**.28*****	**.22*****	**-.16**
8. SUPIQ-Risky Use	.20**	.19**	.34***	.11	.05	.18**	.28***	1	**.59*****	**.60*****	**-.06**	**.001**	**.24*****	**.20****	**-.19**
9. SUPIQ-Withdrawal	.46***	.60***	.75***	.54***	.50***	.43***	.41***	.15*	1	**.68*****	**-.07**	**.02**	**.14**	**.17***	**-.08**
10. SUPIQ-Tolerance	.45***	.49***	.67***	.44***	.37***	.43***	.41***	.14*	.36***	1	**-.07**	**.02**	**.20****	**.19****	**-.07**
11. Total screen time per day (hours)	.03	.07	.11	.11	.09	.06	.07	.04	.08	.07	1	**.58*****	**.002**	**-.002**	**.20****
12. Non-social screen time per day (hours)	.08	.14*	.16**	.12*	.16**	.10	.12*	.04	.11	.11	.66***	1	**.08**	**.05**	**.04**
13. Active social media use frequency per day	.12*	.28***	.25***	.27***	.10	.19**	.15*	-.06	.27***	.14*	.04	.03	1	**.84*****	**.01**

14. Passive social media use frequency per day	.03	.27***	.21***	.29***	.15*	.29***	-.05	-.08	.19**	.10	.09	.07	.63***	1	**.004**
15. Pickup frequency per day	-.04	.05	.07	.04	.01	.03	.15**	.08	.004	.01	.37***	.20**	.09	.03	1

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire, SAS-SV=the short version of smartphone addiction scale. * $p < .05$, ** $p < .01$, *** $p < .001$. Numbers of missing values in smartphone use statistics are separately 17 in the university community sample and 82 in the general population sample, the method to deal with the missing values is pairwise deletion.

Table 4.7 Hierarchical multiple regression results with the two samples

Independent variables	University community sample (N=292)				General population sample (N=397)			
	B	*β*	R^2	SE	*B*	*β*	R^2	SE
Step 1			0.210					
SAS-SV	0.576***	0.458***		0.066	1.192***	0.714***	0.510	0.059
Step 2			0.277				0.642	
SAS-SV	0.179	0.142		0.099	0.453***	0.272***		0.079
SUPIQ	0.314***	0.409***		0.060	0.539***	0.573***		0.045

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire; SAS-SV=the short version of smartphone addiction scale. Dependent variable = mental health problems. The possible multicollinearity problems have been checked by VIF (variance inflation factor), the VIF values of SAS-SV and SUPIQ were 2.474 for the university community sample and 2.481 for the general population sample. These values are lower than the universal criterion of 10 when detecting multicollinearity (Vatcheva & Lee, 2016). * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4.8 Relative importance and 95% confidence interval indicated by relative contribution percentages (%) of the SAS-SV and the SUPIQ in the regression model of step 2.

Attribute	University community sample (N=292)				General population sample (N=397)			
	LMG	LAST	FIRST	PRATT	LMG	LAST	FIRST	PRATT
SAS-SV	39.30	10.82	43.80	23.52	42.02	18.36	45.44	30.20
	[27.42, 52.53]	[0.04,61.91]	[35.19, 51.44]	[-5.75, 56.70]	[36.87, 47.06]	[6.30,36.32]	[42.24, 48.35]	[18.12, 42.20]
SUPIQ	60.70	89.18	56.20	76.48	57.98	81.64	54.56	69.80
	[47.47, 72.58]	[38.09, 99.96]	[48.56, 64.81]	[43.30, 105.75]	[52.94, 63.13]	[63.68, 93.70]	[51.65, 57.76]	[57.80, 81.88]

Note. SUPIQ = the Smartphone Use Problems Identification Questionnaire; SAS-SV=the short version of smartphone addiction scale. Dependent variable = mental health problems, n of bootstrap = 2000. LMG, LAST, FIRST, PTATT are the four different estimation methods offered by package "relaimpo". 27.7% and 64.24% of mental health problems' variances could be explained in university community and general population samples separat

CHAPTER 5

General Discussion

The smartphone is an indispensable tool in modern society, offering convenience in accessing information, entertainment, and communication (Fullwood et al., 2017; Harkin & Kuss, 2021; Li & Lin, 2019; Yang et al., 2019). However, smartphone use can be problematic, impacting physical and mental health, as well as social and economic well-being (Elhai et al., 2017; Jannusch et al., 2021; Olson et al., 2022). This dissertation aimed to investigate both the positive and negative consequences of smartphone use, as well as the comprehensive definition and the possible etiology of problematic smartphone use with a mixed-methods approach. This approach included employing a longitudinal cross-lagged panel analysis, an in-depth qualitative exploration, and the development of a novel questionnaire - the Smartphone Use Problems Identification Questionnaire (SUPIQ). My studies addressed three research questions: (1) What is the relationship between problematic smartphone use and the quantity and quality of peer engagement? (2) How do individuals with problematic smartphone use perceive their experiences, and what insights do these experiences offer to the understanding of PSU? (3) To what extent is the newly developed SUPIQ a reliable and valid instrument for measuring PSU?

In the following sections, I will first summarize the main findings derived from the three empirical chapters of my dissertation. I will then delve into the theoretical and practical implications of these findings. Finally, I will discuss the strengths and limitations of this dissertation and outline potential directions for future research.

Summary of the main findings

In Chapter 2, I investigated the longitudinal relationship between PSU and adolescent peer engagement. This chapter addressed the role of peer engagement in PSU development drawing on self-determination theory, which highlights autonomy, competence, and relatedness as basic needs (Ryan & Deci, 2017; Vasconcellos et al., 2020). I found PSU was positively correlated with both active and passive social media messaging on the smartphone longitudinally. Notably, the relationships between passive social media messaging and PSU were reciprocally cross lagged, while the relationship with active social media messaging were not completely bidirectional (i.e. active social media messaging at Time 2 did not predict PSU at Time 3). The findings align with previous research indicating that passive social media messaging on the smartphone is more closely associated with negative outcomes such as PSU when compared to active social media messaging on the smartphone (Allegrante & Sigfusdottir, 2019; Ding et al., 2017; Hu & Liu, 2020; J. L. Wang et al., 2018). For offline peer engagement, the study examined the intensity of face-to-face meetings with friends. Results indicated a negative cross-sectional correlation while no longitudinal correlations between the intensity of face-to-face

meetings with friends and PSU, suggesting more face-to-face peer contact may have potential indirect protective effects on PSU severity (Caplan, 2003; M. T. Wang & Hofkens, 2020). When evaluating the relationship between the quality of peer engagement and PSU, my results showed a downward spiral relationship between perceived competence in close friendships and PSU: lower perceived competence in close friendships at Time 1 was associated with higher PSU at Time 2; higher PSU at Time 2 was correlated with lower perceived competence in close friendships at Time 3. This downward spiral is consistent with the relationship observed between internet gaming disorder (IGD) and perceived social competence (Peeters et al., 2018; Van Den Eijnden et al., 2018), as well as the poor-get-poorer hypothesis (Snodgrass et al., 2018). The study also explored the relationships between online peer engagement, offline peer engagement, and the quality of peer engagement. The results revealed that using smartphones to engage in active social media messaging, rather than passive social media messaging, is beneficial for adolescents' social competence development. Such finding is in line with the transformation theory (Nesi et al., 2018) and the previous studies on different roles of active and passive social media use play in other outcomes like mental health (Allegrante & Sigfusdottir, 2019).

In Chapter 3, I conducted an in-depth semi-structured interview study to explore the experiences of university students with PSU. The interview protocol encompassed questions about the symptoms of PSU, motives of smartphone use, and both the perceived positive and negative impacts of use to the individual. My analysis revealed the relevant themes of problematic smartphone use symptoms in the light of the DSM-5 and ICD-11 diagnostic addiction criteria, which are also consistent with the previous measures on PSU (American Psychiatric Association, 2013; Kwon, Lee, et al., 2013; Lin et al., 2014, 2016; World Health Organization, 2019). My findings also revealed PSU symptoms themes like "Habitual smartphone use", which aligns with the previous findings on PSU and habitual smartphone use (e.g., Van Deursen et al., 2015; Wilmer et al., 2017). Furthermore, I identified the central emerging themes related to perceived PSU etiology like "Motives for smartphone use and restrictive motives", which has emphasized informational motives and enriched the existing scope of smartphone use motives (Chen et al., 2017a; Haug et al., 2015). Using the themes that emerged from my qualitative analysis as a base, I developed a preliminary theoretical framework for the etiology of PSU. This framework contextualized all the identified themes within the dynamic interplay of the trade-off process. This trade-off process involved the positive and negative consequences of smartphone use, motives for smartphone use and restrictive motives, and was modulated by the perceived social norms. This frameworks aligns with existing theories including Rational Addiction Theory

(Becker & Murphy, 1988), Uses and Gratifications Theory (Blumler, 1979), and Motivational Theory (Brand et al., 2016; Cooper et al., 1995; Köpetz et al., 2013; Kuss et al., 2012). Smartphone users aim to maximize utility of smartphones to get positive outcomes (Rational Addiction Theory: Becker & Murphy, 1988; Köpetz et al., 2013) and fulfill their various needs (Uses and Gratifications Theory: Blumler, 1979;) and motives (Motivational Theory: Brand et al., 2016; Cooper et al., 1995; Köpetz et al., 2013; Kuss et al., 2012). In addition, the findings on perceived social norms are consistent with results from prior research on PSU (Hong et al., 2021; McAlaney et al., 2020) and other substance use scenarios (Vallentin-Holbech et al., 2017; Wood et al., 2012). I will elaborate on this framework in detail in the theoretical implications section below.

In Chapter 4, I developed a novel tool to assess PSU - the Smartphone Use Problems Identification Questionnaire (SUPIQ). This tool was developed in keeping with the key themes and responses identified in Chapter 3. Exploratory and confirmatory factor analyses confirmed a 7-factor structure derived from 26 items. The SUPIQ exhibited good reliability, as indicated by both Cronbach's α and McDonald's ω values. Linear correlation analyses revealed good convergent validity of the SUPIQ and the SAS-SV, as well as mental health problems. Partial correlation network analyses revealed positive associations between mental health problems and specific SUPIQ factors in the two samples. However, regarding frequency and intensity-related smartphone use metrics, there were no associations between total screen time, nonsocial screen time, and pickup frequency and the SUPIQ factors. Interestingly, active social media use and passive social media use were correlated with different factors of the SUPIQ across the two samples. Active social media use showed a positive correlation with Social Conflicts and a negative correlation with Habitual Use in the general population sample. On the other hand, passive social media use displayed positive correlations with Habitual Use in both samples and negative correlations with Social Conflicts in the university community sample. Finally, in terms of explanatory power, the SUPIQ outperformed the SAS-SV when predicting mental health problems in multivariate regression models. In sum, the SUPIQ is suggested to be a valid and reliable novel tool for measuring problematic smartphone use across diverse populations.

Theoretical Implications

This dissertation holds significant theoretical implications for both PSU research and society. I believe the included studies have advanced our comprehension of problematic smartphone use (PSU) in several ways.

The positive and negative consequences of smartphone use

As I have mentioned in Chapter 1, the research on smartphone use should consider both the positive and negative consequences of smartphone use. In Chapter 2, my findings also underscore the importance of considering both active and passive smartphone use behaviors. Active social messaging positively influenced face-to-face meetings with friends and perceived competence in close relationships, while passive social messaging exhibited stronger associations with PSU development. These results align with prior research, emphasizing the multifaceted nature of smartphone use (Allegrante & Sigfusdottir, 2019; Escobar-Viera et al., 2018; Hu & Liu, 2020). Chapter 3 delved deeper into a more complete understanding of PSU through qualitative research, revealing the dynamic trade-off process between positive and negative consequences of smartphone use. These findings align with a beneficial and balanced perspective as has been proposed in the context of video gaming: the positive effects of video gaming on cognitive, motivational, emotional, and social should be considered (Granic et al., 2014). My research advocates for a shift away from solely focusing on either the positive or negative consequences of smartphone use. Instead, it highlights the nuanced dynamic interplay between the positives and negatives. When the negative consequences outweigh the positive consequences, individuals may suffer from addiction-like symptoms related to their smartphone use, which can be considered as "problematic smartphone use". This perspective expands existing literature, which has predominantly focused on negative outcomes or symptom measurement of PSU only (Larsen et al., 2023).

The proposal of the possible PSU etiology

Beyond considering the trade-off process between positive and negative consequences of smartphone use, my dissertation has delved deeper into understanding PSU etiology. My findings shed light on the complex interplay of social, motivational, and normative factors that contribute to PSU development. Chapter 2 identified low competence in close friendships and frequent social media message checking as potential risk factors for PSU development. Chapter 3 revealed the influences of motives for smartphone use and the perceived social norms surrounding smartphone use (see Figure 5.1 below). Chapter 4 added further weight to these findings by illustrating the associations between the SUPIQ score, mental health problems, and frequency and intensity measures of smartphone use. Within the preliminary theoretical framework I proposed in Chapter 3, I have marked the components that have been investigated with quantitative methods in Chapter 2 and Chapter 4 (see Figure 5.1 below).

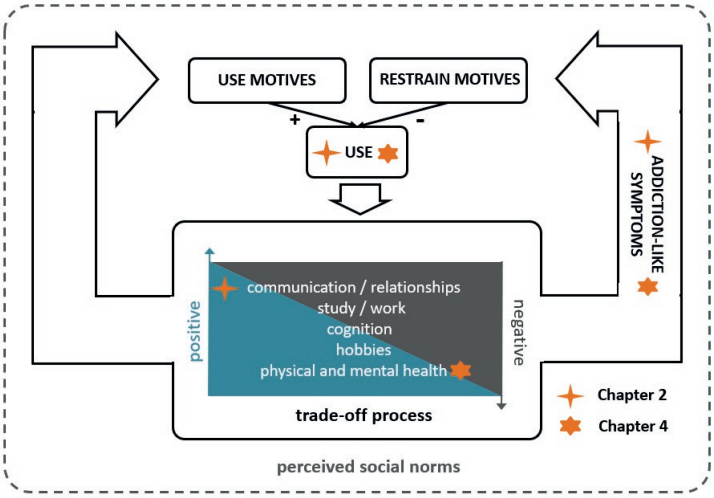


Figure 5.1. The components have been investigated in Chapter 2 and Chapter 4 within the theoretical framework proposed in Chapter 3

The advancement of PSU measurement

This dissertation has made a significant contribution to advancing the understanding and measurement of PSU within the PSU etiology framework. In Chapter 2, the SAS-SV was employed to assess PSU, including six factors like overuse and tolerance. While this approach provided valuable insights, it became apparent that existing scales do not comprehensively capture the contemporary PSU-related symptoms experienced in everyday life (For a review see, Nawaz, 2023). Chapter 3 addressed this limitation by identifying key themes related to PSU symptoms, aligning with the DSM-5 and ICD-11 diagnostic addiction criteria. It also revealed emerging themes, providing insights into novel aspects of PSU, such as the vital roles of the smartphone, habitual smartphone use, and smartphones as disruptive distractions.

Based on these identified themes in Chapter 3, I developed the SUPIQ - a novel questionnaire assessing problematic smartphone use (Chapter 4). The findings from Chapter 4 underscored the importance of incorporating a novel factor, Habitual Use into PSU assessment compared to the popular PSU scales like MPPUS (Bianchi & Phillips, 2005), PMPUQ (Billieux et al., 2008), SAS (Kwon, Lee, et al., 2013), and SPAI (Lin et al., 2014). The SUPIQ improved upon existing scales by adapting the definitions and measurements of Craving, Coping, Social Conflicts, Risky Use, Withdrawal and Tolerance. The SUPIQ appears to be a valuable tool for assessing PSU with robust psychometric properties and a comprehensive consideration of problematic smartphone users' daily experiences. However, further studies are

required to assess the validity of the SUPIQ in different populations (e.g., clinical samples), as well as to further optimize the assessment tool. For example, with considerations of optimal sensitivity, specificity and diagnostic accuracy, the cut-off points of the SUPIQ should be developed for problematic smartphone users (Kwon, Kim, et al., 2013; Lemmens et al., 2015; Paschke et al., 2022).

PSU in context: the role of sample composition

The type of problems people may have with their smartphones depend partly on the developmental stage they are in and on their social context. This is evidenced by my findings that PSU manifested itself differently across each distinct sample tested in this dissertation. In Chapter 4, it became apparent that Risky Use exhibited weaker correlations with other factors of the SUPIQ within the university community sample compared to the general population sample. Furthermore, it is important to note that except for configural invariance, measurement invariances of the SUPIQ were not entirely established across different samples. These findings underscore the need to refine PSU measurement tools, tailoring it to diverse populations. This observation aligns with observations from other fields, particularly in domains like problem drinking; for example, specialized scales for adolescents have been developed to account for age group differences effectively (c.f., White & Labouvie, 1989).

Moreover, the type of problems co-occurring with PSU may also vary across various demographic groups. Among adolescents (explored in Chapter 2), my findings highlighted the significance of competence in close friendships and passive social media messaging on smartphones as potential key contributors to PSU development. In addition, active social media messaging was positively correlated with PSU concurrently. In the university community sample (outlined in Chapter 4), active social media use exhibited a positive correlation with Social Conflicts. Conversely, passive social media use demonstrated a positive association with Habitual Use and a negative relationship with Social Conflicts. Additionally, mental health problems exhibited positive correlations with Withdrawal and Tolerance. In the general population sample (detailed in Chapter 4), active social media use displayed a positive correlation with Social Conflicts and a negative correlation with Habitual Use. Passive social media use showed a positive association with Habitual Use. These differences align with findings from previous studies involving different demographic groups (Busch et al., 2021; Rosales & Fernández-Ardèvol, 2019). Past research has suggested that the older generation may exhibit different smartphone use patterns in comparison to the younger generation (Busch et al., 2021; Rosales & Fernández-Ardèvol, 2019). For instance, older Spanish adults aged over 75 years used their smartphones less than the younger groups, and they tended to mostly use

the basic functions of smartphone like photographing and ordinary voice calls instead of more advanced functions like multimedia message service and music (Rosales & Fernández-Ardèvol, 2019). In addition, the PSU prevalence among older Norwegian adults aged over 60 years was low (2.4%) with the 10-item mobile phone problematic use scale (MPPUS-10; Foerster et al., 2015). Also, the older adults tended to use their smartphones to reduce the feelings of loneliness (Busch et al., 2021).

In summary, these discrepancies emphasize the necessity of accounting for distinct contexts and developmental stages when investigating PSU. The multifaceted nature of PSU becomes evident when considering different populations, further enriching the understanding of this phenomenon, and highlighting the importance of context-specific research approaches. While I have provided some important first steps in this dissertation, it is important to acknowledge that research in this regard is still in its infancy.

Practical Implications

My research holds some significant practical implications for professionals, policymakers, and smartphone users seeking a healthier approach to smartphone use. First, professionals need to recognize that smartphones have become an integral part of our daily lives due to their numerous advantages (e.g., Fullwood et al., 2017; Harkin & Kuss, 2021; Li & Lin, 2019b; Yang et al., 2019). Consequently, interventions aimed at addressing PSU should not solely focus on eliminating smartphones from daily life but rather strive to promote "digital well-being" - a state characterized by a healthy balance in smartphone use (Pedrero-Pérez et al., 2019; Vanden Abeele, 2020). More concretely, interventions can be designed to raise awareness about the potential negative consequences of PSU in the trade-off process, encouraging mindful smartphone use (Abhari & Vaghefi, 2022; Carlson & Larkin, 2009). Additionally, interventions can draw from the concept of perceived social norms, which may offer a promising avenue for addressing PSU. Furthermore, it is crucial to consider the motives behind smartphone use and different usage patterns, drawing on theories like the Rational Addiction Theory (Becker & Murphy, 1988), Uses and Gratifications Theory (Blumler, 1979), and Motivational Theory (Brand et al., 2016; Cooper et al., 1995; Köpetz et al., 2013; Kuss et al., 2012). For instance, when devising interventions to manage adolescents' PSU, it may be necessary to place greater restrictions on passive social media use compared to active social media usage. In the interventions, the person-specific factors like impulsivity and state boredom should also be considered (Vanden Abeele, 2020).

Furthermore, the integral role of smartphones should be acknowledged by policymakers, including governments, universities, and secondary schools. While there is evidence indicating that problematic smartphone use can have detrimental effects on academic (e.g., Zhou et al., 2022) and professional performance (e.g., Alan et al., 2022), it is equally important to recognize the significant ways in which smartphones facilitate these domains (e.g., Rizal et al., 2022; Tadiboina, 2022). Therefore, efforts should be directed towards promoting healthy smartphone use rather than imposing outright bans in classrooms and workplaces. Specific aspects, such as Risky Use (i.e., smartphone usage in physically dangerous situations, like crossing the road or operating heavy machinery), should also receive attention to ensure public safety. Additionally, when identifying problematic smartphone use behaviors, developing intervention protocols, and formulating new policies, it is imperative to consider distinct contexts and developmental stages, as my research has provided preliminary evidence of such variations in terms of PSU in context.

Finally, it is imperative for smartphone users to prioritize attaining "digital well-being" - the optimal equilibrium between the positives and negatives of smartphone use (Pedrero-Pérez et al., 2019; Vanden Abeele, 2020). They should mindfully evaluate the affective and cognitive effects of smartphones on their daily life, aiming for maximum enjoyment and practical support while minimizing loss of control and functional impairment (Abhari & Vaghefi, 2022; Carlson & Larkin, 2009). As previously emphasized, smartphone users should consider their smartphone use motives (i.e., social, emotional and informational) as well as the goal-directed nature of their smartphone use to maximize the benefits of smartphones to achieve digital well-being (Hogarth, 2020). Equally important is the need to recognize that experiencing negative consequences of smartphone use is common, and it is unwise to fixate on the stigma associated with the minor issues related to smartphone use, since such stigmas may amplify more severe problems, potentially leading to psychological distress (e.g., K.-Y. Lee et al., 2023). While minor concerns like the disruptive distractions from daily life are relevant, it is crucial to place more emphasis on the recognition and cautious assessment of severe smartphone use problems, such as Risky Use, Withdrawal, and Tolerance of the SUPIQ.

Strengths, Limitations, and Research Implications

A core strength of this dissertation lies in my mixed-methods research design, adopting longitudinal quantitative studies, in-depth qualitative interviews, and questionnaire development. This multifaceted approach offers a relatively comprehensive exploration of problematic smartphone use (PSU) and its potential etiology, effectively addressing the criticisms previously outlined in Chapter 1 of

this dissertation. The longitudinal investigation of adolescents' PSU, examining both the quantity and quality of peer engagement, yielded valuable insights into the longitudinal trajectory of PSU, offering a deeper understanding of the contributing factors for PSU among adolescents. The in-depth qualitative study delved into the experiences of problematic smartphone users, offering rich context and perspectives that complemented the quantitative findings. Additionally, the development and validation of the Smartphone Use Problems Identification Questionnaire (SUPIQ) add to the field by providing a reliable and valid tool for assessing PSU in real-life situations that moves beyond traditional addiction criteria. The findings offer practical implications for promoting "digital well-being", emphasizing a balanced approach to smartphone use rather than extreme measures like complete elimination. The inclusion of both qualitative and quantitative research enhances the holistic understanding of PSU. Lastly, the efforts to enhance PSU measurement and definition through the study are noticeable, particularly the development of the SUPIQ in Chapter 4, providing a novel approach to PSU assessment when compared with Chapter 2.

While my research has made notable contributions, it is essential to acknowledge its limitations, and future studies should aim to address these issues. First, within the PSU etiology framework proposed in Chapter 3, I primarily investigated the associations between addiction-like symptoms (measured by the SAS-SV in Chapter 2 and the SUPIQ in Chapter 4) and frequency and intensity of smartphone use, relationship indicators, and mental health problems. Future research can incorporate more diverse indicators for such associations. For example, in terms of relationships with others, variables like peer influence, peer victimization, and peer status (Huang et al., 2014; Nesi et al., 2018b), online friendship preferences (e.g., Smahel et al., 2012), and friendship detected by the co-locations of smartphones (e.g., Malik et al., 2020) can be explored. In terms of smartphone use patterns, it is important to consider the more nuanced individual differences in smartphone use patterns like the use of specific apps and use contexts (e.g., Griffioen et al., 2021; Montag et al., 2021), moving beyond the simplistic gauge of objective measures like total screen time (for a review see, Ryding & Kuss, 2020). Regarding the consequences of smartphone use, further investigations can explore the relationships between PSU and study/work efficiency (Alan et al., 2022; Rizal et al., 2022; Tadiboina, 2022; Zhou et al., 2022), cognitive functioning (Wilmer et al., 2017), and physical health (e.g., AlAbdulwahab et al., 2017). In current dissertation, I have mainly focused on the social motives for smartphone use, while it is crucial to disentangle different motives (i.e., social, informational, and emotional and more elaborate motives) for smartphone use and goal-directed behaviors when identifying users with severe smartphone use problems (e.g., Chen et al., 2017; Merchán

Tamayo et al., 2024). For example, further research should also examine the trade-off processes between non-problematic and problematic smartphone users, considering specific smartphone use goals, values, and comorbidities with other mental health problems (Gao, 2022; Hogarth, 2020). The potential influences of perceived social norms on PSU, including descriptive (i.e., perceptions of the prevalence of specific behaviors) and injunctive (i.e., perceptions of the outcomes of specific behavior, such as approval or sanction in a given context) social norms, with different referent groups (e.g., family, friends, classmates, etc.) across different situations, warrant further investigation (Barman-Adhikari et al., 2018; Hong et al., 2021). Moreover, the overlap between PSU and problematic internet use, as well as other behavioral and substance-related addictions, can be explored further using the newly developed SUPIQ (e.g., Andrade et al., 2022; Kwon, Lee, et al., 2013).

In this dissertation, my research questions were primarily tested among participants from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) countries and student populations. Future research can qualitatively investigate nuanced cultural and population differences by including smartphone users from other countries and age groups (e.g., Dreier et al., 2012). Quantitative research should encompass larger and more diverse samples, including possible clinical samples identified by clinicians or psychotherapists as problematic smartphone users (Körmendi et al., 2016), to assess the SUPIQ's broader applicability (Billieux, Philippot, et al., 2015; Billieux, Schimmenti, et al., 2015; Flayelle et al., 2022; Lopez-Fernandez, 2017), and to validate, generalize, and refine the proposed PSU etiology. Longitudinal quantitative designs, with larger sample sizes, longer intervals, and more time points or longitudinal ecological momentary among diverse samples, can deepen the understanding of PSU stability and its etiology. Additionally, person-centered analyses, such as latent profile analysis with cross-sectional data (e.g., Yue et al., 2021), growth mixture modeling with longitudinal data (e.g., Lai et al., 2022), and multilevel analysis with longitudinal ecological momentary data (e.g., Armstrong-Carter et al., 2023) can be employed to identify problematic subgroups, revealing more individual differences with the SUPIQ.

Regarding the definition and measurement of PSU, the factors like Craving, Coping, and Tolerance require further refinement since the restored items were used in the current version of the SUPIQ. In addition, the significance of factors needs to be determined to identify the central symptoms in defining PSU (Fournier et al., 2023). Future studies should test the test-retest reliability of the SUPIQ and generate a short form of the questionnaire to check the applicability of the SUPIQ (c.f. Kwon, Kim, et al., 2013). Moreover, it may be necessary to adapt the SUPIQ may for different demographic groups like younger and older generations, individuals with

lower and higher education levels and so on (e.g., Kwon, Kim, et al., 2013). Additionally, specific cut-off points for identifying individuals with severe smartphone use problems should be established within diverse cultural, national, and age-specific contexts (e.g., White & Labouvie, 1989). Based on my development of the SUPIQ, it is essential to address the stigma and misunderstandings surrounding normal smartphone use (Kardefelt-Winther et al., 2017; Wiers & Verschure, 2021). To be concrete, PSU should be conceptualized without pathologizing the normal smartphone use The significant and persistent harm or distress should thus be identified to further define PSU (Kardefelt-Winther et al., 2017).

Conclusions

In summary, this dissertation provides a comprehensive understanding of PSU on both the benefits and drawbacks of smartphone use, by adopting the mixed-method approach. The longitudinal investigation highlights that adolescents who perceive lower competence in close friendships and engage in frequent text checking via smartphones are at a heightened risk of developing PSU over time. Moreover, the qualitative study emphasizes the trade-off process, motives for smartphone use, and perceived social norms. It transcends conventional addiction criteria and exclusive reliance on psychometric measures. Furthermore, the questionnaire development study exhibits the SUPIQ has strong reliability and validity, showing it is a valuable tool for assessing PSU in real-life scenarios. Interventions aiming at PSU should prioritize promoting “digital well-being” through mindful smartphone use rather than advocating complete smartphone elimination.

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Supplementary material of Chapter 3

S3.1 The interview protocol of Chapter 3

Introduction: Give consent form, introducing yourself and the project, ask permission for the audio tape. Say "Please notice that there are no right or wrong answers or attitudes, and I'm just interested to learn your personal story regarding smartphone use. During the interview, I may write down some notes, and the notes are just simple records of our conversation, not judgements".
PART 1: 1. To begin with, could you fill out the demographic questionnaire?

PART 2: Description of Smartphone Use Experience
2a. Could you describe how you use your smartphone on a typical work day from the time you wake up to the time you go to sleep? What about waking up during your sleep? **frequency, duration, settings (silence, vibration etc.)?**
2b. Could you describe how you use your smartphone on a typical day off from the time you wake up to the time you go to sleep? What about waking up during your sleep? **frequency, duration, settings (silence, vibration etc.)?**
3a. What types of things do you usually do with your smartphone (max. 5)?
3b. What apps do you usually use to do the things you have mentioned?
3c. To be specific, what roles does your smartphone play in your social life? Could you give me an example?
3d. Do you prefer communicating through your smartphone to communicating face to face? Why? And in what situations?
3e. How often do you download new apps? If you do it frequently, why? What motivated you to download new apps?
3f. How often do you update the existing apps? Why?

PART 3: Problematic Smartphone Use Symptoms Part
4a. How does your smartphone positively influence your everyday life?
Prompts:
- How does it positively influence your study (e.g., academic efficiency, performance， procrastination etc.)/work (e.g., job efficiency, performance, procrastination etc.)?
- How does it positively influence your health?
- How does it positively influence the way you think (e.g., memory, solve problems, etc.)?
-How does it positively influence other activities?
4b. How does your smartphone negatively influence your everyday life?
Prompts:
- How does it negatively influence your study (e.g., academic efficiency, performance, procrastination etc.)/work (e.g., job efficiency, performance, procrastination etc.)?
- How does it negatively influence your health? (e.g., sleep, back/neck, eyesight, meals, etc.)
- How does it negatively influence the way you think (e.g., memory, solve problems, etc.)?
-How does it negatively influence other activities?
Have you ever noticed you that you were losing interest in previous hobbies and entertainment because of your smartphone use?
4c. Even though you think your smartphone has some negative influences on your life, you will still use it, right? Why?
5. What signs have you noticed in yourself that make you think you pay too much attention to your smartphone?
Prompts: a. Does it happen that you do not notice other things around you when you are using your smartphone? And if so, in what kinds of situations? How often does it happen?
b. Do you think about your smartphone when you are not using it? And if so, in what kinds of situations? How often does it happen?
c. Do you still use your smartphone when you are not allowed to use it (for example: in the classroom)? And if so, in what kinds of situations? How often does it happen?
d. Do you automatically get out your smartphone without thinking about it? And if so, in what kinds of situations? How often does it happen?
When you have your smartphone out, do you automatically open apps on it without thinking? And if so, in what kinds of situations? How often does it happen?
e. Does it happen that you have the illusions that your smartphone is ringing/vibrating (prompt: the signal light of your smartphone is flashing, or the screen lights up)? And if so, in what kinds of situations? How often does it happen?
f. Do you ever use your smartphone when you are crossing the road/riding a bike 、driving a car? If yes, what's that like? How often does it happen? Has that ever been dangerous? – How so?
g. Do you have dreams about your smartphone? If yes, what's that like? How often does it happen?

6. Motivation/ Emotional Effects
6a. Do you find that you will use your smartphone when you are in certain moods? What's that like?
Prompts: Does it happen that you will use your smartphone when you feel:
positive feelings: happy/ excited/creative/funny
negative feelings: bored/stressful/sad/anxious/helpless/guilty/lonely
frustrated/insecure/tired/sleepy.
How often does that happen? What's it like?
6b. How do you usually feel when you are using your smartphone?
Prompts: positive feelings and negative feelings
6c. How do you usually feel after you use your smartphone?
Prompt: positive feelings and negative feelings
7a. Could you picture yourself without being able to use your smartphone for an extended period of time (especially in a situation where you felt you really needed it)? How would you feel? How would you feel after being connected again?
7b. If your smartphone could not get connected to the internet /the signal is not stable (ask both situations), how would you feel? How would you deal with that?
7c. If the battery of your smartphone was low or insufficient to use it, how would you feel? How would you deal with that?
7d. If somebody/something were to interrupt you when you were using your smartphone, how would you feel? How would you deal with that?
8a. Could you tell me about changes about your personal smartphone use? Do you spend more time on your smartphone than before? If yes, what's that like? How do you explain that?
8b. Do you ever use your smartphone longer than you initially intended? If yes, what's that like? How often does it happen?
8c. Have you ever tried to restrict your smartphone use?
- IF YES: What motivated you to restrict your use? How did you go about restricting your smartphone use? Did it work? How do you think it worked (or why didn't it work)?
- IF NO/or it didn't work/have answered the YES part: Do you want to change your patterns and habits regarding smartphone use in the future (e.g., shorter time, more effective, etc.)?
IF YES: Why do you want to change your smartphone use? What do you think it would be like to change your use? What conditions or people do you think would help you to change your smartphone habits?
IF NO: Why do you not want to change your smartphone use?
9. What do you think your parents/friends/other people around you think about the way YOU use your smartphone?
Prompts: a. Have they ever said you were addicted to your smartphone? Do you have any idea about the possible reasons they think this?
b. Have you concealed/hided your smartphone use from them? What's that like? How often does it happen?
c. Have you experienced conflicts with family, friends, or other people around you because of your smartphone use? What's that like? How often does it happen?
d. Do you think you spend more time on your smartphone than other people around you?
10a. What do you think about the idea of "smartphone addiction?" How would you describe it?
10b. Why could people get addicted to their smartphone? (Do not block the participants' free thinking)

PART 4: Summaries and Complements
11a. Could you please describe to me the roles your smartphone plays in your life? While answering try to integrate some relevant examples based on your own experiences.
11b. Could you imagine what your life would be like without your smartphone? How would you feel?
12. Is there anything else you would like to add or clarify in terms of your smartphone use? Is there anything you think we didn't cover that is important for me to know?
Thank You.

S3.2 The codebook of Chapter 3

Experiences of problematic smartphone use in the light of DSM-5 and ICD-11 addiction criteria

Urges to be always on one's smartphone: craving

Categories	Codes	Quotes
Think about things on smartphone when not using	Think about the emotional part of smartphone	When I'm organizing an event, for example, birthday party or if I talked to the person earlier that day I just text them to maybe because I think about them more, I want to see them again probably just like when I feel like I need some social interaction (S06, Pos. 608)
	Think about the informational part on smartphone	For example, when I want to find out something when I want to have some information, that it's easy to do through the smartphone. (S31, Pos. 456)
	Think about the social part on smartphone	But I'm like, what if I got something on Instagram? I really want to see there is always this thing about. I think the need of having some attention from other people. And you want to know if you got some likes. You want to know if you got some matches. So, you go and check it. (S10, Pos. 100)
Want to use smartphones when not using	Want to check if there is a new message after a while	Once I leave the room it's like I haven't checked my phone for an hour, let's check it. (S06, Pos. 508)
	Think about how easy it is with smartphone	I had problems with my SIM card. And I couldn't use it. Then I was thinking about. Oh, how easy would it be now to just use my phone for that. (S03, Pos. 406)

Salience andpreoccupation

Categories	Codes	Examples/Quotes
Ignore the regulations that one is not allowed to use smartphones under some specific situations	-	For example, today, I was a bit late for my lecture. I was thinking, oh, no, I don't want to be the last in the lecture, because I missed the beginning. So, while I was biking, I actually checked the first few lectures slides on my phone. (S24, Pos. 220)
Illusions of new messages or notifications on smartphone	I have such illusions when waiting for important information	Barely, I have that when I'm waiting, for example, let's say I'm waiting for an important answer to finish any project or I'm waiting for an email or anything. So, I'm really looking forward that someone's calling me or any notification whatever, then I sometimes imagine it would light up when I'm doing something else and I see my phone laying on a table in front of me. (S22, Pos. 581)
	I have such illusions when doing serious things	I think if it's during a serious study session, it happens frequently. So, I have exams every month. (S04, Pos. 298)
	I have such illusions when I was walking	Mostly when I was walking, because the movement would simulate the vibration (S14, Pos. 316)
	I have such illusions across different situations/no specific situations	Every time, I don't think about the situation it's just when I see I think I saw, I just notice. (S17, Pos. 578)
	Illusion of ringing	Like, I think sometimes I just hear sounds like even. That's just like some ringing in my head. (S10, Pos. 529-538)
	Illusion of vibration	I feel like I heard this or like these vibrations of the smartphone. (S02, Pos. 674)
	Illusion of signal light	I will look at it like sometimes, like when I had my old phone, it had a signal light. And sometimes I would be writing something and then in the corner of my eye, I think I would see it the signal light is appearing. (S33, Pos. 443-448)
Get immersed when using smartphones	Don't notice other things when using smartphone	I think if I'm in the library, looking at stuff at my smartphone, and someone drops a cup of coffee, I would probably not notice that when I'm busy with my smartphone. (S12, Pos. 478)
	Get immersed with my smartphone when travelling/moving/walking	I just don't focus on my surroundings. So, if I'm just on my phone, when I'm walking or something, and I don't pay attention to the way I'm walking. It could also be like, instead of like a dangerous situation, it could also just be annoying because you kind of walk slower when you're on your phone. So, people like cross me very angrily, like ugh why are you on your phone. (S04, Pos. 272)

I’m always paying attention to my smartphone	I pay too much attention to it	I think what kinds of circumstances I pay too much attention to my smartphone. Uhm, I don't know, I think all the time, I pay too much attention to it. (S18, Pos. 208)
	I always have my smartphone with me	I mean it's always there with me, I never leave my house without my smartphone, it's always just with me, it's like a part of my life (S06, Pos. 1008)
	Think about where the phone is	One sign is probably when I don't have my phone in my pocket, there's like a sort of alarm system. And I'm like, Where's my phone? Or I do notice that when I don't have my phone when I don't use my phone, some of the things I'll ask my systems to show me my notes, whatever, or I just want to write So I notice my phone when it's not there, that's I think the most noticeable thing. (S25, Pos. 380)
	Think about the battery	Interviewer: Do you think about your smartphone where you are not using it? Interviewee: Yes, I do. I'm like, should I charge my phone? If my phone runs out of battery on the way home, what do I do? Oh my god, but what like my way home will be so boring without my phone. Oh my god, it's terrible. When my phone runs out of battery, it's nightmare. (S10, Pos. 452-454)
Smartphone use is the first choice when having nothing to do	Don’t know what to do without smartphone	It's like my smartphone helps me so much my daily life I don't even know what to do without it honestly. (S06, Pos. 216)
	Use smartphone when I don't know what to do	When I have nothing to do, I just take my smartphone out and just start scrolling through things with no point. (S21, Pos. 430)
Living in the virtual world on smartphone instead of the real world	Choose to use my smartphone even when I have better choices	I'm traveling, I have like books, and I can look or talk to someone, but I'm choosing to use my smartphone, so this is weird, because I have like, better things to do. (S02, Pos. 532)
	Use smartphone when watching TV series	But I'm while watching (Netflix) on my laptop I'm still on my phone, too strange. (S06, Pos. 28)
	I don't care living the moment	If I don't care about the view but taking a photo of the view. And forget having a conversation with the other person. And just looking at my phone, that means I am really paying more attention. I'm really missing out from the real life. Those are the signs. (S10, Pos. 434)

Dreams about smartphones	Use smartphone for calling in some dreams	I can recall the one dream or two that FaceTiming itself appeared in my dream. (S03, Pos. 68)
	Dreams about texting via phone	Do I have dreams about my smartphone? Well, yes, sometimes I send accidental full messages to people, and then I can't understand them. And it really scares me, like sending wrong messages to wrong people. (S10, Pos. 48)
	Dreams about games on phone	Sometimes I used to be really addicted to this one game that you have to like, fit pieces. And then I would like dream about the game about like moves that I could make. (S09, Pos. 184)
	Dream more about the information on my phone	So more about what I saw on my smartphone, than about my smartphone. So, some information I got. (S17, Pos. 64)

Negative consequences of smartphone use on daily life

Categories	**Codes**	**Examples/Quotes**
Negative effects on cognitive process	Worse problem-solving abilities	However, in terms of problem solving, I think it makes me dumber. Less smart. Yes. Because it's very simplistic. The actions are very simplistic. (S21, Pos. 402-414)
	Worse memory since I could check the information easily	I think it might be causing that I remember less because I know where it is saved. For example, when I know that somebody sent me a link to the website. Then I don't remember the website, but I remember that that person send me the link so if I know it, I checked the conversation and find the link instead
	Worse memory since it is hard to concentrate when memorizing something	But maybe if I use it, and I want to memorize something, I think it might disturb that process when I want to memorize something. (S18, Pos. 176)
	Decreased attention span	If I see the smartphone, I will have shorter like attention span (S02, Pos. 380)
	Worse thinking abilities	But I think overall, life may get a bit more superficial by thinking of too many things at once. And to end is that the way it is right now, smartphone usage plays a gigantic role. And I don't really think that it's really a good thing. (S03, Pos. 262)
Negative effects on real-life relationships	Jeopardize real-life communication/ meeting	It still gets me to be anti- social because I stay social in media. Like sometimes I'll just stay home and talk people in the media instead of meeting them. (S10, Pos. 210)
	Miss social information when immersed on phone	It happened a lot like because I would be talking to someone and texting at the same time. It's like, they would say something and then I'll be like finish typing, and then go back to the conversation. It is weird with this, this and this. And then the person's like, already at another point. (S09, Pos. 476)
	Hiding/telling lies about one's own smartphone use	When I was in the bathroom, I used my phone. So that they don't see it (I'm using my smartphone). (S05, Pos. 1233)
	Have conflicts with important others about smartphone use	Yes, I had conflicts with my family on my smartphone use. Around lunchtime, because they think lunchtime should be special. And no distractions should be there. And I used to be on my smartphone on our lunchtime as well. (S33, Pos. 766)

Negative effects on hobbies	More time on smartphone, and then less time for other hobbies	I think that some hobbies I forgot about them right there, I don't call them hobbies anymore because of my smartphone. (S18, Pos. 192)
	Smartphone use is easier than other hobbies	I think yes, it's much harder to read books, it's much harder to play a guitar, it's much harder to do anything, which does not instantly evoke this as I already explained this, let's say release of serotonin and dopamine, which keeps me going. So, if it requires effort, and browsing your smartphone obviously does not. Then it becomes way harder. (S33, Pos. 292)
Negative effects on study	General negative effects on study	It has a negative effect on my study. (S05, Pos. 272)
	Negative effects on study efficiency	I think if I didn't have my phone with me all the time, I would be done more quickly with studying. (S11, Pos. 240)
	Negative effects on academic performance	Yeah, because if I wouldn't have wasted so much time on my phone. I would have worked more. And that would have meant better grades. (S27, Pos. 455)

Mental health risks	Get impatient when can't get things done quickly	Maybe in a way that I am not happy when I don't finish the things fast because with the smartphone. If you want to know something, because of the internet, you can usually find it out very fast. So it makes me impatient, it makes me quite impatient, to be honest. (S31, Pos. 376)
	Social comparisons in social media	It doesn't also encourage me to do it is just like there is no bad nor benefit or some negative things but when it comes down to mental health, I think that using your smartphone, especially social media on your smartphone, has a negative impact as you scroll through an Instagram or something and you see how this perfect people have the perfect life and you think, oh god, I'm not that perfect and I don't have this perfect life. And it's a bit negative. (S18, Pos. 144)
	Not living in real world	Sometimes I feel like I don't actually live something to live it, but just to share it. Like, I will eat something. And then sometimes I'm like, I really want to share this. (S10, Pos. 80)
	Bad feelings about loss of control in phone use	I feel guilty, like, using my phone, when I used it longer than I intended. (S15, Pos. 874)
	Bad feelings about overuse of smartphone	My smartphone on the way I think I'm. I feel like a useless person sometimes. Like, you know, I feel useless. I feel like I'm doing nothing with my life. And I'm like, I could do something better. I feel like I'm nothing, I'm a loser. Like I should do something with my life. I just waste myself like doing nothing. Like for you know for and what good came out of it? Nothing, probably. (S10, Pos. 386)
	Pressure/stress about the outcome of smartphone overuse	I get mad at myself for not getting things done. And I get really stressed. (S10, Pos. 330)
	The stress from instant messaging	Because I feel like it is expected when you use your smartphone to react immediately. And I am someone who I like to think about things. (S12, Pos.322)

Physical health risks	Physical risks in traffic	When I'm driving, I tend to use it sometimes. Maybe to check this, to change the song or something. And once I almost like crashed very badly. So yeah, it is dangerous. (S20, Pos. 686)
	Less physical activities/exercise	I do things that are more into like just photography and just like chatting, and conversations. I just use my hands and I just lay like a dead person. And it makes me lazy in you know, it gets in the way of me doing physical activities. (S10, Pos. 258)
	Physical complaints	I noticed that sometimes just my hands just get numb. It hurts a bit with the wrist if I use it too much. (S27, Pos. 547)
	Negative effects on meals/eating	It affects my meals because if I stay up too late at night. Then I maybe I grab a snack. And when I wake up in the morning, I don't have an appetite. So it happens that I'm not in the mood to eat sometimes. Maybe it's because of my smartphone use. (S27, Pos. 487)
	Negative effects on sleep	Interviewee: I don't get enough sleep because of my phone use. Interviewer: Like how many hours? Interviewee: Like 5, 6. (S10, Pos. 341-346)
Negative effects on hobbies	More time on smartphone, and then less time for other hobbies	I think that some hobbies I forgot about them right there, I don't call them hobbies anymore because of my smartphone. (S18, Pos. 192)
	Smartphone use is easier than other hobbies	I think yes, it's much harder to read books, it's much harder to play a guitar, it's much harder to do anything, which does not instantly evoke this as I already explained this, let's say release of serotonin and dopamine, which keeps me going. So, if it requires effort, and browsing your smartphone obviously does not. Then it becomes way harder. (S33, Pos. 292)

Loss of control

Categories	Codes	Examples/Quotes
Use smartphones longer than intended	-	I tried to be, my initial goal is to like to be pragmatic and answer any social things through WhatsApp or Instagram or something like that. And what often happens is there's like little clips from either on Facebook or Instagram, that of people. For instance, dancing, and then I get one and then automatically another one pops up, and then like, nothing has happened, like half an hour's gone. Or 20 minutes or something like that. (S12, Pos. 418)
Failures of control	-	I want to stop myself from checking it. That's the thing. I can't stop myself from checking my smartphone. (S10, Pos. 100)

Coping

Categories	**Codes**	**Examples/Quotes**
Reduce the negative feelings with smartphones	-	When I'm disappointed in my grade, or when I argue with someone or I find some news that is sad, I guess and then I just automatically try to make myself feel better by watching a video or finding something on the internet, that's happier. (S27, Pos. 683)
Get distracted/escape with smartphone when having negative feelings	-	Well, maybe when I feel kind of distressed and unhappy. I use it just to distract myself. And maybe that's mostly it. (S20, Pos. 746)
Seek social connections or support via smartphone when having negative feelings	-	If I'm anxious, I text a lot of my friends to get rid of that anxiousness and tell them what I'm feeling. And then they can give their opinions about that. (S04, Pos. 364)

Tolerance-like symptoms

Categories	Codes	Examples/Quotes
Can't get bored anymore with the smartphone	-	I wish I would be just bored and would just sit there. Maybe I would have gotten some nice ideas. (S22, Pos. 457)
Get bored easily since one has used the smartphone a lot	-	Because your phone lets you do so many things, sometimes when I'm off my phone, it's like, I get bored easily. But then I realized that I'm doing that. And then I'm like, okay, you need to calm down, but it will negatively impact me in that way (S09, Pos. 420)
No excitement about smartphone use	Neutral feelings during smartphone use	It feels like you're not doing anything, it feels like you're not bored, but you're not feeling anything else. And how to describe it. Like there's this empty feeling inside you like, which you're trying to satisfy. It's like drug addiction like you want to chase this high, which does not exist. So that's the best feeling can be explained to. (S33, Pos. 508)
	Neutral feelings after phone use	When I have looked at other people's lives (on my smartphone), I tend to feel a bit empty or something. (S12, Pos. 646)
Use smartphones more than before	Need more time to get comfortable/satisfied	Interviewer: Do you have such a thing that you need to spend more time on it to comfort yourself? Interviewee: Sometimes. Yes. Maybe, but I feel like I should spend less time on it. (S21, Pos. 1075-1078)
	More time spent on smartphone	I think I've been using it a lot more than like, for example, few years ago. (S15, Pos. 1010-1014)

Withdrawal-like symptoms

Categories	**Codes**	**Examples/Quotes**
Withdrawal-like feelings when one cannot get access to smartphones	Strong negative feelings	I'd be really stressed about it and an angry but mostly like annoyed and stressed. (S18, Pos. 404)
	Weak negative feelings	I would feel disappointed. (S26, Pos. 824)
Attempts to avoid/fix the problem when one cannot access smartphones	Try to fix the problem when can't get access to smartphone	I would try to fix it. I would, like, if the Wi Fi isn't working, I will try to fix the router. I would try to talk to people who can solve my problem. I would restart my phone, let's see if it changes anything. (S08, Pos. 667- 672)
	Get prepared before for the situation	When I'm like, when I'm going to holidays. I definitely make sure I have internet. (S25, Pos. 624)
Excessive use when getting smartphones back	-	Interviewer: So how would you feel after being connected again? Interviewee: I would feel like I would need to spend a lot of time to be known to people again, I would need to put a lot of time and effort to be known to people again. (S10, Pos. 684-686)
Positive feelings when getting smartphones back	General positive feelings	Interviewer: So how would you feel after being connected again? Interviewee: Great. If I really needed it, and I'm back on it, then I would feel great, relieved, probably. (S11, Pos. 696-698)
	Positive feelings related with the functions of smartphone	Like finally, I have the liberty to do whatever I want. Would be so good. (S26, Pos. 816)
	Positive feelings related with the social part	Probably relieved, I think, like, Hey, I'm back. So, a lot of people try to reach me and I reach a lot of people. So, if I wouldn't use my phone, a lot of people probably also worry. So, I would feel relieved I guess. (S25, Pos. 616)

Emerging themes related to PSU beyond DSM-5 and ICD-11 addiction criteria

Vital roles of the smartphone in daily life

Categories	Codes	Examples/Quotes
Important role	Important element/ big role in whole life	I think it's one of the main elements of my life. It plays important role for me in my life. (S02, Pos. 1074)
	Important/big part/role in social life	A really big role, because it would be sometimes hard to reach some people without using a smartphone. (S22, Pos. 242)
Emotional attachment role	Emotional-attachment-human-like roles in whole life	It's sort of like I would describe a good friend, but it's with me all the time. It helps me a lot of times (S22, Pos. 879)
	Emotional-attachment-human-like roles in social life	I think it is like my friend in a way. Like I sleep with my smartphone. So literally, it's like, my baby, my best friend. (S10, Pos. 164)
Self-extension role	A part of my life	It's like a part of my life. I think even if I lost my phone, even though I could get a new one, but it's just like my phone that I've been had for four or five years now like I travelled the world with it (S06, Pos. 1008)
	A part of myself	I can't live a day without my phone. And if I have to leave my phone at home and go out, it will be like, a very bad day. Because I'm not used to it but maybe it's not that bad if you're used to spending time without your phone. But for me, I don't think I can do it. And it's kind of important. It's like part of me. (S20, Pos. 1126)
	My everything	I use it as my alarm like calculator, like my everything. If I lost my smartphone, I don't know what I would do, like I would be out of touch with everything probably. (S10, Pos. 128)

Functional role	Help-function-human-like role	My phone is like a secretary. Like, I want to talk to my parent, I use my phone and talk to my parents. Like, I want to be connected with my friends, my phone gets me connected with my friends. I want some entertainment; my phone gives me entertainment. It's like a secretary that you're like oh, I'm hungry. Do you think you could pop out and get me some food? And the secretary like, sure, I'll get you some food. (S09, Pos. 794)
	Convenient/easy life with the functions of smartphone	It's helping me, it's not consuming me. It's helping me become more productive. (S25, Pos. 768)
	A tool	It's like, definitely a key role. But I do think it's just a tool. (S14, Pos. 532)
	Multi-function	I just have everything in one device. So, when I was like a child with MP3 players so that to listen to music. And you had maybe a small phone, like very old Nokia to call somebody. And now you basically have everything in one you can have, you can send emails with it, you can watch things on it, you can communicate, you have your calendars, so you can see all the things, you can write down tasks, I don't really use a notebook to write down tasks, I do that on my smartphone. So, I think the biggest positive impact is the fact that you have everything at one place, and it's easily accessible. (S32, Pos. 172)

Habitual smartphone use

Categories	Codes	Examples/Quotes
Habitual smartphone use	Unconscious behavior	Let's say when I watch a movie, I have this reflex to check my phone. And sometimes I don't even realize that I'm checking my phone. It's like, if you're a smoker, sometimes it happens that you put a cigarette in your mouth, and you light it, but you don't realize that you did it. It's just instinct. You don't even think about it anymore. It's so habitual, that you don't even think about it. (S33, Pos. 312)
	A lot of people do it	A lot of people nowadays just have a reflex. For example, even though they're not using the smartphone when they talk with somebody, they just set it on the table in front of them and kind of play around. It happens. (S31, Pos. 532)
Habitual Apps use	Unconscious behavior	I do think when I'm not really concentrating on it. It's like my fingers automatically know what they're doing. So, I automatically open WhatsApp and also Instagram and reloaded. To see something new popped up, so for like those two apps probably. (S08, Pos. 528)
Control issues related with such habitual use	It's hard to control the behavior when concentrating on other things	Like I say if I'm concentrating and reading a book, it's much harder to inhibit this response as it would like an addictive like behavior. (S33, Pos. 324)
	I couldn't control myself about the habitual behaviors	This is one of the things that I'm not in control of. (S33, Pos. 312)

Disruptive distractions from daily life

Categories	**Codes**	**Examples/Quotes**
General distractions from everyday life	Not present in life	I'll say, usually, when I have nothing to do, I just take my smartphone out and just start scrolling through things with no point. So, it makes me distracted. And I'm less interested in what's present. (S21, Pos. 430)
	Worse ability of concentration	And it breaks my concentration often. And to be able to do something correctly, you have to be in this fully concentrated mode for a while. Let's say shut off your smartphone, it takes a while, takes like an hour or an hour and a half for your brain to actually start getting into this focus mode. So, it distracts me from everything that is my answer. (S33, Pos. 192)
	Too much time on smartphone, less time for other things	Because I spent so much time on it (smartphone). I don't really have the time for other things. (S11, Pos. 240)
	Unmotivated to do anything else	Especially like, for example, when I come home on Mondays and Tuesdays, I come home late because I have a dance class. And then I'm usually home at half past 10 or something, and then I should take a shower, prepare for the next day and maybe read some parts of my book. What I actually do is I come home, I take my coat off, and I look at my smartphone, and then time just flies. And then all of a sudden, it's half past 11. And I'm like okay, I should really get a shower now. So, it's just once I start (to use smartphone), and I'm not motivated to do anything else (S08, Pos. 292)
Distractions from social settings	-	When I'm somewhere with other friends, I will often talk to other friends via my phone. So, I'm not like fully committed to something when I'm doing it. Like I'm not fully there during the conversation or something because I'm too distracted by my phone. (S04, Pos. 177)

Distractions from study	Keep using smartphone when study	I'm constantly thinking about my smartphone when I'm studying. I'm constantly checking. Like, what did I get? What did I get? (S10, Pos. 92)
	Less concentrated/focused on study	Interviewer: So, how does it negatively influence your study? Interviewee: Totally yes, because I can't concentrate as good as without the smartphone. It affects my study negatively. (S19, Pos. 245-252)
	Automatically get distracted during study	I would say during the study. So, I can concentrate on something like on the book, for example. And I just at some point automatically get distracted, just like pick out of my pocket and start using it straight away. (S23, Pos. 56)
Distractions from other hobbies	-	Sometimes when I'm reading a book or something, I just have to look at my phone. So that's really annoying. Because you're reading something interesting. I have this feeling like, oh, I have to check. You know, I check and maybe I have a message and I'm just distracted. So that's that. (S07, Pos. 474)

The possible etiology of PSU based on the experiences of problematic smartphone users

Motives for smartphone use and restrictive motives

Categories	**Codes**	**Examples/Quotes**
Social motives	Communication is the main function of smartphone	So basic the most important (part of smartphone) is communication. (S02, Pos. 94)
	To keep connected/keep in touch with others	For example, when I'm meeting up with a friend, and she's late, that it's positive that she can let me know that she's going to be late. Or when I'm meeting up somewhere in the city that I can text you "Where exactly are you at?" So that I can find her. I think that's like, the most positive things about it. (S11, Pos. 192)
Informational motives	Easy/convenient informational functions	Like, checking information about everything and in every situation and in every place in the world now almost. So I can also travel and I will always have the source of information with me and be updated with about my social life and also make the just the life of the worlds, I don't know how to say, and so the news and everything. (S02, Pos. 296)
	Informational motives for cognitive process	And then usually, it's something I can have an opinion about. I start thinking about it. Or maybe the news, when I read the news, then I learn new stuff. And it may help me to gain new perspective or whatever. (S25, Pos. 304)
	Informational motives for study	For example, we have like Canvas and a timetable, and I have those on my phone so I remember once we were at amusement park, and I forgot to do the weekly assignment and it was Sunday, so I just started doing it while we were having lunch. So having it with me, allows me to keep track again. (S14, Pos. 144)

Emotional motives	Entertainment	So that's basically listen to music. Entertainment kind of certainly saw the tweet the last and I use it the most. (S32, Pos. 686)
	Record happy feelings	When I just feel good maybe I just want to record something on my smartphone, but I don't check messages at all at that moment (S06, Pos. 708)
	Enhance positive feelings	When I'm feeling happy then I'm using it to listen to happy music to make myself even more happy. (S11, Pos. 556)
	Share with others when having positive feelings	Like if I'm happy because something happened and make me happy, then I want to share that with my friends, so I go and text them. (S14, Pos. 376)
	Seek social connections when having negative feelings	If I'm helpless, then I'd like to call my friends or text them to feel like: "Oh, yeah, what should I do in this situation?" That just like kind of gets someone's opinion on it. Or like someone's help. (S04, Pos. 366)
	Enhance negative feelings	If I'm angry I look up like angry music. And like I just kind of make my mood worse. (S04, Pos. 340-342)
	Coping with negative feelings	Bored as well. Like boredom is NO.1 for using smartphone, it's just like it saves you from boredom in some way. (S23, Pos. 600)
Restrictive motives	-	So, I want to like reduce the screen time for my health of my eyes. And I feel just tired. When I look too long for the smartphone, I need to do something else like exercising or something like this. So, I want to have more time for other things. (S02, Pos. 982-986)

Positive consequences of smartphone use on daily life

Categories	Codes	Examples/Quotes
Positive effects on communication/relationships	Smartphone facilitates offline communication/relationships	And social life, for example, also just meet new people in real life, and if you want to establish that connection, then you could add them on Instagram or Facebook. I feel it's a bit more established and that you know each other, rather than just like, oh, we spoke once. (S24, Pos. 156)
	Communication on smartphone is easier, faster, and convenient	My smartphone is makes it easier to, for instance, when you have like a group project with other students, you can just send out an email or make a WhatsApp group chat. And that's really convenient. (S12, Pos. 306)
	Get more prepared for communication via phone	So then when you're texting, you can think more about what you actually want to say. (S04, Pos. 128)
	Feel more comfortable when communicating on phone	It's easier with a smartphone. Especially if you're not familiar with the person. Like, if it's someone that you don't know very well, through texting is easier because there's no awkwardness. (S14, Pos. 104)
	Communication on phone is better for others' sake	I guess, if, in some discussions when you also want to give the other person time to think about their answers. Then communicating through phone or through messages is much better. (S24, Pos. 176)
Positive effects on cognitive process	Solve problems more effectively with information	For instance, when I have to take the tram, or I am on holiday in a country where I don't speak their language. I remember like, back in the day, when you have to take the train there would be like, forth to the station, and you would either have to remember the times or have to write them down somewhere. So, you know what time the train leaves. And now I can just basically half an hour before I go and just see if anything has changed. But so like, how I get from A to B. It takes me less time to solve it. Well, I don't know if it takes me less time. But it's, I don't have to think about it. (S12, Pos.378)
	Facilitates memory	Reminder. And then I don't have to keep thinking about, oh, I have to do that. Because it's there. So, it kind of frees my memory up a little bit. (S05, Pos. 358)
	Facilitate thinking process/good for brain	I feel like insights of information (on smartphone) make me smarter. Even if it's useless information. I was just like, there is useful and useless info. So, I feel any type of info makes me smarter in a way that like, I'm just like, more knowledgeable. And I really value it. (S23, Pos. 300)

Positive effects on mental health	Relaxing/soothing effects of smartphone	Apart from that, I think it's a very nice break between what I'm doing, because it (smartphone) offers me entertainment without the commitment. Like the fact that it allows me to stop it so easily. It's very important for me. (S26, Pos. 456)
	Keep in touch/connected with people/communicate better	The biggest positive thing is that I can be in touch with my friends, people from my country, I didn't look at it that way when I lived home, it was important but now I think there's like this huge benefit and it makes everything easier to communicate with others and to do everything. (S18, Pos. 104)
	Accessibility to support system	When I'm sad, for example, like when I had a bad day or I'm frustrated, then I can call my friends or my parents. And they can cheer me up again. So that's a good thing (for my mental health). (S11, Pos. 208)
Positive effects on physical health	Positive effects on sleep	But at the same time, they have this like tools as Apps for meditation, you know, the ones you can turn on and try to fall asleep. (S23, Pos. 324)
	Positive effects on meals and weight	I think like, the biggest thing for me is that I could easily get to a healthier weight because of my smartphone. Because I was just like, looking at my phone, oh, I need to eat this and these more calories. And that made me a lot healthier because I was too skinny. (S04, Pos. 142)
	Get health information	Well, if I'm sick, I can just look up treatment and what to do. Sometimes it's going to be a bit, the response is going to be a bit extreme and maybe false. But most of the time, there's very good information that you can use. (S24, Pos. 216)
	Track health data	But I used a fitness tracker, water tracker, like, how many cups of water are needed blah, blah. So that in that sense, it would help body health. (S09, Pos. 342)
	Encouragement and materials for exercise/workout	I have this running app on my phone and like it keeps giving me push up notification to go running. So I guess this is good for my physical health (S06, Pos.252)
	Don't need to carry lots of devices	I said before, like that combines everything, so that's extremely useful for me I don't have to carry lots of devices and stuff. Because men, we don't really have bags to throw in everything. (S26, Pos. 464)
	Make my body more flexible	Hand-eye, like hand and eye coordination. Because when you when you learn to type things faster, you might develop better hand reflexes. (S31, Pos. 307-312)

Positive effects on study	General positive effects of smartphone on study	No, no, I think it just helps me. So, I wouldn't say it (smartphone) has a negative influence. (S25, Pos. 328)
	Positive effects on study efficiency	Because of my phone, I'm really aware of the time. Because you check it like constantly, you know what time it is and how long you spend something on the studying or not. And that's why it's good. (S07, Pos. 364)
	Positive effects on academic performance	Interviewer: You will get answers from your phone? Interviewee: From a friend, yeah, who's really good at the subject that we're doing right now or something, so I think it just positively affects my (academic performance) (S06, Pos. 365-368)
Positive effects on hobbies	Have new hobbies on smartphone instead of the old hobbies	It's just shift. It doesn't mean I'm not interested in other things anymore, but I just like maybe new things (S22, Pos. 405)
	Smartphone helps with my existing hobbies	Because I really like dancing and music. And I think my smartphone just motivates me to do more, because it shows me the videos of dancers, or I see videos of musicians making music that just motivates me to keep doing it instead of the other way around. (S08, Pos. 396)

The trade-offprocess for smartphone use

Categories	Codes	Examples/Quotes
I can control my smartphone use when I realize its negative effects	-	I don't have anything that I want to restrict. As I said, if I want to restrict it, I will. I wanted to use Snapchat less, I just deleted it. So, I'm aware of what I want to restrict, and then I just do it. I just, it's not hard. (S25, Pos. 700)
I don't restrict my smartphone use though I'm aware of its negative effects	-	I've tried to restrict it, not really, just like a personal challenge, I guess. I'm clearly wasting time on it, but I'm like, I've never felt like it actually affected my life in any way. So, it was like I'm wasting time, but I probably would be wasting it some other way. So, it doesn't really matter, like I'm not taking time away from study. I'm taking time away from watching a TV show or something like that. So, it doesn't really matter if I'm on my phone or not. (S14, Pos. 456)
I don't think my smartphone has negative effects on me	-	Personally, I don't regard myself as an addict. I need it (my smartphone) for my professional life. If I would have other means to do the things and arrange things, I would use that too, but it's just convenient and fast and is the fastest option there is to use a smartphone. (S03, Pos. 618)
I can't give up my smartphone completely	-	I think I wouldn't be able to give up my smartphone use. (S23, Pos. 982)
My smartphone is generally positive	It makes life easier	Well, because it does make life easier. And for me, it's also a nice way to communicate with my friends. And what I also do is when I don't really feel that good, I tend to look at my phone, and then I will be very distracted. So I think that's like the main reasons. (S12, Pos. 446)
	The multi-functionality	For example, like I said there's an alarm clock and it has a calculator, Google Maps, maybe work email, we can even like do art on your smartphone you can have a hobby on your smartphone so I think yeah it's just more positive than negative (S06, Pos. 492-493)
	My smartphone could bring pleasures for me	I think pleasure from checking things and being updated and everything. So this is a bit kind of rewards for me, I do some hard task, and then I can relax using my smartphone. (S02, Pos. 460)
	It is a necessity	I still use it because as I said it's kind of necessary. (S03, Pos. 326)
My smartphone has more positive effects than negative effects	-	I think it (my smartphone) is still more positive than negative. (S22, Pos. 429)

The role of perceived social norms

Categories	Codes	Examples/Quotes
Others' evaluations of one's smartphone use		
Others said I'm "addicted" to my smartphone	-	My mom always said like you were addicted to your phone, I will say no, no. But actually I am. (S10, Pos. 790)
Others think I use my smartphone too much	-	But for my boyfriend because I've known him for like six years now. And I tend to use it more often. And he is someone who, I think he uses his phone for like half an hour the max, so very little. So he thinks I use it a lot (S12, Pos. 718)
Others, mainly my friends think my smartphone use is okay	-	I think my friends think that I use it a little less than average. (S12, Pos. 718)
One's evaluation of their smartphone use		
I don't use my smartphone more than the average	-	Interviewer: Do you think you spend more time on your smartphone than other people around you? Interviewee: No, not of my own age. (S07, Pos. 1087-1090)
I use my smartphone as much as the average	-	Interviewer: Okay, so do you think you spend more time on your phone than other people around you? Interviewee: I think I spend the same amount of time. (S18, Pos. 513-516)
I use my smartphone more than the average	-	Definitely more than average, definitely more than my family or something like this. But like in my like peer group? I think everyone. Yeah, maybe I am a bit above that for that definitely. (S02, Pos. 1042)
I use my smartphone less than the average	-	But in general, when I see all my friends, they definitely use it more or it seems that way. But I'm sure there is this bias that everyone thinks that they are not as bad as others. (S24, Pos. 574)

Supplementary material of Chapter 4

Content:

Figure S4.16. *The estimation of significant differences between edge weights and bootstrapped (nboots=100) confidence intervals of edge weights for the network modeling (Fig 1.) with the university community sample (N=292)*

Figure S4.17. *Stability test with bootstrapping (nboots=2000) for network modeling with students sample (Fig 2.) with the general population sample (N=397)*

Figure S4.18. *The centrality indices for the network modeling (Fig 2.) with the general population sample (N=397)*

Figure S4.19. *The bridge centrality indices for the network modeling (Fig 2.) with the general population sample (N=397)*

Figure S4.20. *The estimation of significant differences between edge weights and bootstrapped (nboots=100) confidence intervals of edge weights for the network modeling (Fig 2.) with the general population sample (N=397)*

Table S4.1 Questionnaires and scales for measuring problematic smartphone use (PSU)

Paper title	Questionnaire name	Authors	Sources of items	Students or general population	Item format	Are the calculations based on the polychoric correlation matrix	EFA or CFA?	Sample Size	Factors	Fit indexes based on CFA	Internal consistencies: Cronbach's α or McDonald's ω?	External validities or correlates
Psychological Predictors of Problem Mobile Phone Use	Mobile Phone Problem Use Scale (MPPUS)	Bianchi & Phillips (2005)	Literatures related to addiction and questions related with the social side of mobile phone use	University students and the general population (aged 18-85 years)	From 1 ("not true at all") to 10 ("extremely true"), 27 items	No	-	195	Tolerance, escape from other problems, withdrawal, craving, and negative life consequences in the areas of social, familial, work, and financial difficulties, loss of control over the amount of mobile phone usage and time spent on mobile phone–related activities, social motivational aspects of mobile phone use	-	Cronbach's α of the whole scale= 0.93	MMPI-2 Addiction Potential Scale, Coopersmith Self Esteem Inventory, Eysenck Personality Questionnaire—Revised Short Scale, and mobile phone usage including social calls, business calls, and other features
Problematic internet and cell-phone use: Psychological, behavioral, and health correlates	Cell-Phone Over-Use Scale (COS)	Jenaro et al. (2007)	Seven of the ten pathological gambling criteria in DSM–IV	College students (aged 18-32 years) in Spain	From 1(''Never '') to 6 (''Always ''), 23 items	No	-	337	-	-	Cronbach's α of the whole scale= 0.87	anxiety measured by BAI, depression measured by BDI, and other psychiatric disorders measured by GHQ-28
The Role of Impulsivity in Actual and Problematic Use of the Mobile Phone	Problematic Mobile Phone Use Questionnaire (PMPUQ)	Billieux et al. (2008)	Previous studies, for example Bianchi & Phillips (2005), Billieux et al. (2007)	Young adults (aged 20-35 years) from the community	From 1 ("I strongly agree") to 4 ("I strongly disagree"), 30	No	EFA and CFA	339	dangerous/prohibited use, financial problems and dependence-related symptoms	$\chi^2(399) = 1093.78$, RMSEA= 0.072, AIC=12205.78,BIC =1862.81	Cronbach's α values: dangerous use = 0.65, prohibited use = 0.73, financial problems =	impulsivity measured by UPPS., and the number and duration of phone calls, number of

					items						0.85, dependence = 0.84	SMSs sent per day
Characteristics of excessive cellular phone use in Korean adolescents	Excessive Cellular Phone Use Survey (ECPUS)	Ha et al. (2008)	Clinical experience and hypothesis from the authors	Technical high school students (aged 15.9±0.8 years) in South Korea	-	No	-	595	control difficulty, a persistent need for connection with others, and specific communication patterns via cellular phone	-	Cronbach's α of the whole scale= 0.87	Beck Depression Inventory (BDI), Toronto Alexithymia Scale (TAS-20), Interactional Anxiousness Scale, Rosenberg Self-Esteem Scale, and Young's Internet Addiction Scale (IAS)
Leisure boredom, sensation seeking, self-esteem, addiction	Mobile Phone Addiction Index (MPAI)	Leung (2008)	The Phone Problem Use Scale (MPPUS) developed by Bianchi & Phillips (2005) and the diagnostic criteria of pathological gambling from Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)	Teenagers and young adults (aged 14-28 years) in Hong Kong	From 1("not at all") to 5("always"), 27 items	No	EFA	624	inability to control craving, anxiety and feeling lost, withdrawal and escape, productivity loss	-	Cronbach's α values: inability to control craving = 0.78, anxiety and feeling lost = 0.76, withdrawal and escape = 0.81, productivity loss = 0.79	Leisure Boredom, Sensation-seeking, Self-esteem, Mobile Phone Call Usage, and Features Use
Symptoms of problematic cellular phone use, functional impairment and its association with depression	Problem Cellular Phone Use Questionnaire (PCPU-Q)	Yen et al. (2009)	The taxonomies of substance use dependence on the DSM-IV-TR	Junior high and senior high/vocational schools students (aged 12-19 years) in	Yes or no,12 items	No	-	10191	Symptoms of problematic cellular phone use including tolerance, withdrawal, cellular phone	-	Cronbach's α of the whole scale= 0.854	Depression measured by Center for Epidemiological Studies' Depression Scale (CES-

among adolescents in Southern Taiwan				Southern Taiwan					use longer than intention, persistent desire and/or unsuccessful attempts to cut down or reduce cellular phone use, excessive time spent on cellular phone use or excessive effort spent on activities necessary to obtain cellular phone, giving up or reducing important social, academic, or recreational activities because of cellular phone use and continued heavy cellular phone use despite knowledge of having a persistent or recurrent physical or psychological problem likely to have been caused or exacerbated by cellular phone use Functional impairment caused by cellular phone use including poor relationship with friends or			D)

									classmates, poor academic performance, poor relationship with family members, compromised physical or psychological function and problems in financial affairs			
Needing to connect: The effect of self and others on young people's involvement with their mobile phones	Mobile Phone Involvement Questionnaire (MPIQ)	Walsh et al. (2010)	Previous research on mobile phone, especially the framework of Brown's (1993, 1997) behavioral addiction components including cognitive and behavioral salience, interpersonal and other activities conflict, relief/euphoria, loss of control/ tolerance, withdrawal, relapse and reinstatement	Australian youths (aged 15-24 years)	From 1 (strongly disagree) to 7 (strongly agree), 8 items	No	EFA	946	Cognitive salience, behavioral salience, interpersonal conflict, conflict with other activities, euphoria, loss of control, withdrawal, relapses and reinstatement	-	Cronbach's α of the whole scale= 0.78	Mobile phone use frequency, self-identity, and validation from others
Problematic mobile phone use in adolescence: a cross-sectional study	Mobile Addiction Test (MAT)	Martinotti et al. (2011)	Self-developed questionnaire from Italian authors to assess problematic	High school students (aged 15-24 years) in southern Italy	A (1 point), B (2 points), C (3 points), 10 items	No	-	2790	-	-	-	South Oaks Gambling Screen-Revised for Adolescents (SOGS-RA), Compulsive Buying

			mobile phone use									Scale (CBS), Internet Addiction Test (IAT), Work Addiction Risk Test (WART), Exercise Addiction Inventory (EAI)
Mobile-phone addiction in adolescence: the test of mobile phone dependence (TMD)	The Test of Mobile Phone Dependence (TMD)	Choliz (2012)	Dependence disorder criteria from Diagnostic and Statistical Manual for Mental Disorders-Fourth Edition-Text Revision (DSM-IV-TR)	Adolescents (aged 12–18 years)	Likert-type scale ranging from 0 (never) to 4 (frequently) for 18 items; Likert-type scale ranging from 0 (completely disagree) to 4 (completely agree for another 28 items	No	EFA	2486	Abstinence, Lack Control/ Problems, Tolerance/ Interference	-	Cronbach's α of the whole scale= 0.94	Basic parameters of mobile-phone use
Development of a problematic mobile phone use scale for Turkish adolescents	Problematic Mobile Phone Use Scale (PMPUS)	Güzeller & Coşguner (2012)	PMPUS developed by Billieux et al. (2008)	Turkish public high school students (EFA: aged 16.12±0.86; CFA: aged 16.01±0.90)	1 (never) to 5 (always); 32 items	No	EFA and CFA	950 in total; EFA:309; CFA:641	interference with negative effect, compulsion/persistence, and withdrawal/tolerance	$\chi^2(126) = 477.23$, GFI=0.97, AGFI=0.90, NFI=0.95, TLI=0.96, CFI=0.97, RMSEA=0.066, SRMR=0.052	Cronbach's α of the whole scale= 0.94	Beck Depression Inventory, UCLA Loneliness Scale

A model of the relationship between psychological characteristics, mobile phone addiction and use of mobile phones by Taiwanese university female students	Mobile Phone Addiction Scale (MPAS)	Hong et al. (2012)	The internet addiction criteria by Young (1998)	Female undergraduate students from three universities in Taiwan	From 1 (‘‘incompletely agreed’’) to 6 (‘‘completely agreed’’), 11 items	No	-	269	(1) Time Management and its Problems (2) Academic Problems in School and its Influence (3) Reality Substitute	-	Cronbach’s α values: the whole scale= 0.8645, Time Management and its Problems = 0.8342, Academic Problems in School and its Influence = 0.8435, Reality Substitute = 0.6712	the most frequently used mobile phone functions, mobile phone usage situation (mobile phone usage time per day, monthly money spent on mobile phone), mobile phone usage behavior (the number of calls per day, daily number of text messages sent), self-esteem, social extroversion and anxiety
Development and Validation of a Smartphone Addiction Scale (SAS)	Smartphone Addiction Scale (SAS)	Kwon, Lee, et al. (2013)	K-scale revised from Kimberly Young’s scale (Kim et al., 2008; Young, 2009) and items describing the features of smartphone	Adults (aged 18-53 years, 26.06±5.96 years) from two companies and two universities in South Korea	From 1 (‘‘strongly disagree’’) to 6 (‘‘strongly agree’’), 33 items	No	EFA	197	daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance	-	Cronbach’s α values: the whole scale= 0.967, daily-life disturbance = 0.858, positive anticipation = 0.913, cyberspace-oriented relationship = 0.876, overuse = 0.825, tolerance = 0.865	Internet addiction measure by K-scale., Y-scale with replacing “Internet’’ with ‘‘smartphone’’, substance dependence and abuse diagnosis of DSMIV.
The Smartphone Addiction Scale: Development and Validation	The short version of Smartphone Addiction Scale (SAS-SV)	Kwon, Kim, et al. (2013)	SAS developed by Kwon, Lee, et al. (2013)	2nd year junior high school students (average age =14.5 years)	From 1 (‘‘strongly disagree’’) to 6 (‘‘strongl	No	-	540	One factor as smartphone addiction	-	Cronbach’s α of the whole scale= 0.91	Smartphone Addiction Proneness Scale (SAPS) and he Korean

of a Short Version for Adolescents				in South Korea	y agree''), 10 items							self-reporting internet addiction scale short-form scale (KS-scale)
Measuring Problematic Mobile Phone Use: Development and Preliminary Psychometric Properties of the PUMP Scale	Problematic Use of Mobile Phones (PUMP) Scale	Merlo et al. (2013)	informal interviews with several self-identified "cell phone addicts" with the first author; (2) the DSM-IV criteria for substance use disorders; (3) existing questionnaires measuring consequences of excessive internet use.	Participants from public locations and university (aged 18-75 years, 29.8±14.1 years)	From 1 ("strongly disagree") to 5 ("strongly agree"), 20 items	No	EFA	244	One factor as Problematic Use of Mobile Phones (PUMP)	-	Cronbach's α of the whole scale= 0.94	Cellular Phone Dependency Tendency Questionnaire (CPDQ), the Cell Phone Use Questionnaire (CUQ), and the self-assessed smartphone use
The validity and reliability of the Turkish version of the smartphone addiction scale-short form for adolescent	The short version of Smartphone Addiction Scale (SAS-SV), the same as Kwon, Kim, et al. (2013)	Akın et al. (2014)	SAS-SV developed by Kwon, Kim, et al. (2013)	high school students (average age=16.2 years)	From 0 ("largely untrue") to 4 ("largely true"), 10 items	No	CFA	312	One factor as smartphone addiction	$\chi^2(31)$ = 56.92, RMSEA= 0.052, NFI= 0.96, CFI= 0.98, IFI= 0.98, RFI= 0.94, GFI= 0.96, and SRMR= .040	The internal consistency coefficient of the whole scale= 0.88	Smartphone Addiction Proneness Scale (SAPS), The Korean self-reporting internet addiction scale short-form (KS-Scale)
Psychometric properties of smartphone addiction questionnaire (SPAQ) among sultan qaboos	Smartphone Addiction Questionnaire (SPAQ)	Al-Barashdi et al. (2014)	From previous studies measuring smartphone addiction	undergraduate students aged 18-27 years	17 items	No	EFA	140	Productivity loss, feeling anxious and lost, disregard of harmful consequences, preoccupation,	-	Cronbach's α of the whole scale= 0.764	Level of smartphone usage, level of smartphone addiction symptoms

university undergraduate students									inability to control craving			appearances, smartphone addiction scale (SAS)
The invisible addiction: cell-phone activities and addiction among male and female college students	Manolis/Roberts Cell-Phone Addiction Scale (MRCPAS).	Roberts et al. (2014)	Two items adapted from a cell-phone addiction scale and two self-developed items	College undergraduates in Texas (aged 19-22 years; average age=21 years)	7-liket type response, 4 items	No	CFA	164	One factor as cell-phone addiction	$\chi^2(2) = 18.71$, CFI = 0.94; IFI = 0 .94; BBNFT= 0.93 and RMSEA = 0.02.	Cronbach's α of the whole scale= 0.87	daily engagements with activities on cell-phone
A preliminary investigation into the prevalence and prediction of problematic cell phone use	The Adapted Mobile Phone Use Habits (AMPUH) and The Adapted Cell Phone Addiction Test (ACPAT)	Smetaniuk (2014)	AMPUH: pathological gambling criteria based on pathological gambling in DSM-IV; ACPAT: Internet addiction Test developed by Young (1998)	Study1: undergraduate students (mean age = 21 years, age range: 18–59 years); Study2: working adults (average age = 32, age range: 18–74 years)	AMPUH: yes or no, 10 items; ACPAT: from 1 ("rarely") to 5 ("always"), 20 items	No	-	Study1: 301; Study2: 362	-	-	Cronbach's α of the whole scale= 0.96	Zung's Self-Rating Depression Scale, Emotional Stability Scale, Rosenberg's Self-Esteem Scale, Impulse Control scale, The Mobile Phone Problem Use Scale
Development and Validation of the Smartphone Addiction Inventory (SPAI)	Smartphone Addiction Inventory (SPAI)	Lin et al. (2014)	Chen Internet Addiction Scale (CIAS; S. H. Chen et al., 2003)	Young adults (aged 22.9±2.0 years) of two universities in Northern Taiwan	From 1 ("strongly disagree") to 4 ("strongly agree"), 26 items	No	EFA	283	compulsive behavior, functional impairment, withdrawal and tolerance	-	Cronbach's α values: the whole scale= 0.94, compulsive behavior = 0.87, functional impairment = 0.88, withdrawal = 0.81, tolerance = 0.72	phantom vibration/ringing
Development of Korean Smartphone Addiction Proneness Scale for youth	Smartphone Addiction Proneness Scale (SAPS)	D. Kim et al. (2014)	Previous research about internet/phone addiction and the clinical	Elementary, middle, and high school students in south Korea	From 1 ("strongly disagree") to 4 ("strongly agree"), 15 items	No	CFA	795	Disturbance of adaptive functions, virtual life orientation, withdrawal, and tolerance	NFI=0.943, TLI=0.902, CFI=0.962, RMSEA=	Cronbach's α of the whole scale= 0.880	Mental health problems scale

			experiences from the experts involved in this study							0.034		
Prevalence of Problematic Mobile Phone Use in British Adolescents	Mobile Phone Problem Use Scale for Adolescents (MPPUSA)	Lopez-Fernandez et al. (2014)	MPPUS developed by Bianchi & Phillips (2005)	Secondary school pupils aged between 11 and 18 years (young adolescents, 11–14 years, and older adolescents, 15–18 years) in London, UK	From 1 (‘totally false”) to 10 (“completely true”), 26 items	No	EFA	1026	Tolerance, escape from problems, withdrawal, craving, negative consequences, social motivational	-	Cronbach’s α of the whole scale= 0.97	Mobile phone use
Validation of a Malay Version of the Smartphone Addiction Scale among Medical Students in Malaysia	Malay version of the SAS (SAS-M)	Ching et al., (2015)	SAS developed by Kwon, Lee, et al. (2013)	First- and second-year medical students from Universiti Putra Malaysia	From 1 (‘‘strongly disagree’’) to 6 (‘‘strongly agree’’), 33 items	No	EFA	228	daily-life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance	-	Cronbach’s α values: the whole scale= 0.94, daily-life disturbance = 0.843, positive anticipation = 0.865, cyberspace-oriented relationship = 0.877, overuse = 0.837, primacy = 0.865, withdrawal = 0.861	Internet Addiction Test
Development of a Brief Instrument to Measure Smartphone Addiction Among Nursing Students	Brief Instrument to Measure Smartphone Addiction for Nursing Students	Cho & Lee (2015)	A survey among nursing students, existing literatures and interviews with 6 nursing students who used smartphone over 2 and overused	Nursing school students in south Korea	From 1 (‘‘Never) to 5 (‘‘Always’’), 18 items	No	EFA and CFA	EFA and CFA with the same sample, n=528	Withdrawal, Tolerance, Positive expectancy, Interference with daily routines	$\chi^2(126)$= 441.814, GFI =0.909, AGFI = 0.876, and NFI = 0.907	Cronbach’s α values: the whole scale = 0.902, withdrawal = 0.854, tolerance = 0.793, positive expectancy = 0.793, interference with daily routines = 0.801	Distractions caused by smartphones and opinions about smartphone use policies

			smartphone									
Problematic mobile phone use in adolescents: derivation of a short scale MPPUS-10	The shortened scale of Mobile Phone Problem Use Scale (MPPUS-10)	Foerster et al. (2015)	Mobile Phone Problem Use Scale developed by Bianchi & Phillips (2005)	7th, 8th and 9th grade students (aged 12–17 years) attending secondary schools in Central Switzerland	From 1 (‘‘not true at all’’) to 10 (‘‘extremely true’’), 10 items	No	EFA	First time: 377; Follow-up:378	Loss of Control, Withdrawal, Negative Life Consequences and Craving, Peer Dependence	-	Cronbach’s α of the whole scale = 0.85	Objective mobile phone use traffic data, and original Mobile Phone Problem Use Scale (MPPUS-27)
Exploring smartphone addiction: insights from long-term telemetric behavioral measures	Smartphone Addiction Measurement Instrument (SAMI)	Tossell et al. (2015)	Cellular Phone Addiction Scale (Koo, 2009) and Internet Addiction Test (Young, 1998)	10 community college students and 24 major university students	From never (1) to always (5), 15 items	No	--	34	One factor as smartphone addiction	-	-	Objective mobile phone use data
Exploring the dimensions of nomophobia: Development and validation of a self-reported questionnaire	Nomophobia Questionnaire (NMP-Q)	Yildirim & Correia (2015)	Interviews with nine undergraduate students who had smartphone use problems identified by Test of Mobile Phone Dependence (TMD; Choliz, 2012)	Undergraduate students (mean age = 20 years) from a Midwestern university in the U.S	From 1 (‘‘strongly disagree’’) to 7 (‘‘strongly agree’’), 20 items	No	EFA	301	Not being able to communicate, losing connectedness, not being able to access information, and giving up convenience.	-	Cronbach’s α values: whole scale = 0.945, not being able to communicate = 0.939, losing connectedness = 0.874, not being able to access information = 0.827, giving up convenience = 0.814	Mobile Phone Involvement Questionnaire (MPIQ)
A growing fear: Prevalence of nomophobia among Turkish college students	Nomophobia Questionnaire (NMP-Q)	Yildirim et al. (2016)	Nomophobia Questionnaire (NMP-Q) developed by Yildirim & Correia (2015)	College students (aged 20.02±1.65 years) at a public university in Turkey	From 1 (‘‘strongly disagree’’) to 7 (‘‘strongly agree’’), 20 items	No	-	537	Not being able to communicate, losing connectedness, not being able to access information, and giving up convenience.	-	Cronbach’s α values: the whole scale = 0.92, not being able to communicate = 0.90, losing connectedness = 0.74, not being able to access	Duration of mobile phone and smartphone ownership

											information = 0.94, giving up convenience = 0.91.	
Smartphone Addiction Inventory (SPAI): Psychometric properties and confirmatory factor analysis	Smartphone Addiction Inventory - Italian (SPAI-I)	Pavia et al. (2016)	Smartphone Addiction Inventory (SPAI) developed by Lin et al. (2014)	College students (aged 20.02±1.65 years) at a public university in Italy	From 1 (strongly disagree) to 4 (strongly agree), 26 items	No	CFA	485	Functional Impairment, Withdrawal, Compulsive Behavior and Tolerance	$\chi^2(44)=2303.40$, CFI = 0.87, TLI = 0.95, RMSEA = 0.07; WRMW = 1.28	Cronbach's α values: the whole scale = 0.90, Time Spent = 0.73, Compulsivity = 0.70, Daily Life Interference = 0.74, Craving = 0.75, Sleep Interference = 0.81.	Internet Addiction Test (IAT)
Smartphone addiction among university students in the light of some variables	a smartphone addiction questionnaire	Aljomaa et al. (2016)	Previous literatures and questionnaires relevant to this topic	Students using smartphones and attending one University in Saudi Arabia	From 1 ("never or almost never true of me") to 5 ("always or almost always true of me"), 80 items	No	-	416	overuse of smartphone, the technological dimension, the psychological social dimension, preoccupation with smartphones, and the health dimension	-	Cronbach's α of the whole scale = 0.97, Cronbach's α of five dimensions ranged from 0.84 to 0.94	Gender, social status, educational level, hours of daily use, monthly income
Development of a Brief Multicultural Version of the Test of Mobile Phone Dependence (TMDbrief) Questionnaire	Test of Mobile Phone Dependence-Brief (TMDbrief)	Chóliz et al. (2016)	The test of mobile phone dependence (TMD) developed by Choliz (2012)	Graduate or postgraduate students (aged 18-27 years) from six regions: Southern Europe, Northwest Europe, South-America, Mesoamerica, Pakistan, and India	From 0 (completely disagree) to 4 (completely agree), 12 items	No	EFA	2028	Abstinence, Abuse and interference with other activities, Tolerance and Lack of control	-	Cronbach's α values: Abstinence = 0.81, Abuse and interference with other activities = 0.70, Tolerance = 0.75, Lack of control = 0.64.	Gender
Development and psychometric validation of the Brief Smartphone Addiction Scale	Brief Smartphone Addiction Scale (BSAS)	Csibi et al. (2016)	The 'components' model of addiction proposed by (Griffiths, 2005)	Hungarian speaking schoolchildren aged 13.4± 2.22 years	6-point agree-disagree Likert scale, 6 items	No	EFA	441	One single factor of smartphone addiction	-	Cronbach's α of the whole scale = 0.82	Smartphone Addiction Inventory (SPAI; Lin et al., 2014)

(BSAS) with schoolchildren												
Development and validation of the mobile addiction scale: the components model approach	Mobile Addiction Scale (MAS)	Fidan (2016)	Previous relevant questionnaires and the components model proposed by Brown (1986) and Griffiths (1995)	Most pf the participants aged 15-45 years and lived in city-center the towns of Turkey	-	No	EFA and CFA	284	withdrawal, relapse, tolerance, and salience	χ^2/df = 3.215, CFI = 0.916, RMR=0.078, GFI = 0.918, NFI = 0.905 and RMSEA = 0.088	Cronbach's α of the whole scale = 0.910	-
Development of a Problematic Mobile Phone Use Scale for university students: Validity and reliability study	Problematic Mobile Phone Use Scale (PMPUS)	Pamuk & Atli (2016)	The previous relevant papers, university students' answers for the open-ended questions on smartphone use and the criteria for substance use disorder and internet gaming disorder in the DSM V	Students from a University in Turkey	From 1 ("Not at all appropriate") to 5 ("Completely appropriate"), 26 items	No	EFA and CFA	725 in total; EFA:362; CFA:363	Deprivation, Adverse outcomes, Control problem, Interaction avoidance	GFI = 0.91, AGFI = 0.89, CFI=0.96, TLI = 0.95, RMSEA = 0.044, SRMR = 0.0419	Cronbach's α of the whole scale = 0.94	Mobile Phone Problem Use Scale (MPPUS)
Developing a shorter version of the Estonian smartphone addiction proneness scale (E-SAPS18)	Estonian smartphone addiction proneness scale (E-SAPS18)	Rozgonjuk et al. (2016)	SAS developed by Kwon, Lee, et al. (2013)	Adults (aged 18-71 years, mean age=26.10± 6.73 years) from social media posts and university mailing lists	From 1 (''strongly disagree'') to 6 (''strongly agree''), 18 items	No	EFA and CFA	767 in total; EFA:427; CFA:340	Tolerance, positive anticipation, cyberspace-oriented relationships, withdrawal and physical symptoms	$\chi^2(125)$ = 269, RMSEA = 0.058, CFI=0.93, SRMR = 0.056	Cronbach's α of the whole scale = 0.87, Cronbach's α of the five factors ranged from 0.68 to 0.82.	The Estonian Internet Addiction Test, and the Visual Analogue Scale measuring subjective severity of smartphone addiction
Development of a mobile phone addiction craving scale and its	Mobile Phone Addiction Craving Scale	De-Sola et al. (2017)	The Spanish scale of cocaine craving developed	Participants aged 16-65 years, , mean	From 1 (not at all true) to 10 (complete	No	EFA and CFA	1126	One factor as mobile phone addiction craving	CFI = 0.939, RMSEA = 0.124,SRMR = 0.	Cronbach's α of the whole scale = 0.919	The state anxiety of the State-Trait Anxiety

validation in a Spanish adult population	(MPACS)			age=32.8± 11.67 years in Spain	ly true), 8 items					040		Inventory, problematic cell phone use measured by MPPUS and impulsivity measured UPPS-P by, including the urgency, premeditation, perseverance, and sensation seeking scales
An investigation into problematic smartphone use: The role of narcissism, anxiety, and personality factors	Problematic Smartphone Use Scale	Hussain et al. (2017)	Modified DSM-5 criteria of Internet Gaming Disorder and the Internet Gaming Disorder Scale Short-Form (IGDS9-SF) developed by Pontes & Griffiths (2014, 2015)	Smartphone users aged 13-69 years, mean age= 24.89 ±8.54 years	From 1 (‘‘strongly disagree’’) to 5 (‘‘strongly agree’’), 9 items	No	-	640	One factor as problematic smartphone use	-	Cronbach’s α of the whole scale = 0.86	Narcissism measured by the Narcissistic Personality Inventory, anxiety measured by the Narcissistic Personality Inventory, and personality factors measured by the Ten-Item Personality Inventory
Assessment of the accuracy of a new tool for the screening of smartphone addiction	The Brazilian version SPAI (SPAI-BR)	Khoury et al. (2017)	Smartphone Addiction Inventory (SPAI) developed by Lin et al. (2014)	Undergraduate students in Brazil	From 1 (“strongly disagree”) to 4 (“strongly agree”), 26 items	No	CFA	415	Compulsive behavior, functional impairment, withdrawal syndrome and tolerance syndrome	$\chi^2(293)$ = 767.861, CFI =0.913, TLI =0.905, RMSE =0.061, WRMR =1.465	The Kuder-Richardson Coefficient of the whole scale = 0.887	Addictions criteria proposed by Goodman (1990)
Development and validation study of the	Smartphone Overuse Screening	Lee et al. (2017)	Previous research about	Participants from six ‘I will center’	4-point scale (Not at all,	No	EFA	158	Preoccupation, loss of control, craving,	-	Cronbach’s α values: the whole scale =	Young's internet addiction

Smartphone Overuse Screening Questionnaire	Questionnaire (SOS-Q)		smartphone/ cell phone related scales, existing criteria, subject interviews	locations in South Korea, mainly adolescents and young adults (mean age=22.12 ± 7.56 years)	Sometimes, Often, or Always). 28 items				insight, overuse, and neglect of other areas		0.95, Preoccupation = 0.886, Loss of control = 0.874, Craving = 0.727, Insight = 0.902, Overuse = 0.630, Neglect = 0.718	scale, Korean scale for internet addiction, and Smartphone Scale for Smartphone Addiction (S-Scale)
Development of short-form and screening cutoff point of the Smartphone Addiction Inventory (SPAI-SF)	Short-Form of Smartphone Addiction Inventory (SPAI-SF)	Lin et al. (2017)	Smartphone Addiction Inventory (SPAI) developed by Lin et al. (2014)	Undergraduate and graduate students (aged 18-31 years, mean age=20.89± 1.58 years) in Taiwan	From 1 (strongly disagree) to 4 (strongly agree), 10 items	No	CFA	268	compulsive behaviors, tolerance, withdrawal, and functional impairment	CFI = 0.97, NFI = 0.94, IFI = 0.97, and RMSEA =0.061	Cronbach's α of the whole scale = 0.84	Self-report time spent on smartphone use and Smartphone Addiction Inventory (SPAI)
Short version of the Smartphone Addiction Scale adapted to Spanish and French: Towards a cross-cultural research in problematic mobile phone use	The short version of Smartphone Addiction Scale (SAS-SV)	Lopez-Fernandez, (2017)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Adults in Spain (aged 18-68 years, mean age=25.61± 11.65 years) and adults in Belgium (aged 18-73 years, mean age=29.111± 15.33 years)	From 1 (''strongly disagree'') to 6 (''strongly agree''), 10 items	No	EFA	Spanish adults: 281 Belgian adults: 144	One factor as smartphone addiction	-	Cronbach's α values: the whole scale for Spain = 0.88, the whole scale for Belgium = 0.90	-
Addiction-like Behavior Associated with Mobile Phone Usage among Medical Students in Delhi	Mobile Phone Addiction Scale (MPAS)	Basu et al. (2018)	Self-administered questionnaire by the authors	Undergraduate medical students in India (aged 18-68 years, mean age=20.48± 11.65 years)	From 1 (''strongly disagree'') to 6 (''strongly agree''), 20 items	No	EFA	388	Intense desire, impaired control, withdrawal, tolerance, decreased interest in alternate pleasures, and harmful use	-	Cronbach's α of the whole scale = 0.90	-
The Psychometric Properties of the Smartphone Application-Based Addiction Scale (SABAS)	Smartphone Application-Based Addiction Scale (SABAS)	Csibi et al., (2018)	The Smartphone Application-Based Addiction Scale (SABAS) developed	English-speaking adults (aged 18-69 years, mean age=25.4 years)	From 1 (''strongly disagree'') to 6 (''strongly agree''),	No	EFA	240	A single factor as Smartphone Application-Based Addiction	-	Cronbach's α of the whole scale = 0.81	SABAS, the NMP-Q, the Brief Sensation Seeking Scale, the Deprivation Sensation

			by Csibi		6 items							Scale, and the Patient Health Questionnaire Depression Scale
Smartphone Restriction and Its Effect on Subjective Withdrawal Related Scores	Smartphone Withdrawal Scale (SWS)	Eide et al. (2018)	Cigarette Withdrawal Scale (CWS) developed by Etter (2005)	Participants aged 18-48 years (mean age=25± 4.5 years), 79.5% of the sample were full-time students attending higher education in Bergen	From 1 (totally disagree) to 5 (totally agree), 15 items	No	-	127	Depression-Anxiety, Craving, Irritability-Impatience, Difficulty Concentrating	-	Cronbach's α of the whole scale ranged from 0.88 to 0.92	the Fear of Missing Out Scale (FoMOS) and the Positive and Negative Affect Schedule (PANAS)
Problematic Smartphone Use: Investigating Contemporary Experiences Using a Convergent Design	Problematic Mobile Phone Use Questionnaire-Revised (PMPU-Q-R)	Kuss et al. (2018)	PMPUQ developed by Billieux et al. (2008)	Participants aged 13-68 years (mean age=25.5 years)	From 1 (strongly disagree) to 4 (strongly agree), 17 items	No	EFA and CFA	512	Smartphone dependence, dangerous driving, and antisocial smartphone use factors	$\chi^2(101) = 190.424$, CFI = 0.927, TLI = 0.906, RMSEA = 0.062, SRMR = 0.054	Cronbach's α of the whole scale = 0.88	Smartphone Addiction Scale (SAS), Social Media Disorder Scale (SMD), psychopathological symptoms including depression, anxiety, stress (measured by Depression-Anxiety-Stress Scale, DASS-21), and ADHD symptoms, impulsivity measure by short form of the Barratt Impulsiveness Scale (BIS-15), and the big

												five personality traits (i.e., neuroticism, extraversion, conscientiousness, agreeableness and openness)
Measurement Invariance of the Short Version of the Problematic Mobile Phone Use Questionnaire (PMPUQ-SV) across Eight Languages	Short Version of the Problematic Mobile Phone Use Questionnaire (PMPUQ-SV)	Lopez-Fernandez et al. (2018)	PMPUQ developed by Billieux et al. (2008)	Participants from eight European countries, mean age=26.505 ±9.395 years	From 1 (‘I strongly agree’) to 4 (‘I strongly disagree’), 15 items	Polychoric method was used in CFA	Multigroup CFA	3038	Dangerous, prohibited, and dependent use	$\chi^2(87)$ = 1858.371, CFI = 0.947, TLI = 0.936, RMSEA = 0.082, SRMR = 0.074	Cronbach’s α of the Dangerous use ranged from 0.77 to 0.90, Cronbach’s α of the Dangerous use ranged from 0.56 to 0.75, Cronbach’s α of the Dangerous use ranged from 0.82 to 0.90.	-
Short version of the Smartphone Addiction Scale in Chinese adults: Psychometric properties, sociodemographic, and health behavioral correlates	The short version of Smartphone Addiction Scale (SAS-SV)	Luk et al. (2018)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Participants (aged 18–96 years, mean age=43.3 ±15.7 years) in Hong Kong	From 1 (‘‘strongly disagree’’) to 6 (‘‘strongly agree’’), 10 items	No	-	3211	One factor as smartphone addiction	-	Cronbach’s α of the whole scale = 0.844	Sociodemographic factors, health behaviors, and chronic disease status
Validation of a Spanish Questionnaire on Mobile Phone Abuse	The Mobile Phone Abuse Questionnaire (ATeMo)	Olivencia-Carrión et al. (2018)	DSM-5 diagnostic criteria for addiction (American Psychiatric Association, 2013) and craving	Participants (aged 17–45 years, mean age=21.12 ± 3.05 years) Granada, Spain	From 0 (strongly disagree) to 4 (strongly agree), 25 items	Polychoric method was used in CFA	-	856	Craving, loss of control, negative life consequences, and withdrawal syndrome	$\chi^2(265)$ = 274.18, GFI = 0.97, CFI = 1, AGFI = 0.97, NFI= 1, RMSEA = 0.021, SRMR = 0.06	Cronbach’s α values: the whole scale = 0.91, Craving = 0.74, Loss of Control = 0.70, Negative Life Consequences = 0.77, Withdrawal Syndrome = 0.77.	History of drug abuse and addiction behavior measure by the ULTICAGE CAD-4
Reliability of	The Arabic	Sfendla et al.	SAS	Sample 1:	From 1	No	EFA	750 in	Six factors of	-	Cronbach’s α	The short

the Arabic smartphone addiction scale and smartphone addiction scale-short version in two different Moroccan samples	Smartphone Addiction Scale (SAS); The short version of Smartphone Addiction Scale (SAS-SV)	(2018)	developed by Kwon, Lee, et al. (2013); The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	aged 14–64 years, mean age = 27.4 ± 6.4 years); Sample 2: mean age = 23.1 ± 4.6 years)	(''strongly disagree'') to 6 (''strongly agree''), 33 items in SAS; From 1 (''strongly disagree'') to 6 (''strongly agree''), 10 items in SAS-SV			total; Sample 1: 440; Sample 2: 310	SAS: daily life disturbance, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, tolerance; one factor for SAS-SV		values: the whole SAS = 0.94, daily life disturbance = 0.81, positive anticipation = 0.86, withdrawal = 0.84, cyberspace-oriented relationship = 0.83, overuse = 0.78, tolerance = 0.81	version of Smartphone Addiction Scale (SAS-SV)
Psychometric Properties and Demographic Correlates of the Smartphone Addiction Scale-Short Version among Chinese Children and Adolescents in Hong Kong	The short version of Smartphone Addiction Scale (SAS-SV)	Cheung et al. (2019)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Primary school children and secondary school pupils (aged 7-17 years) in Hong Kong	From 1 (''strongly disagree'') to 6 (''strongly agree''), 10 items	No	EFA and CFA	1901	SAS-SV Factor 1: Dependence; SAS-SV Factor 2: Problems; SAS-SV Factor 3: Time spent.	χ^2= 153, CFI = 0.96, TLI = 0.95, RMSEA = 0.06, CR = 0.90, AVE = 0.48	Cronbach's α of the whole scale = 0.86	Time spent on phones per day, the Smart Device Addiction Screening Tool (SDAST), the Pittsburgh Sleep Quality Index (PSQI), the Multidimensional Scale of Perceived Social Support (MSPSS), and the Center for Epidemiological Studies Depression Scale for Children (CES-DC)
Development	Smartphone	Ding et al.	Individual	University	From 1	No	EFA	1296 in	Three subscales	χ^2/df of	Cronbach's α	Young's

Of A Smartphone Overuse Classification Scale	Overuse Classification Scale (SOCS)	(2019)	and focus-group interviews and the experts	students in Shanghai	(‘‘strongly disagree’’) to 5 (‘‘strongly agree’’), 24items		and CFA	total; EFA:849; CFA: 447	including social network app overuse (S-scale), recreational app overuse (R-scale), and information overload (I-scale). Each subscale contains three factors including cognitive disorder, behavioral disorder, and mood disorder.	the three subscales were 2.20, 2.11 and 7.81 for the S-scale, R-scale and I-scale, respectively; the CFI values were 0.97, 0.98 and 0.91; the NFI values were 0.94, 0.97 and 0.89; and the RMSEA values were 0.052, 0.050 and 0.124.	values: the whole scale = 0.849, social network app overuse (S-scale) = 0.813, recreational app overuse (R-scale) = 0.726, information overload (I-scale). = 0.706.	Diagnosis Questionnaire (Young’s DQ) and the demographic information
Reliability and construct validity testing of a questionnaire to assess nomophobia (QANP)	Questionnaire to assess nomophobia (QANP)	Ferri-García & Olivencia-Carrión (2019)	Previous literatures on scales measuring Nomophobia and the views from experts	Participants (aged 17–55 years, mean age=23.19 ± 7.23 years) in Granada, Spain	5 numeric responses, 11 items	No	EFA and CFA	968 in total; 484 for EFA and CFA respectively	Mobile Phone Abuse, Loss of Control, Negative Consequences	GFI = 0.966, TLI = 0.936, RMSEA = 0.055	Cronbach’s α values: the whole scale = 0.80, Mobile Phone Abuse = 0.75, Loss of Control = 0.64, Negative Consequences = 0.57.	-
An urdu adaptation of smartphone addiction scale-short version (SAS-SV)	The short version of Smartphone Addiction Scale (SAS-SV)	Khalily et al. (2019)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Participants (aged 11-30 years) at school schools, colleges and universities within Rawalpindi and Islamabad in Urdu	From 1 (‘‘strongly disagree’’) to 6 (‘‘strongly agree’’), 10 items	No	CFA	348	One factor as smartphone addiction	CFI = 0.95, TLI = 0.93, NFI = 0.92, RMSEA = 0.05	Cronbach’s α of the whole scale = 0.81	-

Metacognitions about problematic Smartphone use: Development of a self-report measure	Metacognitions about Smartphone use Questionnaire (MSUQ)	Casale et al. (2020)	Previous studies relevant to this topic	Participants (aged 15–70 years, mean age = 28.08 ± 9.81 years) in Italy	From 1 (“Do not agree”) to 4 (‘‘Agree very much’’), 24 items	No	EFA and CFA	701 in total; EFA:350; CFA:351	F1 = positive metacognitions about emotional and cognitive regulation (MSUQ – PM ECR); F2 = negative metacognitions about uncontrollability and cognitive harm (MSUQ – NM UH); F3 = positive metacognitions about social advantages (MSUQ – PM SR).	$\chi^2(246) = 661.70$, CFI = 0.95, RMSEA = 0.07, RMR = 0.04	Cronbach’s α values: F1 = 0.91, F2 = 0.85, F3 = 0.74; Composite Reliabilities: F1 = 0.91, F2 = 0.86, F3 = 0.74.	Problematic Smartphone use measured by SAS-SV (Kwon, Kim, et al., 2013), anxiety and depressive symptoms assessed by The Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983)
Development and validation of a Smartphone Impact Scale among healthcare professionals	Smartphone Impact Scale (SIS)	Altamimi et al. (2020)	Previous literatures related to the impacts of smartphone	Participants (most aged 25–45 years, mean age = 40.72 ± 9.10 years) in Saudi	From 1 (‘‘strongly disagree’’) to 5 (‘‘strongly agree’’), 23 items	No	EFA	1436	The extent of smartphone use, and the impact of smartphone use on personal and professional life.	-	Cronbach’s α of the whole scale = 0.91	-
Translation of the Chinese version of the Nomophobia Questionnaire and its validation among college students: Factor analysis	Nomophobia Questionnaire (NMP-Q)	Gao et al. (2020)	Nomophobia Questionnaire (NMP-Q) developed by Yildirim & Correia (2015)	College students (aged 16-25 years) in China	From 1 (‘‘strongly disagree’’) to 7 (‘‘strongly agree’’), 18 items	No	EFA and CFA	2000 in total; EFA:1022; CFA:978	Factor 1: losing connectedness; Factor 2: giving up convenience; Factor 3: not being able to communicate; Factor 4: not being able to access information	$\chi^2/df = 4.967$, GFI = 0.933, AGFI = 0.909, TLI = 0.942, IFI = 0.952, CFI = 0.952, RMSEA = 0.064, SRMR = 0.049	Cronbach’s α values: the whole scale = 0.925, losing connectedness = 0.882, giving up convenience = 0.843, not being able to communicate = 0.895, not being able to access information = 818.	Number of hours of mobile phone use and demographic information
Factor structure and measurement invariance of the problematic	Chinese version of the Problematic Mobile	Wang et al. (2020)	PMPUQ-SV developed by Lopez-Fernandez et al. (2018)	College and University students (aged 14-25 years) in	From 1 (‘‘strongly disagree’’) to 7	No	EFA and CFA	2086 in total; 1043 for EFA and CFA	Dangerous use, perceived dependence, and prohibited use	S-Bχ^2 = 134.716, $df = 41$, P < 0.01; RMSEA	Cronbach’s α of the whole scale = 0.742	Socio-demographic variables, patterns of mobile

mobile phone use questionnaire-short version across gender in Chinese adolescents and young adults	Phone Use Questionnaire-Short Version (C-PMPUQ-SV)			China	(“strongly agree”), 11 items			respectively		= 0.047; CFI = 0.942; TLI = 0.922; SRMR = 0.41		phone use, the Chinese version of the Smartphone Addiction Proneness Scale (C-SAPS), and the Depression Anxiety Stress Scales (DASS-21).
Translation and psychometric evaluation of Smartphone Addiction Scale—Short Version (SAS-SV) among Chinese college students	Smartphone Addition Scale—Chinese Short Version (SAS-CSV)	Zhao et al. (2022)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Chinese college students (most aged 17–24 years, mean age = 20.49 ± 1.398 years)	From 1 (“strongly disagree”) to 6 (“strongly agree”), 10 items	No	CFA	557	Tolerance, withdrawal and negative effect	χ^2/df = 1.883, RMSEA = 0.056, NFI = 0.954, RFI =0.935, IFI =0.978, TLI =0.969, CFI =0.978	Cronbach’s α of sample 1= 0.829, Cronbach’s α of sample 1= 0.881.	-
Psychometric properties of the Smartphone Addiction Inventory-Short Form (SPAI-SF) in Brazilian adolescents	Smartphone Addiction Inventory-Short Form (SPAI-SF)	Andrade et al. (2022)	Smartphone Addiction Inventory-Short Form (SPAI-SF) developed by Lin et al. (2017)	Brazilian adolescents (mean age = 12.76 ± 1.00 years)	10 dichotomous items (0= yes, 1= no)	No	CFA	392	Compulsive behavior, Functional Impairment, Withdrawal, Tolerance	χ^2/df = 1.07, RMSEA = 0.013, TLI =0.996, SRMR =0.037, CFI =0.997	Cronbach’s of the whole scale = 0.722, McDonald’s ω of the whole scale = 0.725.	Smartphone Addiction Scale - Short Version (SAS-SV), Internet Addiction Test (IAT), Depression, Anxiety and Stress Scale (DASS-21)
The Italian version of the mobile phone problematic use scale for adults (MPPUS): A validation study	Mobile Phone Problematic Use Scale for Adults (MPPUS)	Agus et al. (2022)	Mobile Phone Problem Use Scale (MPPUS) developed by Bianchi & Phillips (2005)	Italian adults (aged 18–60 years, mean age = 21.7 ± 6.4 years)	From 1 (“not at all true”) to 5 (“very true”)	No	EFA and CFA	568 in total; EFA:260; CFA:308	Factor 1: Withdrawal and social aspects Factor 2: craving and escape from other problems	χ^2/df = 1.75, RMSEA = 0.05, TLI =0.95, WRMR =0.87, CFI =	The ordinal reliability of factor 1 was 0.87. The ordinal reliability of factor2 was 0.91.	Smartphone Addiction Scale (SAS)

										0.96		
Short version of the smartphone addiction scale: Measurement invariance across gender	The short version of Smartphone Addiction Scale (SAS-SV)	Yue et al. (2023)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Chinese university students (aged 18–25 years, mean age = 20.28 ± 1.43 years)	From 1(strongly disagree) to 6(strongly agree)	Weighted least squares means and variance adjusted (WLSMV) estimator was employed	CFA	1112	One factor as smartphone addiction	χ^2/df = 5.227, RMSEA = 0.062, CFI = 0.985, TLI =0.980, SRMR =0.029	Cronbach's α values: the whole scale = 0.883, male participants = 0.895, female participants = 0.872.	-
Validity, reliability, and correlates of the Smartphone Addiction Scale–Short Version among Japanese adults	The short version of Smartphone Addiction Scale (SAS-SV)	Hamamura et al. (2023)	The short version of Smartphone Addiction Scale (SAS-SV) developed by Kwon, Kim, et al. (2013)	Japanese adults who aged over 20 years old and had smartphone	From 1(strongly disagree) to 6(strongly agree)	-	CFA	Study 1: 99156. Study2: 3419	three-factor structure including Daily-life disturbance, Withdrawal, Others	$\chi^2(19)$ = 419.34, RMSEA = 0.059, CFI = 0.99, TLI =0.97	Cronbach's of the whole scale = 0.88, McDonald's ω of the whole scale = 0.76.	Another measure of PSU The short version of the Smartphone-based Internet Addiction Tendency Scale (SIATS-SV), Smartphone use time, Compulsive Internet Use Scale (CIUS), Internet Gaming Disorder Scale (IGD-9), The Alcohol Use Disorder Identification Test (AUDIT), The Adult ADHD Self-Report Scale-V.1.1 Symptoms Checklist (ASRS-V1.1), The

												Autism-Spectrum Quotient (AQ), Impulsiveness, Big-five personality traits, The Obsessive-Compulsive Inventory (OCI), The Center for Epidemiological Studies Depression (CES-D), The Liebowitz Social Anxiety Scale (LSAS), The State-Trait Anxiety Inventory (STAI)

Table S4.2 The Initial Version of The Smartphone Use Problems Identification Questionnaire (SUPIQ)

Designed Factor	Item	Order in Survey
Impaired Control	I use my smartphone longer than I intend to.	17
	I waste a lot of time on my smartphone.	49
	When I start checking my smartphone, I find it hard to stop.	37
	When I start checking my smartphone, I forget my initial aims of why I check my smartphone and get distracted by other content.	11
	People around me tell me that I use my smartphone too much.	55
	I try to restrict my smartphone use, but I fail to do so.	18
	I automatically unlock my smartphone.	48
	I automatically open apps on my smartphone.	30
	I automatically check my smartphone, even when I just checked it.	31
Preoccupation	I am emotionally attached to my smartphone.	38

	I feel incomplete without my smartphone.	45
	I have illusions (ringing/vibrating/blinking) about getting a new notification on my smartphone when there is nothing.	6
	I have dreams about my smartphone (use).	23
	I do not notice other things around me when I am using my smartphone.	32
Craving	I long for my smartphone when I cannot use it.	34
	I think about my smartphone even when I am not using it	1
	I feel a strong urge to check my smartphone.	2
	I feel a strong need to be available via my smartphone.	35
Escapism/Relief/Coping	I know what to do in my free time without my smartphone. **R**	56
	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).	7
	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.	43
	My smartphone is the solution to my boredom.	20
Negative effects/ Consequences/Risks	I miss planned school/work assignments due to my smartphone use.	24
	My school/work performance is negatively influenced by my smartphone use.	12
	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.	19
	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.	25
	I am distracted from my tasks at home (e.g., cleaning, cooking, household responsibilities, etc.) due to my smartphone use.	9
	I spend less time on hobbies due to my smartphone use.	13
	I cancel/miss in-person social activities with family/friends due to my smartphone use.	51
	I check my smartphone even when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).	57
	I (almost) get into accidents (e.g., driving a car/cycling/walking/crossing the road) due to my smartphone use.	5
	I have physical complaints in some parts of my body (e.g., eyes/head/wrists/ fingers/ back/neck, etc.) due to my smartphone use.	40
	I have sleep problems (e.g., falling asleep, staying asleep, etc.) due to my smartphone use.	47
	I have diet problems (e.g., mindlessly eating more, forgetting to eat) due to my smartphone use.	54
	I have attention problems due to my smartphone use.	36
	I have memory problems due to my smartphone use.	39

	I can solve problems without my smartphone. **R**	8
	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, operating heavy machinery, etc.).	29
Ignorance of Negative Effects/Consequences/Risks	I continue using my smartphone after others ask me not to.	15
	I do not reduce my smartphone use when it negatively influences my personal life (e.g., work, school, family).	52
	I can use my smartphone in traffic (e.g., cycling/walking/crossing the road, etc.) without endangering myself or others.	26
	I use my smartphone in traffic (e.g., cycling/walking/crossing the road, etc.) even though I (almost) get into traffic accidents due to my smartphone use.	53
	I do not reduce my smartphone use when I have physical health risks (e.g., physical problems, sleep problems, diet problems etc.) due to my smartphone use.	4
	I do not reduce my smartphone use when I have cognitive problems (e.g., attention problems, memory problems, etc.) due to my smartphone use.	28
	I use my smartphone in situations where I am not allowed to use it (e.g., cinemas, meetings, etc.).	44
	I hide my smartphone use from others (e.g., family, partner, friend, etc.).	21
	I tell lies about my smartphone use.	16
Tolerance	I need to spend more and more time on my smartphone to satisfy myself.	14
	I feel empty even though I spend a lot of time on my smartphone.	3
	I feel unsatisfied even though I spend a lot of time on my smartphone.	27
	I feel more and more impatient in boring situations due to my smartphone	33
Withdrawal	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).	22
	I feel anxious/nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).	46
	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	42
	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	10
	Even though I am doing unimportant things on my smartphone, I feel angry when I get disturbed by others.	50
	I feel a rush of happiness to get my smartphone back after I could not access it (due to e.g., exams, out of battery, etc.).	41

Note. **R** in the table means the item need to be reversed in calculation (i.e., the negatively worded item).

Figure S4.3 The data screening procedure of the current study

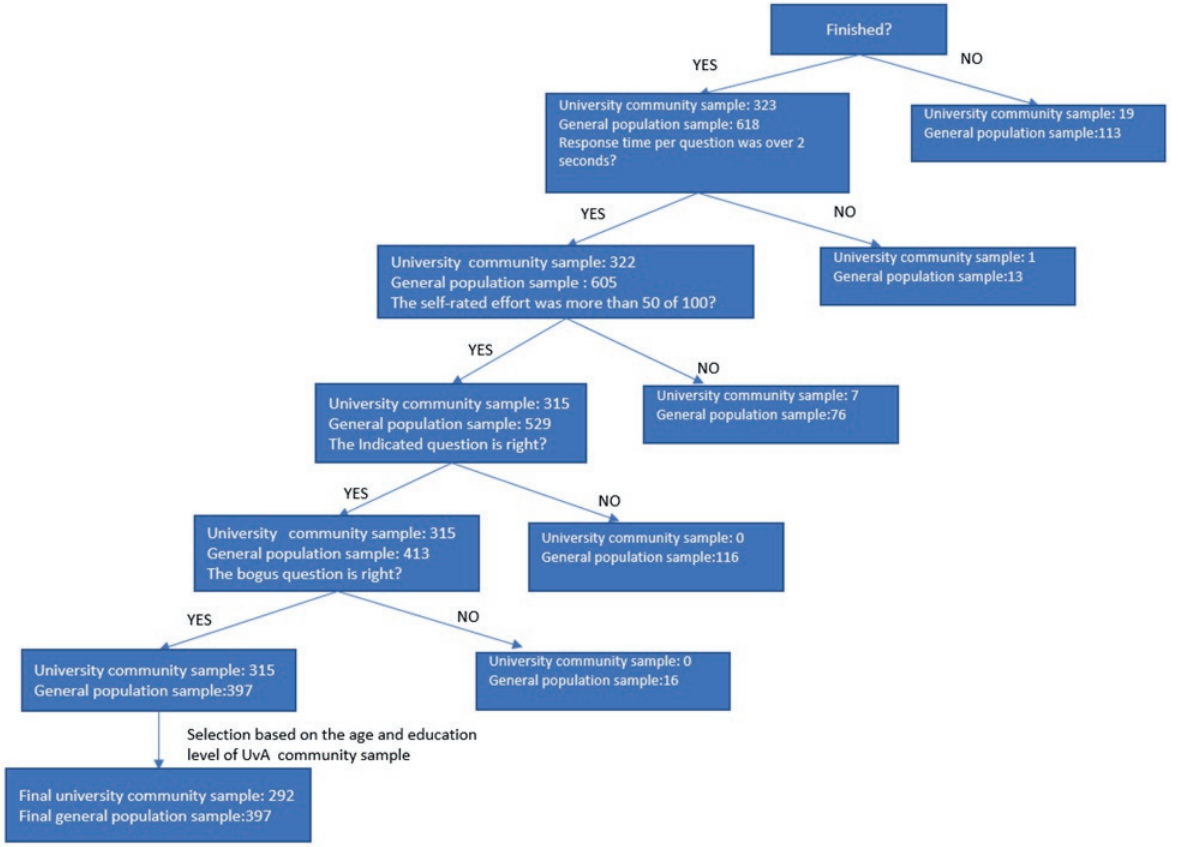


Table S4.4 Factor Loadings of the initial 24 items of SUPIQ based on EFA with the university community sample (N=292)

Final order	Initial order	Item	Factor 1-Craving	Factor 2-Tolerance	Factor 3-Social Conflicts	Factor 4-Coping	Factor 5-Risky Use	Factor 6-Withdrawal	Factor 7-Habitual Use
1	1	I think about my smartphone when I am not using it.	.608						
2	2	I feel a strong urge to check my smartphone.	.627						
3	3	I feel empty even when I spend a lot of time on my smartphone.		.820					
4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.					.822		
5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).				.871			
6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.						.862	
7	15	I continue using my smartphone after others ask me not to.			.537				

8	16	I tell lies about my smartphone use.			.863				
9	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.			.799				
10	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).			.794				
11	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).						.674	
12	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.			.749				
13	26	I can use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) without endangering myself or others.					.540		
14	27	I feel unsatisfied even when I spend a lot of time on my smartphone.		.555					

15	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).					.857		
16	30	I automatically open apps on my smartphone.							.906
17	31	I automatically check my smartphone, even when I just checked it.							.693
18	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.						.763	
19	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.				.525			
20	46	I feel anxious/ nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).						.795	
21	48	I automatically unlock my smartphone.							.875

22	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.					.861		
23	55	People around me tell me that I use my smartphone too much.			.689				
24	57	I check my smartphone when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).							.569

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 24 items, 7 factors. Applied rotation method is oblimin in EFA. Only factor loadings >= .250 were listed in the table. The model fits were good: CFI = .991, TLI = .981, RMSEA = .036, SRMR = .032.

Table S4.5 Factor Loadings of the 27 items based on EFA with the university community sample (N=292)

Final order	Initial order	Item	Factor 1- Craving	Factor 2- Tolerance	Factor 3- Social Conflicts	Factor 4- Risky Use	Factor 5- Withdrawal	Factor 6- Habitual Use	Factor 7- Coping
1	1	I think about my smartphone when I am not using it.	.608						
2	2	I feel a strong urge to check my smartphone.	.627						
3	3	I feel empty even when I spend a lot of time on my smartphone.		.860					

4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.				.824			
5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).							.722
6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.					.853		
7	**14**	**I need to spend more and more time on my smartphone to satisfy myself.**		**.354**	**.285**				
8	15	I continue using my smartphone after others ask me not to.			.536				
9	16	I tell lies about my smartphone use.			.858				
10	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.			.795				
11	**20**	**My smartphone is the solution to my boredom.**						**.309**	**.373**
12	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).			.802				

13	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).					.658		
14	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.			.742				
15	26	I can use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) without endangering myself or others.				.536			
16	27	I feel unsatisfied even when I spend a lot of time on my smartphone.		.544					
17	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).				.855			
18	30	I automatically open apps on my smartphone.						.905	
19	31	I automatically check my smartphone, even when I just checked it.						.680	
20	**35**	**I feel a strong need to be available via my smartphone.**	**.268**				**.306**	**.290**	
21	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.					.760		

22	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.							.648
23	46	I feel anxious/ nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).					.804		
24	48	I automatically unlock my smartphone.						.868	
25	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.				.862			
26	55	People around me tell me that I use my smartphone too much.			.679				
27	57	I check my smartphone when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).						.580	

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 27 items, 7 factors after 3 items have been restored. Applied rotation method is oblimin in EFA. Only factor loadings >= .250 were listed in the table. The model fits were good: CFI = .99 1, TLI = .983, RMSEA = .032, SRMR = .031. The three restored items were marked in bold.

Table S4.6 Item-Total Correlations and Cronbach's α of the 27 items version SUPIQ if single item gets deleted with the university community sample (N=292)

Factor	Final Order	Initial Order	Item	Item-Total Correlation	Corrected Item-Total Correlation	Cronbach's α of the whole scale if the item got deleted	Cronbach's α of the factor if the item got deleted
Craving							
	1	1	I think about my smartphone when I am not using it.	.54	.51	.89	.67
	2	2	I feel a strong urge to check my smartphone.	.68	.65	.89	.54
	20	35	I feel a strong need to be available via my smartphone.	.65	.61	.89	.73
Coping							
	5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).	.38	.32	.89	.61
	11	20	My smartphone is the solution to my boredom.	.53	.48	.89	.66
	22	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.	.63	.59	.89	.45
Habitual Use							
	18	30	I automatically open apps on my smartphone.	.66	.63	.89	.79
	19	31	I automatically check my smartphone, even when I just checked it.	.73	.69	.89	.80
	24	48	I automatically unlock my smartphone.	.63	.59	.89	.80
	27	57	I check my smartphone when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).	.56	.50	.89	.86

Social Conflicts							
	8	15	I continue using my smartphone after others ask me not to.	.49	.50	.89	.84
	9	16	I tell lies about my smartphone use.	.54	.60	.89	.79
	10	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.	.48	.53	.89	.81
	12	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).	.46	.51	.89	.83
	14	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.	.35	.40	.89	.84
	26	55	People around me tell me that I use my smartphone too much.	.58	.61	.89	.81
Risky Use							
	4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.	.30	.33	.89	.60
	15	26	I can use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) without endangering myself or others.	.16	.09	.90	.76
	17	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).	.31	.30	.89	.47
	25	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.	.31	.34	.89	.55
Withdrawal							

	6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	.57	.52	.89	.79
	13	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).	.62	.63	.89	.80
	21	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	.56	.52	.89	.80
	23	46	I feel anxious/nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).	.72	.70	.89	.75
Tolerance							
	3	3	I feel empty even when I spend a lot of time on my smartphone.	.43	.36	.89	.55
	7	14	I need to spend more and more time on my smartphone to satisfy myself.	.65	.48	.89	.66
	16	27	I feel unsatisfied even when I spend a lot of time on my smartphone.	.49	.63	.89	.56

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 27 items, 7 factors after 3 items have been restored. The Cronbach's α values of the whole scale and the factors are as follows: the whole scale=.89, Craving=.73, Coping=.68, Habitual Use=.85, Social Conflicts=.85, Risky Use=.66, Withdrawal=.83, Tolerance=.69. Item-Total Correlation= correlation between the item and the total score from the scale, Corrected Item-Total Correlation= item-total correlation corrected for item overlap and scale reliability.

Table S4.7 Item-Total Correlations and Cronbach's α of the 26 items version SUPIQ if single item gets deleted with the university community sample (N=292)

Factor	Final Order	Initial Order	Item	Item-Total Correlation	Corrected Item-Total Correlation	Cronbach's α of the whole scale if the item got deleted	Cronbach's α of the factor if the item got deleted
Craving							
	1	1	I think about my smartphone when I am not using it.	.55	.51	.90	.67
	2	2	I feel a strong urge to check my smartphone.	.68	.65	.89	.54
	19	**35**	**I feel a strong need to be available via my smartphone.**	**.66**	**.61**	**.90**	**.73**
Coping							
	5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).	.38	.32	.90	.61
	11	**20**	**My smartphone is the solution to my boredom.**	**.53**	**.48**	**.90**	**.66**
	21	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.	.63	.59	.90	.45
Habitual Use							
17		30	I automatically open apps on my smartphone.	.66	.62	.90	.79
18		31	I automatically check my smartphone, even when I just checked it.	.73	.69	.89	.80
23		48	I automatically unlock my smartphone.	.64	.59	.90	.80
26		57	I check my smartphone when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).	.57	.50	.90	.86
Social Conflicts							

	8	15	I continue using my smartphone after others ask me not to.	.48	.50	.90	.84
	9	16	I tell lies about my smartphone use.	.55	.60	.90	.79
	10	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.	.48	.54	.90	.81
	12	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).	.47	.51	.90	.83
	14	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.	.36	.40	.90	.84
	25	55	People around me tell me that I use my smartphone too much.	.59	.62	.90	.81
Risky Use							
	4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.	.29	.33	.90	.68
	16	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).	.27	.27	.90	.77
	24	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.	.29	.33	.90	.61
Withdrawal							
	6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	.57	.52	.90	.79
	13	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of	.62	.63	.90	.80

			battery, etc.).				
	20	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.	.56	.53	.90	.80
	22	46	I feel anxious/nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).	.72	.71	.89	.75
Tolerance							
	3	3	I feel empty even when I spend a lot of time on my smartphone.	.43	.36	.90	.55
	7	**14**	**I need to spend more and more time on my smartphone to satisfy myself.**	**.66**	**.64**	**.90**	**.66**
	15	27	I feel unsatisfied even when I spend a lot of time on my smartphone.	.52	.47	.90	.56

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 27 items, 7 factors after 3 items have been restored. The Cronbach's α values of the whole scale and the factors are as follows: the whole scale=.89, Craving=.73, Coping=.68, Habitual Use=.85, Social Conflicts=.85, Risky Use=.76, Withdrawal=.83, Tolerance=.69. Item-Total Correlation= correlation between the item and the total score from the scale, Corrected Item-Total Correlation= item-total correlation corrected for item overlap and scale reliability.

Figure S4.8 The network for the SUPIQ items with the university community sample (N=292)

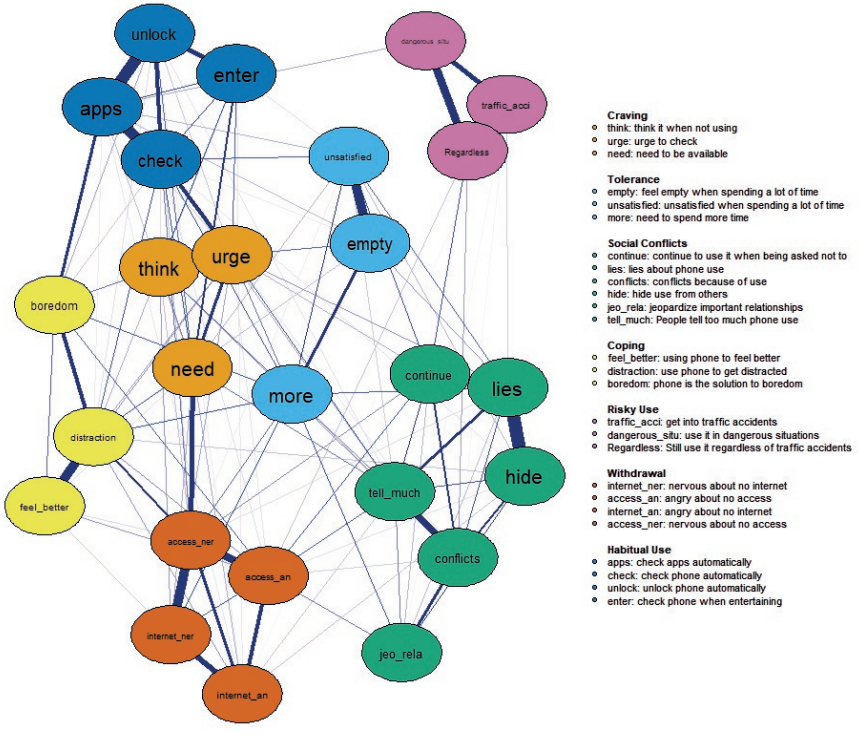


Figure S4.9 The centrality indices of the network for the SUPIQ items with the university community sample (N=292)

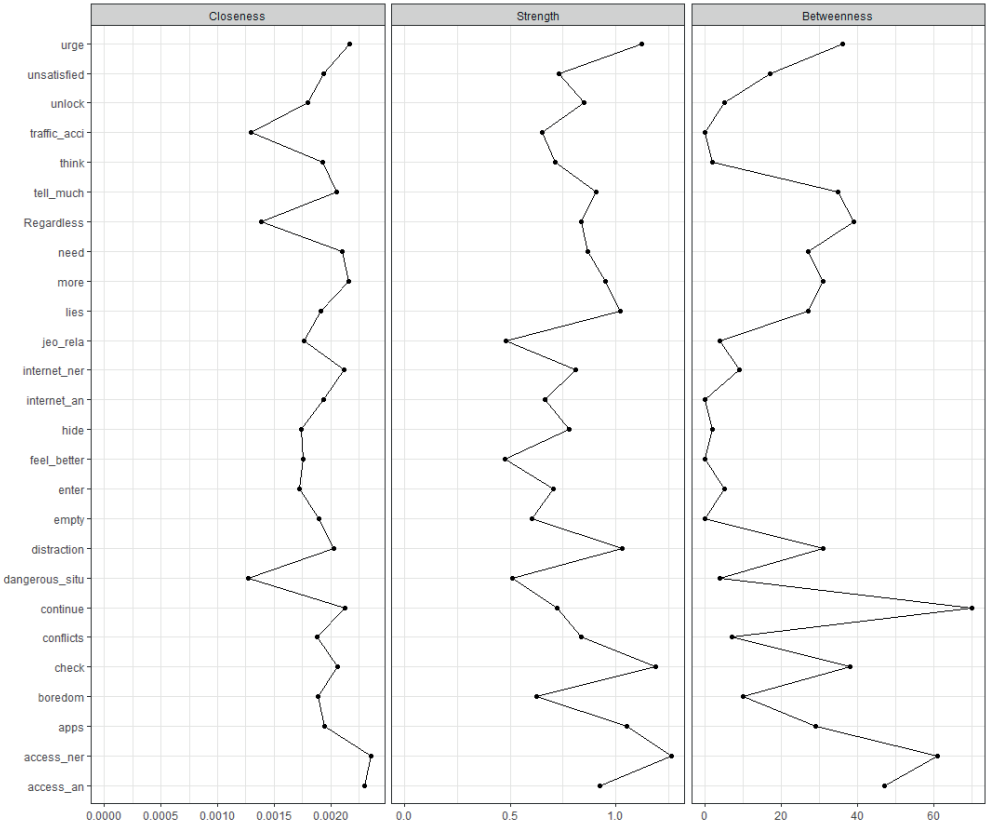


Figure S4.10 The bridge centrality indices of the network for the SUPIQ items with the university community sample (N=292)

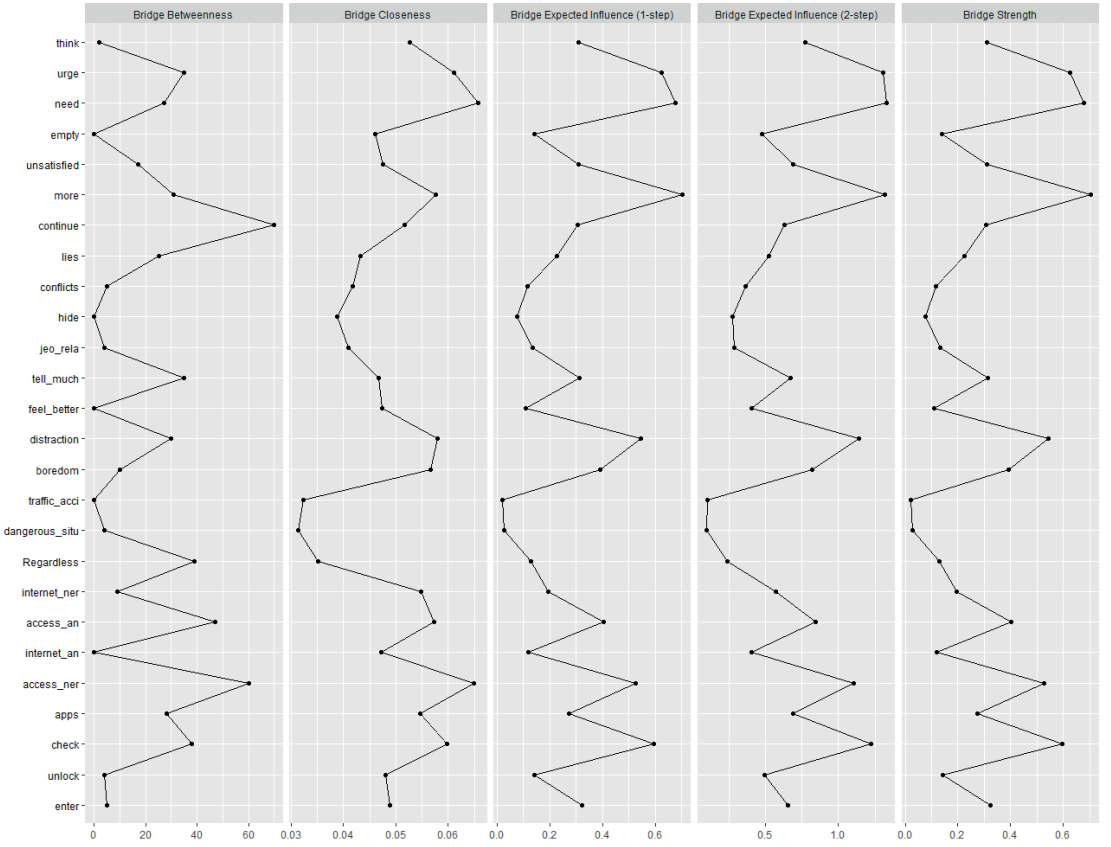


Table S4.11 Standardized Factor Loadings of the 26 items of the SUPIQ based on the CFA with the general population sample (N=397)

Final order	Initial order	Item	Factor 1- Craving	Factor 2- Tolerance	Factor 3- Social Conflicts	Factor 4- Risky Use	Factor 5- Withdrawal	Factor 6- Habitual Use	Factor 7- Coping
1	1	I think about my smartphone when I am not using it.	.772						
2	2	I feel a strong urge to check my smartphone.	.595						
3	3	I feel empty even when I spend a lot of time on my smartphone.		.635					
4	5	I (almost) get into traffic accidents (e.g., when driving a car, when cycling, when walking, etc.) due to my smartphone use.				.863			
5	7	Using my smartphone makes me feel better when I feel bad (e.g., sad, anxious, insecure, lonely, etc.).							.713
6	10	I feel anxious/nervous when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.					.721		
7	14	I need to spend more and more time on my smartphone to satisfy myself.		.773					

8	15	I continue using my smartphone after others ask me not to.			.836				
9	16	I tell lies about my smartphone use.			.885				
10	19	I have conflicts with others (e.g., family, partner, friend, etc.) due to my smartphone use.			.871				
11	20	My smartphone is the solution to my boredom.							.705
12	21	I hide my smartphone use from others (e.g., family, partner, friend, etc.).			.785				
13	22	I feel angry when I do not have access to my smartphone (e.g., exams, out of battery, etc.).					.869		
14	25	I jeopardize important relationships (e.g., family, partner, friend, etc.) due to my smartphone use.			.859				
15	27	I feel unsatisfied even when I spend a lot of time on my smartphone.		.630					
16	29	I use my smartphone in situations that could be physically dangerous (e.g., driving a car, cycling, crossing the road, operating heavy machinery, etc.).				.807			
17	30	I automatically open apps on my smartphone.						.740	

18	31	I automatically check my smartphone, even when I just checked it.						.768	
19	35	I feel a strong need to be available via my smartphone.	.680						
20	42	I feel angry when there are internet connection problems (e.g., unstable connection, no connection, etc.) on my smartphone.					.682		
21	43	I distract myself from negative feelings (e.g., sad, anxious, insecure, lonely, etc.) by using my smartphone.							.661
22	46	I feel anxious/ nervous when I do not have access to my smartphone (e.g., exams, out of battery, etc.).					.772		
23	48	I automatically unlock my smartphone.						.710	
24	53	I still use my smartphone in traffic (e.g., driving a car, cycling, walking, etc.) even though I (almost) get into traffic accidents due to my smartphone use.				.824			
25	55	People around me tell me that I use my smartphone too much.			768				

26	57	I check my smartphone when I am entertaining myself in other ways (e.g., watching movies, TV series, reading, etc.).						.554	

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 26 items, 7 factors. Applied estimation method is weighted least squares estimation.

Table S4.12 Standardized Correlations between factors of the SUPIQ based on the CFA with the general population sample (N=397)

Factors	Factor 1-Craving	Factor 2-Tolerance	Factor 3-Social Conflicts	Factor 4-Risky Use	Factor 5-Withdrawal	Factor 6-Habitual Use	Factor 7-Coping
Factor 1-Craving	1						
Factor 2-Tolerance	.846	1					
Factor 3-Social Conflicts	.632	.875	1				
Factor 4- Risky Use	.494	.803	.943	1			
Factor 5-Withdrawal	.845	.903	.846	.733	1		
Factor 6- Habitual Use	.886	.797	.507	.475	.733	1	
Factor 7- Coping	.850	.917	.698	.621	.797	.906	1

Note. SUPIQ=The Smartphone Use Problems Identification Questionnaire. This version contains 26 items, 7 factors. Applied estimation method is weighted least squares estimation. All the correlation coefficients are significant at .001 level.

Figure S4.13 Stability test with bootstrapping (nboots=2000) for network modeling (Fig 1.) with the university community sample (N=292)

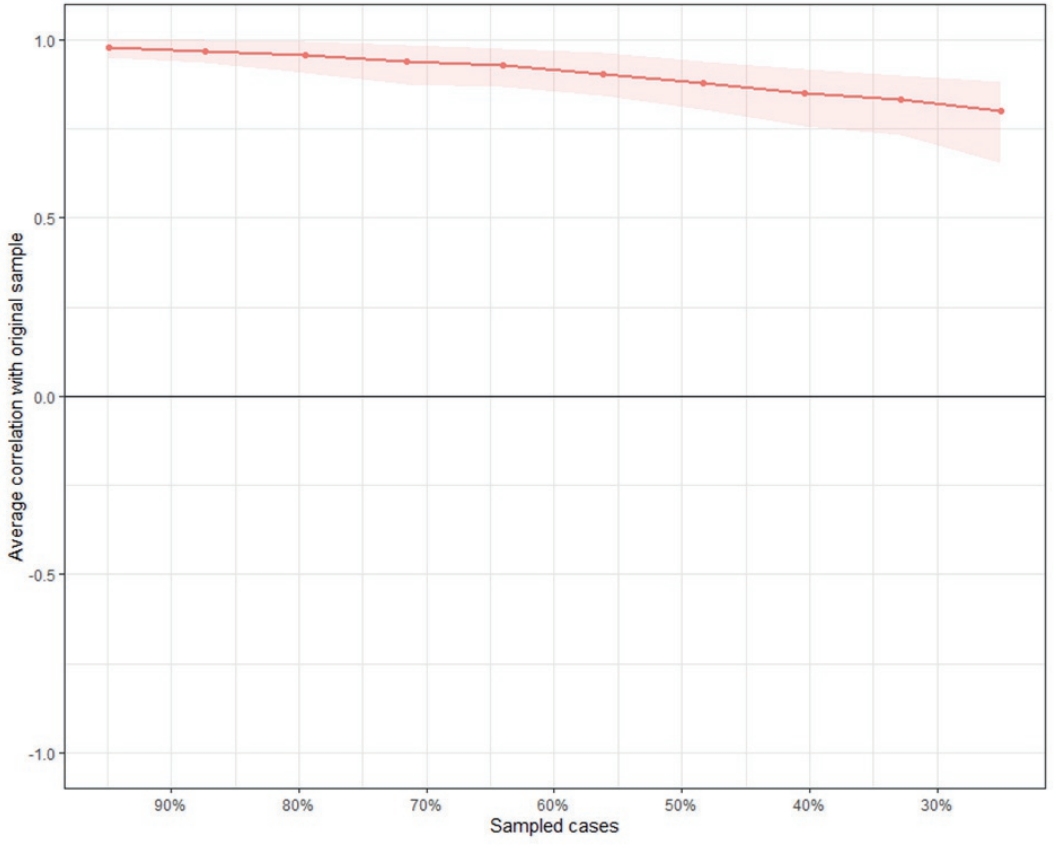
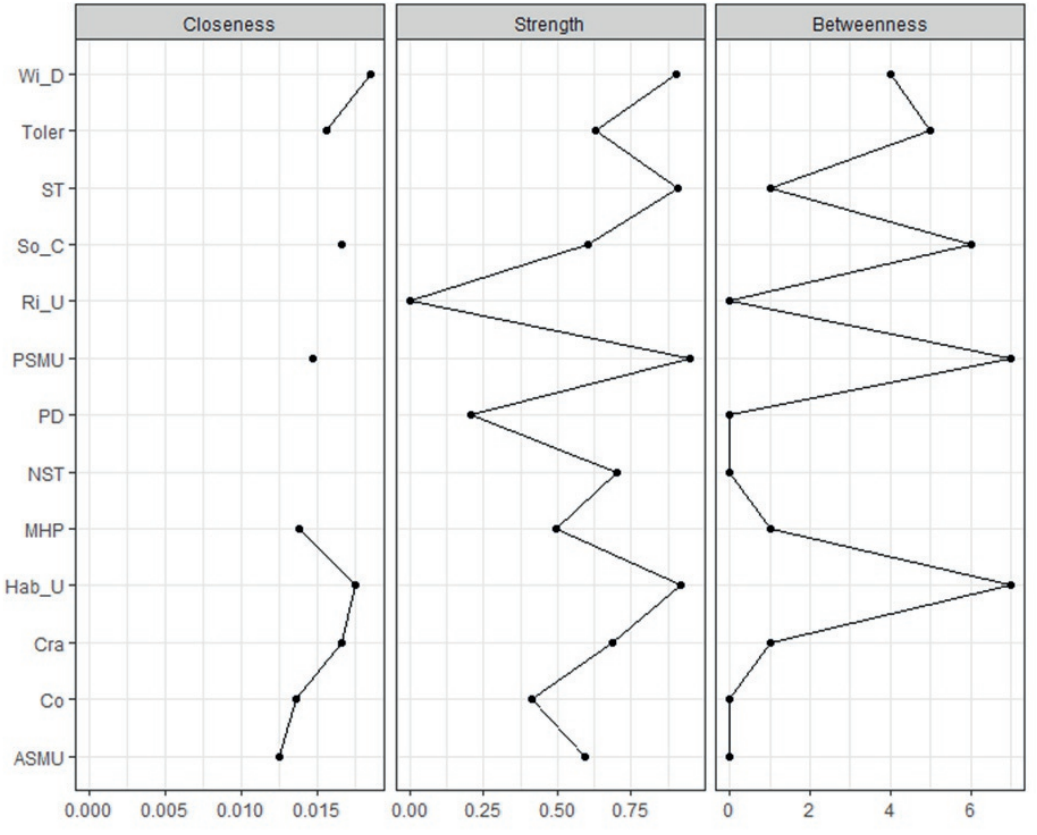


Figure S4.14. The centrality indices for the network modeling (Fig 1.) with the university community sample (N=292)



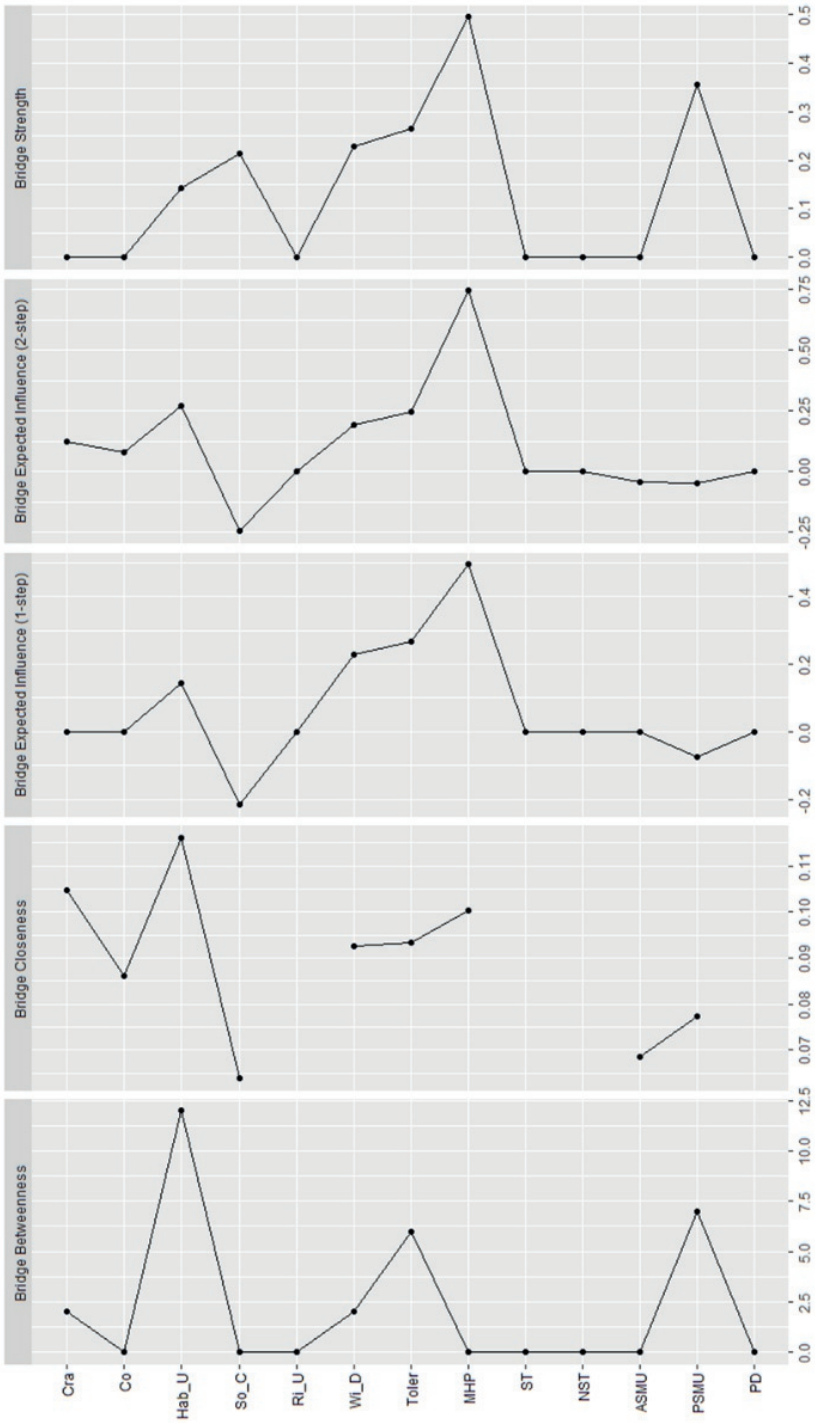


Figure S4.15. The bridge centrality indices for the network modeling (Fig 1.) with the university community sample (N=292)

Figure S4.16. The estimation of significant differences between edge weights and bootstrapped (nboots=100) confidence intervals of edge weights for the network modeling (Fig 1.) with the university community sample (N=292)

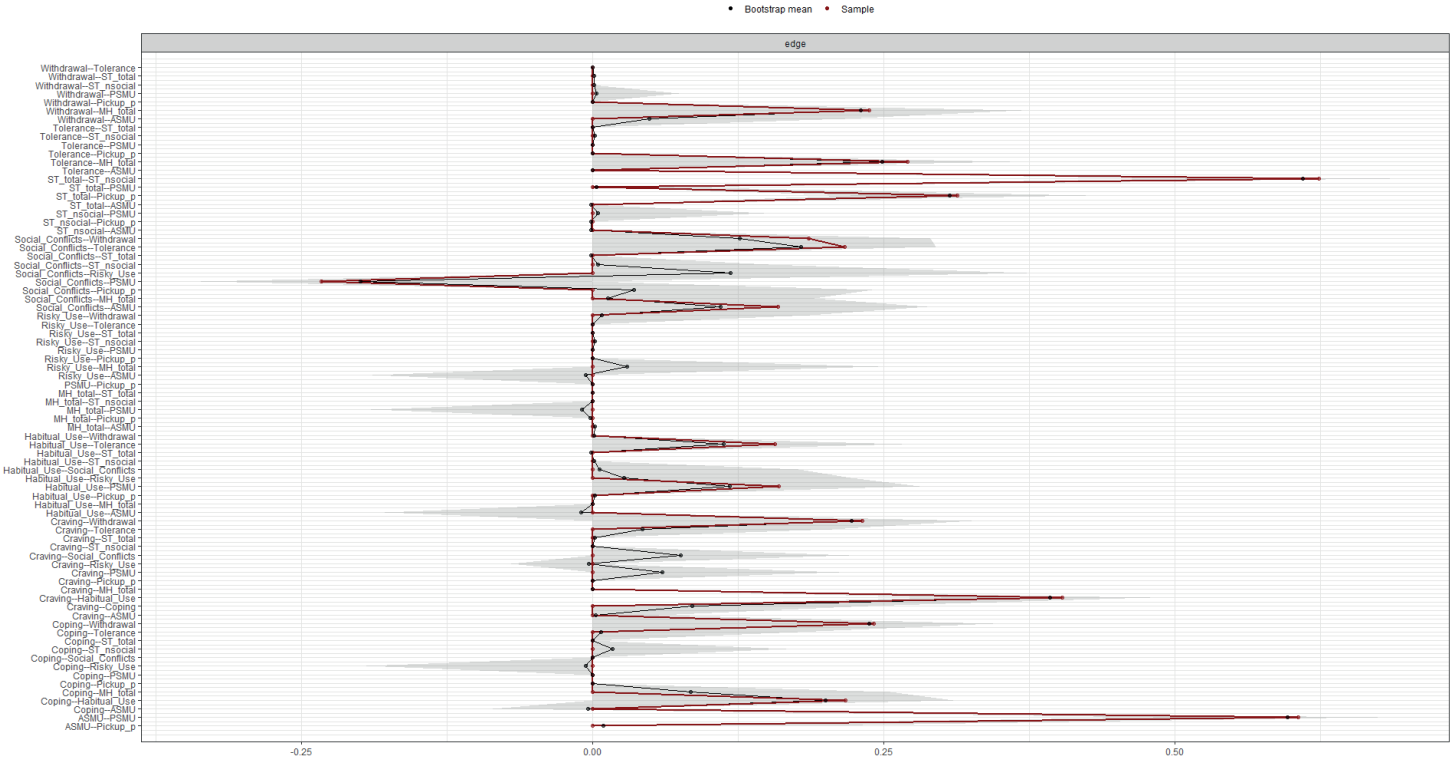


Figure S4.17. Stability test with bootstrapping (nboots=2000) for network modeling with students sample (Fig 2.) with the general population sample (N=397)

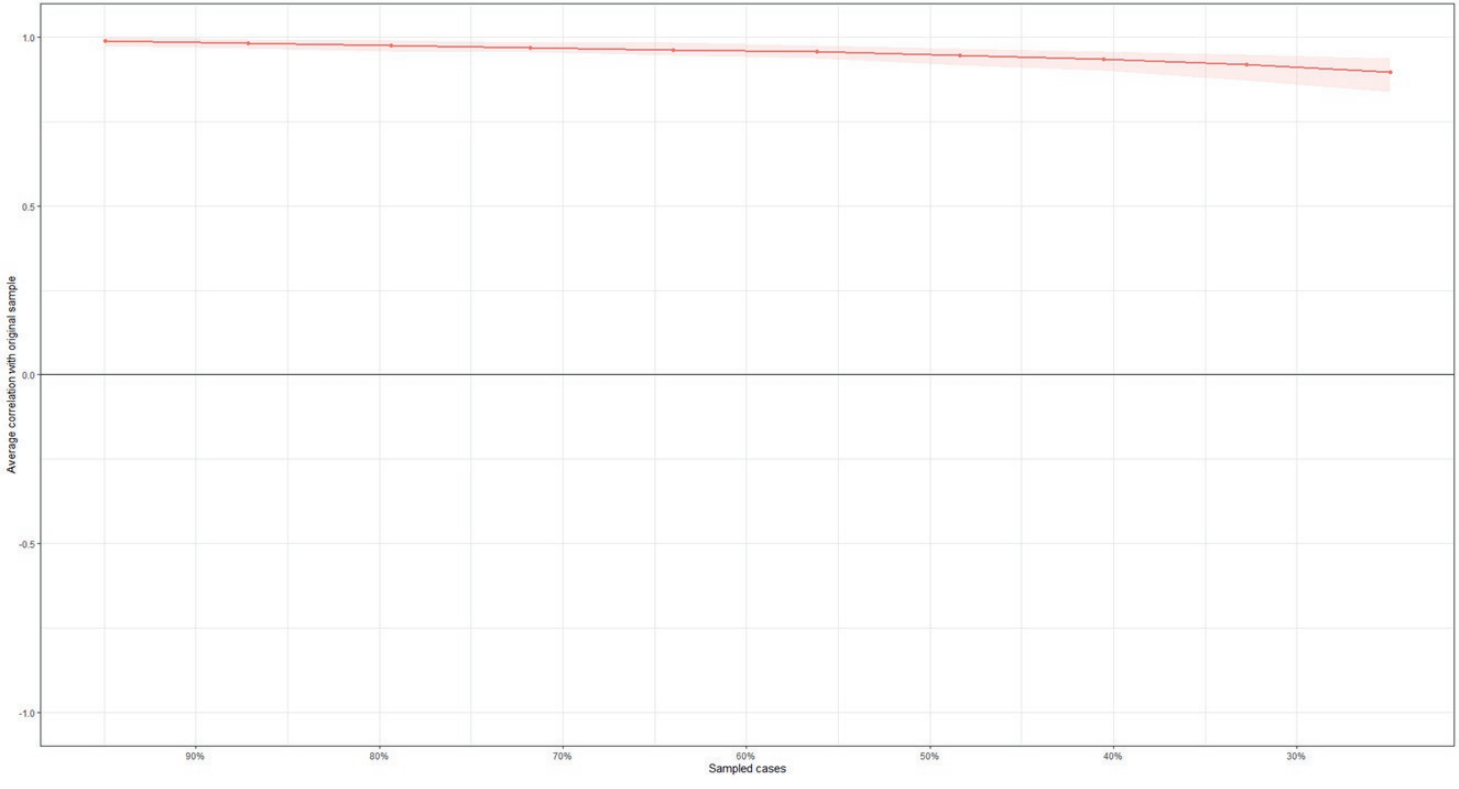


Figure S4.18. The centrality indices for the network modeling (Fig 2.) with the general population sample (N=397)

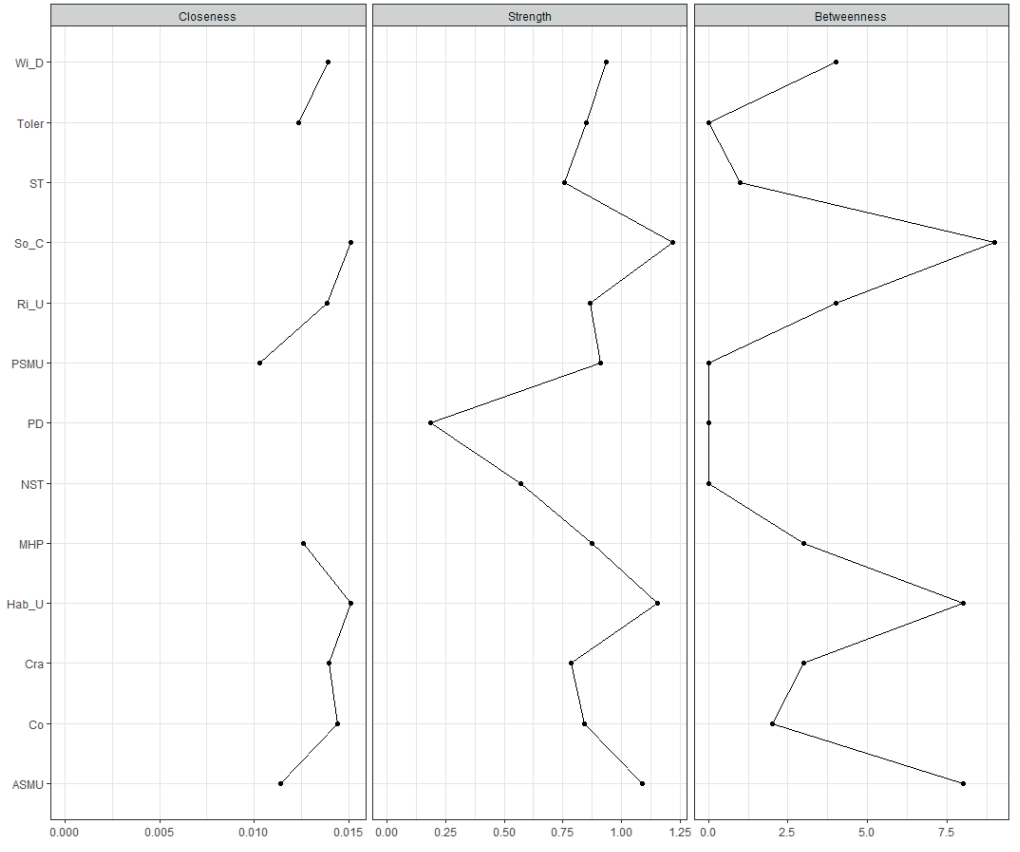


Figure S4.19. The bridge centrality indices for the network modeling (Fig 2.) with the general population sample (N=397)

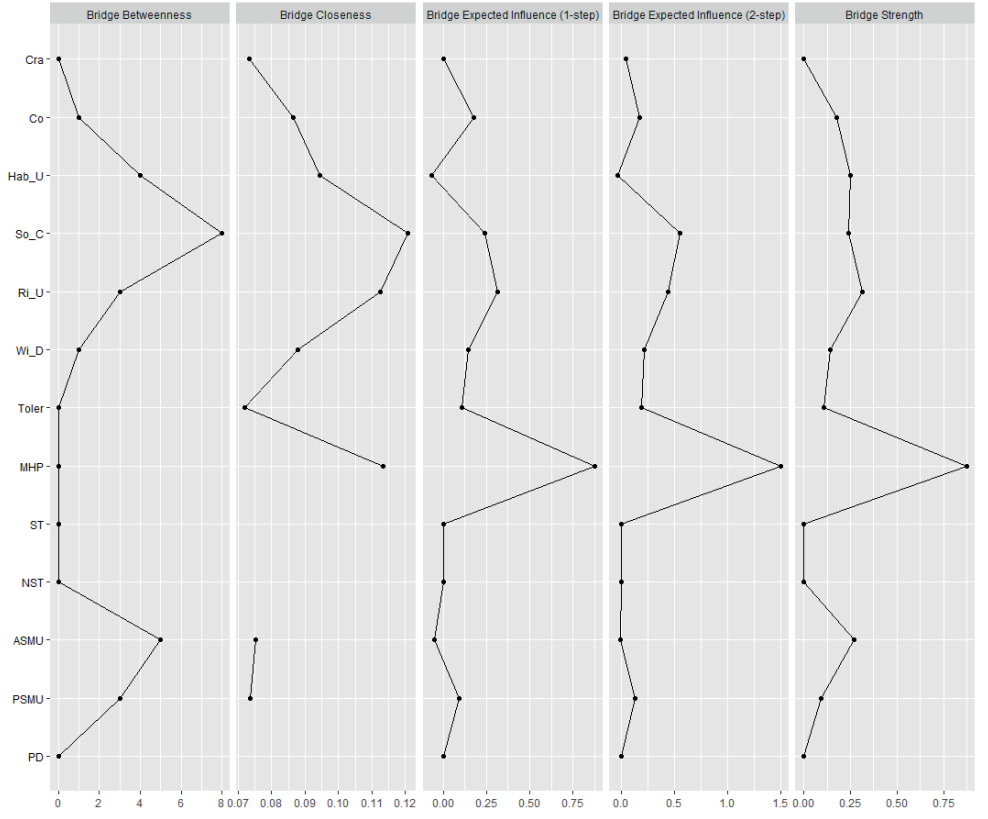
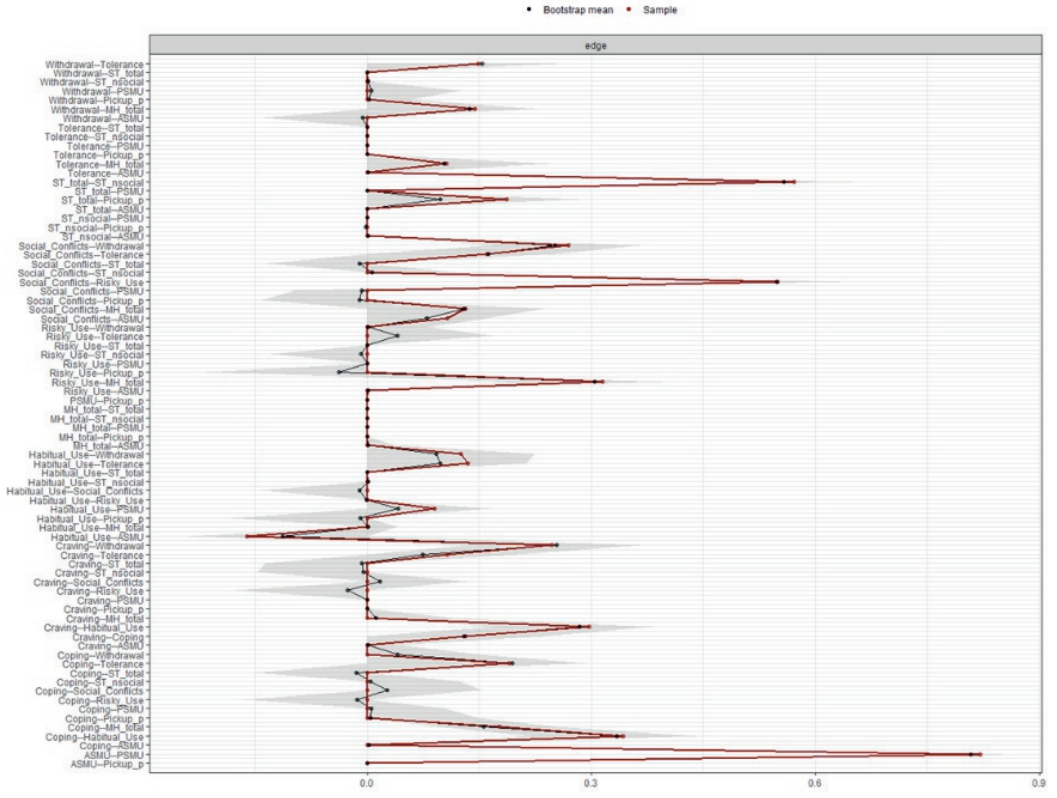


Figure S4.20. The estimation of significant differences between edge weights and bootstrapped (nboots=100) confidence intervals of edge weights for the network modeling (Fig 2.) with the general population sample (N=397)



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Chapter 2

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English Summary

Unraveling Problematic Smartphone Use: The Good and The Bad through Longitudinal, Qualitative and Psychometric Perspectives

As a researcher focusing on problematic smartphone use (PSU), I have often encountered inquiries like “I think I'm addicted to my smartphone, could you help me?”. Throughout my PhD journey, several questions have persisted in my mind: What environmental factors, especially peer-related factors contribute to the development of PSU among adolescents? Can we live a life in modern society without smartphones to avoid possible smartphone use problems? Can we identify and measure problematic smartphone use without pathologizing normal smartphone use?

In this thesis, I aimed to thoroughly explore and understand PSU. To navigate this intricate domain effectively, it is essential to establish clear distinctions between normal smartphone use and PSU. To achieve this goal, it is imperative to examine both the advantages and drawbacks associated with smartphone use. Based on such a foundation, the primary objective was to identify the potential factors and etiology contributing to PSU and to analyze the potential parallels and distinctions between PSU and established addiction criteria. I first introduced the common use and inherent dichotomy of smartphone use in Chapter 1, acknowledging its convenience and challenges in contemporary society. Emphasizing the transformative impact of smartphones on daily life, I also highlighted the emerging concern of PSU, characterized by excessive usage and potential negative consequences. Then I reviewed the theoretical framework underpinning my empirical studies.

In Chapter 2, I reported the findings of a longitudinal study examining the bidirectional relationships between PSU and the quantity and quality of adolescent peer engagement. Various aspects of peer engagement were investigated, including online (i.e., passive and active social media messaging on smartphones) and offline (i.e., intensity of face-to-face meetings with friends) engagement, as well as the quality of peer relationships (i.e., perceived competence in close friendships) among adolescents. Data from a three-wave longitudinal study involving 2100 Dutch high school students were analyzed. In terms of PSU development, the results suggested that adolescents who perceive low competence in close friendships and/or engage intensively in smartphone messaging with their peers may be particularly susceptible to developing problematic smartphone use over time. In addition, the results also showed the positive consequences of smartphone use, which is, using smartphones to engage in active social media messaging is beneficial for adolescents’ social competence development.

In Chapter 3, I conducted an in-depth qualitative exploration, uncovering participants' PSU-related experiences, antecedents, and consequences. My overarching objective was to discern commonalities and disparities between PSU and established addiction criteria (i.e., DSM-5 and ICD-11) while identifying central themes in PSU etiology. This qualitative investigation utilized semi-structured interviews as part of its design and involved twenty-eight European university students identified as having smartphone use problems. Interviews focused on participants' perceptions of PSU, and data analysis involved both deductive and inductive approaches, with thematic coding applied. My findings revealed that participants exhibited addiction-like symptoms, including themes like craving, coping, and tolerance-like and withdrawal-like symptoms. Additionally, participants highlighted the vital roles of the smartphone, habitual smartphone use, and smartphones as disruptive distractions. Despite the negative consequences, all participants acknowledged substantial positive consequences associated with their smartphone use. The study has underscored the pivotal role of the "trade-off process" between positive and negative consequences, as well as motives and perceived social norms for smartphone use, in shaping PSU. It turned out it is not sensible to solely investigate the PSU without considering the benefits of smartphone use in modern society. In addition, the applicability of existing "addiction" to the area of PSU should be further tested.

In Chapter 4, I reported the results of a study where we developed and tested a questionnaire based on the qualitative findings from Chapter 3. This questionnaire is called the Smartphone Use Problems Identification Questionnaire (SUPIQ). I conducted a series of analyses using two distinct samples: a university community sample (N=292) and a general population sample (N=397). The final version of SUPIQ, comprising 26 items and 7 factors (Craving, Coping, Habitual Use, Social Conflicts, Risky Use, Withdrawal, and Tolerance), demonstrated strong construct and convergent validity. Configural measurement invariance across samples was established, indicating consistent measurement properties. Furthermore, the SUPIQ showed a superior ability to explain variances in mental health problems compared to the Short Version of Smartphone Addiction Scale (SAS-SV). The findings suggest that the SUPIQ is a promising tool for assessing PSU comprehensively, which is the initial step in identifying problematic smartphone use without pathologizing the normal smartphone use based on smartphone users' daily experiences.

In Chapter 5, I presented a comprehensive general discussion of the core findings and implications of this dissertation. I highlighted the different effects of active and passive smartphone behaviors (i.e. the positive effects of active social

messaging and the negative effects of passive social media messaging on adolescents' development), the complex interplay of social, motivational, and normative factors and the variations in PSU across different developmental stages and social contexts. I believe this dissertation has taken important first steps toward exploring the comprehensive and complex phenomenon of PSU from a *mixed-method* perspective. Further research should consider the potential negative consequences of smartphone use within the context if its positive effects. As such, I emphasized that interventions targeting PSU should advocate for promoting "digital well-being" (i.e., a healthy equilibrium between benefit and drawbacks of smartphone use) through mindful smartphone use rather than advocating for the complete elimination of smartphones.

Nederlandse Samenvatting

Het Doorgronden van Problematisch Smartphonegebruik: De Goede en Slechte Kanten vanuit Longitudinale, Kwalitatieve en Psychometrische Perspectieven

Omdat ik problematisch smartphonegebruik (PSG) onderzoek, worden mij vaak vragen gesteld zoals “Ik denk dat ik verslaafd ben aan mijn smartphone, kunt u mij helpen?”. Gedurende mijn promotieonderzoek zijn verschillende van dit soort vragen in mijn gedachten blijven hangen: Welke omgevingsfactoren, en met name factoren gerelateerd aan leeftijdsgenoten, dragen bij aan de ontwikkeling van PSG bij adolescenten? Kunnen we een leven leiden in de moderne samenleving zonder smartphones zodat mogelijke problemen met smartphonegebruik voorkomen kunnen worden? Kunnen we problematisch smartphonegebruik identificeren en meten zonder normaal smartphonegebruik te pathologiseren?

In dit proefschrift wilde ik PSG grondig onderzoeken en begrijpen. Om een goed beeld te hebben van dit ingewikkelde concept, is het als eerste essentieel om een duidelijk onderscheid te maken tussen normaal smartphonegebruik en PSU. Daarnaast is het nodig om zowel de voordelen als de nadelen van smartphonegebruik te onderzoeken. Op basis van deze kennis waren het belangrijkste doelen van dit proefschrift het identificeren van mogelijke factoren e die bijdragen aan PSG en mogelijke overeenkomsten en verschillen tussen PSG en vastgestelde verslavingscriteria.. In Hoofdstuk 1 heb ik als eerste het gebruikelijke gebruik en de inherente tweedeling van smartphonegebruik geïntroduceerd: het brengt gemak maar ook uitdagingen in de hedendaagse samenleving. Door de impact van smartphones op het dagelijks leven te benadrukken, heb ik ook de toenemende zorgen over PSG belicht, gekenmerkt door overmatig gebruik en mogelijke negatieve gevolgen. Vervolgens heb ik het theoretische kader besproken dat ten grondslag ligt aan mijn empirische studies.

In hoofdstuk 2 heb ik de wederzijdse relatie tussen PSG en in hoeverre adolescenten de betrokken zijn bij leeftijdsgenoten (hierna *peer engagement*) longitudinaal onderzocht. Verschillende aspecten van *peer engagement* werden onderzocht, zoals online aspecten (bijv. passief en actief sociaal mediagebruik op smartphones) en offline aspecten (bijv. hoe vaak de adolescent afspreekt met vrienden), evenals de kwaliteit van relaties met leeftijdsgenoten (bijv. zelf gerapporteerde competentie in hechte vriendschappen). Gegevens van een longitudinale studie met drie tijdspunten met 2100 Nederlandse middelbare scholieren werden geanalyseerd. Wat betreft de ontwikkeling van PSG, suggereerden de resultaten dat adolescenten die een lage competentie ervaren in hechte vriendschappen en/of intensief communiceren via smartphones met hun leeftijdsgenoten bijzonder vatbaar kunnen zijn voor het ontwikkelen van

problematisch smartphonegebruik. Daarnaast toonden de resultaten ook positieve gevolgen van smartphonegebruik aan, zoals dat wanneer adolescenten smartphones gebruiken om actief deel te nemen aan sociale media dit gunstig is voor hun sociale competentieontwikkeling.

In hoofdstuk 3 heb ik een kwalitatief onderzoek uitgevoerd naar de PSG-gerelateerde ervaringen, oorzaken en gevolgen. Mijn doel was om overeenkomsten en verschillen tussen PSG en bestaande verslavingspathologie (bijv. DSM-5 en ICD-11) te achterhalen en centrale thema's in de etiologie van PSG te identificeren. Dit kwalitatieve onderzoek maakte gebruik van semigestructureerde interviews en omvatte achtentwintig Europese universiteitsstudenten die problemen hadden met hun smartphonegebruik. De interviews richtten zich op de percepties van deelnemers over PSG. die middels thematische analyse met zowel deductieve als inductieve benaderingen werden geanalyseerd.,. Mijn resultaten toonden aan dat de deelnemers symptomen vertoonden die lijken op verslaving, zoals verlangen, coping en symptomen die lijken op tolerantie en ontwenning. Bovendien benadrukten de deelnemers het belang van de smartphone, smartphonegebruik als gewoonte en smartphones als verstorende afleiding. Ondanks de negatieve gevolgen erkenden alle deelnemers ook belangrijke positieve gevolgen van hun smartphonegebruik. Dit onderzoek benadrukt hiermee dat bij het definiëren van PSG rekening gehouden moet worden met het "afwegingsproces" tussen positieve en negatieve gevolgen, evenals met de motieven en waargenomen sociale normen voor smartphonegebruik.. Het bleek niet zinvol te zijn om PSG te onderzoeken zonder rekening te houden met de voordelen van smartphonegebruik in de moderne samenleving. Bovendien moeten de overeenkomsten tussen verslavingsproblematiek en PSG verder worden onderzocht.

In hoofdstuk 4 heb ik de resultaten gerapporteerd van een onderzoek waarin we een vragenlijst hebben ontwikkeld en getest op basis van de kwalitatieve bevindingen uit hoofdstuk 3. Deze vragenlijst heet de *Smartphone Use Problems Identification Questionnaire* (SUPIQ). Er is een reeks analyses uitgevoerd met twee verschillende steekproeven: steekproef geworven op universiteiten (N = 292) en steekproef van de algemene bevolking (N = 397). De definitieve versie van SUPIQ, bestaande uit 26 items en 7 factoren (Verlangen, Coping, Gewoontegedrag, Sociale Conflicten, Risicovol Gebruik, Ontwenning en Tolerantie), vertoonde sterke construct- en convergente validiteit. De factorstructuur was gelijk tussen de steekproeven, wat wijst op consistente meeteigenschappen. Verder bleek de SUPIQ een beter in het verklaren van de varianties in mentale gezondheidsproblemen in vergelijking met de korte versie van de Smartphone Addiction Scale (SAS-SV). De bevindingen suggereren dat de

SUPIQ een veelbelovend instrument is voor het uitgebreid beoordelen van PSG. Dit betekent de eerste stap in het identificeren van problematisch smartphonegebruik op basis van de dagelijkse ervaringen van smartphonegebruikers zonder normaal smartphonegebruik te pathologiseren.

In hoofdstuk 5 heb ik een uitgebreide algemene discussie gepresenteerd over de kernbevindingen en implicaties van dit proefschrift. Ik benadrukte hierin de verschillende effecten van actief en passief smartphonegebruik(d.w.z. de positieve effecten van actief social mediagebruik en de negatieve effecten van passief social mediagebruik op de ontwikkeling van adolescenten), het complexe samenspel van sociale, motivationele en normatieve factoren bij PSG en hoe PSG tussen verschillende ontwikkelingsstadia en sociale contexten kan variëren. Ik ben ervan overtuigd dat dit proefschrift belangrijke eerste stappen heeft gezet in het onderzoeken van PSG als een veelomvattend en complex fenomeen vanuit een *mixed-method* perspectief. Toekomstig onderzoek wordt aangeraden om rekening te houden met de mogelijke negatieve gevolgen van smartphonegebruik binnen de context van de positieve effecten ervan. Daarom is het van belang dat interventies die zich richten op PSG het "digitaal welzijn" kunnen bevorderen (d.w.z. een gezond evenwicht tussen de voor- en nadelen van smartphonegebruik) door bewust smartphonegebruik te benadrukken in plaats van te pleiten voor het volledig uitbannen van smartphones.

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I am fortunate to have wonderful neighbors around my home. Firstly, I want to thank my neighbor and colleague, Jack. It's been a pleasure learning from you about art, beauty, and enjoying parties together. Thank you for always being willing to capture moments as my photographer! Through you, I have also had the pleasure of meeting many kind colleagues from clinical psychology—thank you to Gülde, Hani, and Theresa. I would also like to express my gratitude to my neighbors Xuan, Katherine, Laura, and Diederik. It has been lovely getting to know each of you and having conversations together. And a special thank you to Nana and Evert—it feels like magic that we crossed paths and bonded over our shared love for books. 也感谢晓霞阿姨和王叔叔一家，你们真的非常善良，也帮了我好多，感恩遇见。

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豆和 Youssef 一家，还有珍珍和玲瑶，还有在乌特的文蕊和映晴(Joyce)，以及在马大的刘豫师姐和吴怡，跟你们的每次见面我都非常快乐，感恩！也谢谢仰君（张姐），希望你在英国一切顺利。还有仲芳师姐，于兰师姐以及 Paul，宋潮师弟，你们真的给我提供了很多无条件的支持，我每次想到都很感动。我感谢虽然在国内，却给了我很多线上支持的朋友， 我的高中挚友张展、何明睿以及当当和张鸣一家、靳永朝、刘悦和李玥，我的研究生同学雅超还有东丽表姐，谢谢你们一直关心我，我觉得非常温暖！In addition, it is nice to meet Maartje, Channah, Shekou, Eileen, Dyon, Xiaocheng, Jinyao, Jian, Shuai, and Qian here.

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Finally, I want to thank myself. Dear Shuang, thank you for your courage, bravery, enthusiasm, and perseverance, which have paved the way for me to become Dr. Su. Your resilience and determination have been key to achieving this milestone. 在这里，我想跟致谢的开头呼应一下。在我小学毕业时，我在同学录上写，我想长大以后去荷兰。在我初中时，我知道，我想拿到博士学位，成为一名大学教师，在我高中时，我就选择了心理学作为自己未来的专业方向。我以为自己既然早就有了职业规划，一切应该很顺利。但是事实并非如此，在这条路上，我有过很多的犹疑，彷徨，挫败，自我怀疑，以至于我在这条路上常常会远离

自己的初心。就像英雄故事中写的一样，英雄必须历经千难万险而不忘初心，才可以完成他/她的目标。我也像一个在自己生活中的女英雄一样，经历千难万险，与自己和解，不忘初心，才接近了我内心蕴藏的宝藏。

篇幅有限，我甚至不知道我有没有感谢到每一个我想感谢的人。但是，我真心地感恩在生命中遇到的每一份善意希望大家都顺利，平安，快乐！

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