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Smartphone usage among older adults

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ABSTRACT

Problematic smartphone usage, associated with impaired daily functioning, has gained increased attention among researchers. However, extant research is focusing on adolescents and younger adults. This paper investigates smartphone usage among older adults, of which less is known. To do so, we conducted a cross-sectional survey of 154 smartphone users (60+ years) in Norway using structural equation modeling (PLS-SEM). We examined the contributing roles of loneliness, habit, social influence, emotional gain, fear of missing out, self-control, and problematic smartphone usage. We further investigated how older adults engage with their smartphones. Our findings suggest that older adults use smartphones for various social and non-social reasons and that social media and news reading are the most common use areas. Furthermore, we found a low prevalence of problematic smartphone usage among older adults. Whereas social influence and habit were strong predictors of smartphone usage among older adults, loneliness was not. Fear of missing out was not prevalent among older adults. As we expected, higher self-control was associated with lower problematic smartphone use. Finally, we discuss the contributions and implications of our findings.

1. Introduction

Smartphone usage has increased over the last decade, engaging users from a young age until the old. The advent of smartphones and other wireless mobile devices has increased the frequency of previously carried out digital activities on other devices such as laptops and desktop computers (Rosen, Whaling, Carrier, Cheever, & Rokkum, 2013). Mainly due to its internet connectivity, the smartphone offers various use areas such as playing games, listening to music, and socializing. Whereas studies have investigated how older adults use the Internet, we know less about how they engage with their smartphones specifically. The increased smartphone usage has brought with it both positive and negative consequences. For example, smartphones can help people organize their work, increase availability, and keep in touch with family and friends. On the other hand, smartphone usage can become problematic and lead to severe consequences (Busch & McCarthy, 2021). Much of the research on the negative impacts of excessive smartphone usage has concentrated on children and adolescents. However, less is known about problematic smartphone usage (PSU) among older adults (Busch & McCarthy, 2021; Nahas, Hlais, Saberian, & Antoun, 2018). PSU is characterized by a recurrent craving to use the smartphone, which is difficult to control, and leads to an impaired daily functioning (Ezoe et al., 2009; Horwood & Anglim, 2018; Lepp, Li, & Barkley, 2016; Shin & Dey, 2013). Children and adolescents use the smartphone so much and in such a way that concerns have been raised. Research has shown a range of negative impacts such as depression, withdrawal, lack of sleep, and reduced academic performance (Busch & McCarthy, 2021). Whereas smartphone usage among older adults yet has not been found to be problematic, the increasing adoption of smartphones in this age group makes us question whether older adults also are exposed to PSU.

Various terms in the literature have characterized PSU behavior. Whereas some researchers prefer the term smartphone addiction, others use terms such as nomophobia and smartphone overuse (Busch & McCarthy, 2021). Regardless of the terms used, they describe behavior characterized by symptoms which share characteristics similar to other addictive behaviors. High smartphone usage does not necessarily mean that a person engages in PSU, but PSU presupposes high smartphone usage. Whereas early PSU research did not differentiate between different smartphone usage types, more recent research has considered how different types of smartphone applications such as social media and games can lead to PSU in various contexts (Busch & McCarthy, 2021; Davazdahemami, Hammer, & Soror, 2016).

There are considerable differences between adolescents and older adults. Whereas the younger generations are digital natives, older adults

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have experienced the digital advent in adult age. Consequently, different use patterns have emerged, where younger adults use smartphones more pervasively than older adults (Yu & Sussman, 2020). Studies investigating children and adolescents show a significant portion of this group using the smartphone extensively, averaging more than five hours per day (e.g., Aljomaa, Qudah, Albursan, Bakhiet, & Abduljabbar, 2016). Similar findings are identified among users averaging 28 years of age (e.g., Bragazzi, Re, & Zerbetto, 2019). A few studies investigating older adults suggest that PSU is more associated with younger people (mainly 18–34 years) and the unmarried (Nahas et al., 2018). However, their findings suggest that PSU is also a problem for users aged 34–65, where PSU seems to decline the older people are (Nahas et al., 2018).

Studies investigating antecedent factors leading to PSU found emotional gain and pastime to be motivating factors for students' smartphone usage (Chen et al., 2017). Factors influencing emotional gain in older adults will probably be different from younger adults and adolescents, as life circumstances are not the same. For example, older adults often live alone (or with their spouse), and if retired, have more spare time than younger people. Whereas younger people tend to have large and peripheral networks, older adults prefer to cultivate smaller and more intimate networks (Nicolaisen & Thorsen, 2014). These differences influence the motivations for using their smartphones. Smartphone usage can compensate for emotional and psychological problems such as loneliness, increasing the perception of emotional gain (Zhitomirsky-Geffet & Blau, 2016). Likewise, social influence is a motivating factor for increased perception of emotional gain (Luijkx, Peek, & Wouters, 2015). For example, older adults are willing to adopt several technologies encouraged by their children and grandchildren. Finally, perceiving emotional gain by using the smartphone will generate a reinforcement effect and create habitual behavior (cf., Arenas-Gaitán, Peral-Peral, & Ramón-Jerónimo, 2015; Turel & Serenko, 2012).

The use of smartphones driven by emotional gain can lead to undesirable outcomes such as PSU (Chen et al., 2017; Turel & Serenko, 2012). For example, people who use their smartphones to read the news are less likely to engage in PSU than people who use their smartphones for entertainment (Lin et al., 2017). Furthermore, emotional gain may also create a reinforcement effect in terms of a fear of missing out. For example, once users have experienced the benefits of following their family members' lives online, they may seek this information frequently. Thus, the fear of missing out can create addictive tendencies and lead to PSU (Grohol, 2018).

Self-control can influence the level of engagement in problematic technology use. For example, self-control has been found to influence internet addiction (Li, Dang, Zhang, Zhang, & Guo, 2014; Özdemir, Kuzucu, & Ak, 2014). Hence, we argue that a person with high self-control is less likely to engage in PSU.

Considering the widespread use of the smartphone and its potential adverse outcomes, it has become imperative for researchers to understand smartphone usage and why it becomes problematic to advise proper preventive and corrective actions. Furthermore, researching older adults is vital since their life situation and usage most likely differ from that of the younger generations - and thus, other measures may apply. This paper is an exploratory effort aiming to understand how older adults engage with their smartphones and the motivations driving their smartphone usage. In doing so, we have conducted a cross-sectional survey of 154 older adults in Norway using smartphones. Norway is a country with a high level of digitalization, and thus, this study serves as a novel case of how older adults may engage in PSU.

The remainder of this paper is organized as follows. The next section describes the development of the hypotheses and the research model, followed by a presentation of the data analysis and findings. We end the paper by discussing the implications of the study.

2. Literature review and hypotheses

Based on the literature, we developed our research model and hypothesized the relations between the constructs. Fig. 1 presents the tested research model and hypotheses. We hypothesize that loneliness (LON), social influence (SI), and habit (HAB) are associated with emotional gain (EG). EG is further associated with FoMO. We expect both EG and FoMO to be associated with PSU. Finally, we hypothesize that self-control (SC) will influence PSU behavior.

2.1. Antecedents of PSU

2.1.1. Emotional gain and PSU

Whereas research on technology use has focused much on extrinsic motivations for use (e.g., perceived usefulness), research is now also frequently including intrinsic motivations (e.g., hedonic motivation) to explain the use of applications such as games and social media (Yang, Wang, & Lu, 2016). These intrinsic motivations come under various labels, such as hedonic motivation, perceived enjoyment, and EG. They are used to explain enjoyment-related IS usage activities (Davis, Bagozzi, & Warshaw, 1992; Turel & Serenko, 2012) rather than mere instrumental reasons for technology use. Experiences of enjoyment are considered essential for leisure activities in hedonic situations (Chen, Zhang, Gong, & Lee, 2019). EG is the social and content gratifications a user gains from using the smartphone (Zhitomirsky-Geffet & Blau, 2016). Thus, EG is a motivation for smartphone use that is "apart from any performance consequences that may be anticipated" (Davis et al., 1992, p. 1113).

Most information systems (IS) research on technology adoption and use has considered intrinsic motivations as positive aspects of technology use (Yang et al., 2016). However, EG is closely related to the abuse of substances (cf., Zhang, Chen, & Lee, 2014), and being driven by EG can lead to undesirable outcomes such as PSU (Chen et al., 2017; Turel & Serenko, 2012). For example, research has shown that people who use their smartphone to look up information (e.g., read news) are less likely to engage in PSU than people who use their smartphone to pursue amusement (Lin et al., 2017). These dangers remain scarcely studied in the IS literature (Chen et al., 2019). Studies show that PSU influences smartphone users' perceptions, leading to an overrating of the EG of the smartphone (Huh & Bowman, 2008; Turel, Serenko, & Giles, 2011) and a corresponding underrating of its adverse effects (Huh & Bowman, 2008). EG is associated with motives such as pastime and boredom (e.g., Chen et al., 2017), leading to desires of experiences such as rush, excitement, and sensation seeking. Such experiences have been identified as influences for high smartphone usage and PSU (cf., Bernroider, Krumay, & Margiol, 2014). Continuously reinforcing a specific behavior increases the likelihood of PSU (Zhitomirsky-Geffet & Blau, 2016). This reinforcement effect can also explain why certain types of ICT are more addictive than others (Turel & Serenko, 2012). The smartphone is an excellent example of ICT that is addictive since it offers several opportunities for intrinsic enjoyment, such as social media, listening to music, and watching videos.

Chen et al. (2019) found that users with perceptions of enjoyment from smartphone usage, have a high chance of experiencing PSU. Investigating PSU in three different age cohorts, Zhitomirsky-Geffet and

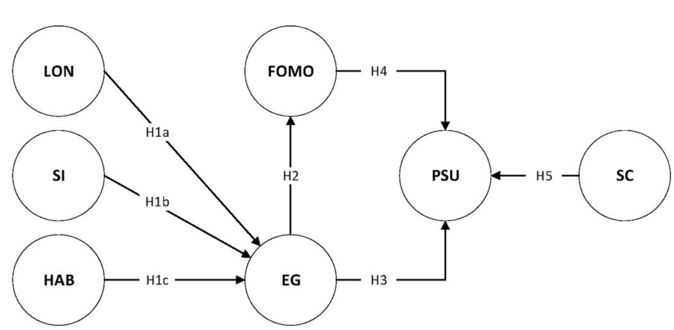

Fig. 1. Research model.

Blau (2016) found that EG was highest for the youngest cohort (13–19 yrs). However, EG was identified as one of PSU's most important predictive factors for all the cohorts. Based on this literature, we expect that an older adult smartphone user, who experiences a high level of enjoyment using the smartphone, is more likely to engage in PSU. Thus, we hypothesized that:

H3: EG is positively related to PSU.

2.2. Fear of missing out and PSU

FoMO is defined as "the fears, worries, and anxieties people may have in relation to being in (or out of) touch with the events, experiences, and conversations happening across their extended social circles" (Przybylski, Murayama, DeHaan, & Gladwell, 2013, p. 1842). This phenomenon is by some researchers labeled a new type of addiction (Grohol, 2018) or a psychological trait (Elhai, Levine, Dvorak, & Hall, 2016; Przybylski et al., 2013). People high in FoMO constantly check online (typically social networks) what others do and share to avoid missing out on any online information (Gezgin, Cakir, & Yildirim, 2018). Several researchers have linked FoMO with impaired daily functioning. For example, college students with higher levels of FoMO experienced adverse outcomes such as fatigue, stress, and less sleep throughout the semester (Milyavskaya, Saffran, Hope, & Koestner, 2018). Smartphone users struggling with FoMO will likely overuse their smartphones to satisfy the need to stay connected (Elhai et al., 2016). This link is most often expressed through social media (e.g., Buglass, Binder, Betts, & Underwood, 2017).

Conducting a literature review, Elhai, Dvorak, Levine, and Hall (2017) suggested that FoMO is an essential driver of smartphone and social media overuse. Studying Facebook intensity, Traş and Öztemel (2019) found that FoMO could predict Facebook intensity. Other studies confirm this link (e.g., Cheever, Rosen, Carrier, & Chavez, 2014; Gezgin et al., 2018; Lepp, Barkley, & Karpinski, 2014). Przybylski et al. (2013) found that FoMO can lead to the overuse of social media. FoMO has also been studied as a mediator between psychological variables and social media overuse (Servidio, 2019). Smartphone users high in FoMO tend to check various social media frequently, potentially resulting in PSU (Elhai et al., 2016). Studies investigating the relationship between FoMO and PSU have mostly focused on adolescents (e.g., Wang et al., 2019). Based on the above literature, we believe it is plausible to suggest that FoMO would predict PSU also among older adults. Hence, we hypothesized:

H4: FoMO is positively linked to PSU.

Furthermore, we linked EG to FoMO. The literature is scarce regarding this link. We base our hypothesis on the fact that FoMO as a concept is closely related to PSU. However, whereas the link between EG and PSU is fueled by motives such as pastime and boredom (e.g., Chen et al., 2017), the link between EG and FoMO is more instrumental. It is a fear of missing out on what the smartphone user perceives as valuable information, and thus the smartphone can help the user satisfying the need for this information. As FoMO is a continuous fear, it can thus create addictive tendencies (Grohol, 2018). Older adults are found to be more lonely than younger age cohorts (Nicolaisen & Thorsen, 2014). We thus expected that they might overuse the smartphone, and social media particularly, to gain information about relevant arrangements and follow the lives of their family members. Based on the above argumentation, we hypothesized that:

H2: EG is positively associated with FoMO.

2.3. Self-control and PSU

Self-control is "the ability to regulate behavior to fulfill personal values and meet social expectations" (Han, Geng, Jou, Gao, & Yang, 2017, p. 364). Thus, self-control describes the extent to which a person can refrain from or trigger specific behaviors. High self-control is associated with the resistance of temptation, an adaption of actions (Kopp, 1982), and both physical and mental health (Tangney, Baumeister, & Boone, 2004). Also, low self-control has been identified as a predictor of problematic behaviors among individuals (Bianchi & Phillips, 2005; Xin, Guo, & Chi, 2007). Self-control has also been used to explain why individuals with good attitudes and intentions still engage in problematic behaviors. For example, whereas a driver may agree that texting while driving is dangerous and must be avoided, the same person may lack the ability to resist the temptation from smartphone signals (Berger, Wyss, & Knoch, 2018). Thus, possessing a corresponding goal (e.g., arriving safely) is not sufficient to avoid problematic behavior. The person must also possess self-control (Berger et al., 2018).

Self-control is found to be an important predictor of several types of addictive behaviors. For example, extant research has found that self-control can influence internet addiction (Li et al., 2014; Özdemir et al., 2014). The higher self-control a person has, the less likely he or she is to engage in Internet gaming and gambling (e.g., E. J. Kim, Namkoong, Ku, & Kim, 2008; Mehroof & Griffiths, 2010). Other researchers have identified links between self-control, alcohol abuse, and drug addiction (Özdemir et al., 2014). PSU is defined as a recurrent craving that is difficult to control (Ezoe et al., 2009; Horwood & Anglim, 2018; Lepp et al., 2014; Shin & Dey, 2013). Additionally, smartphones are portable devices that further challenge their users' self-control (Han et al., 2017). Thus, self-control and PSU are closely related. Self-regulation theory suggests that addictive behaviors are a result of low self-control since individuals are unable to lower their craving and prevent normative use to become PSU (Gökçearslan, Mumcu, Haşlaman, & Çevik, 2016). Several studies have confirmed this link, showing that self-control negatively affects PSU (e.g., Gökçearslan et al., 2016; Van Deursen, Bolle, Hegner, & Kommers, 2015) and the likelihood of engaging in PSU (Jeong, Kim, Yum, & Hwang, 2016). We, therefore, propose the following hypothesis:

H5: Self-control is negatively linked to PSU.

2.4. Motivations for emotional gain

2.4.1. Loneliness

Loneliness is the perception of deficiency when one feels that his/her social networks are smaller (quantity) or less satisfying (quality) than one desires (Peplau, Russell, & Heim, 1979). Despite differences in personality traits, most people prefer to have a social network to acquire social status and experience affective bonding (Jeong et al., 2016). Thus, individuals need people who value and care about them - someone who can be trusted with one's inner thoughts (Cacioppo & Patrick, 2008). According to socioemotional selectivity theory (SST), social motives can be divided into two main categories; acquisition of knowledge and emotion regulation (Carstensen, Isaacowitz, & Charles, 1999). Young people tend to perceive time as unlimited, prioritizing the acquisition of knowledge to broaden their horizons. On the other hand, older adults begin to perceive time as more limited and prioritize intimate social relationships over new knowledge (Sims, Reed, & Carr, 2017). Therefore, social networks are restructured as people age, where younger individuals tend to maintain large and often peripheral social networks online. Older adults, however, prefer to cultivate smaller and more intimate, including online, networks (Nicolaisen & Thorsen, 2014). These shifts in social motives can explain increased mental well-being experienced with age (Carstensen, Fung, & Charles, 2003), including reduction of loneliness.

Loneliness is often experienced when there is a discrepancy between what individuals experience as their existing social network and what they expect (Jeong et al., 2016). In the event of missing effective social networks, the social network approach (Wellman et al., 1996) suggests that new media such as the smartphone could strengthen an individual's existing social networks since it is an effective means of social interaction with the outside world. Research has shown that excessive smartphone usage can compensate for emotional and psychological problems such as loneliness, increasing the sense of EG (Zhitomirsky-Geffet &

Blau, 2016). In contrast to younger cohorts, social technologies used for communication are sometimes associated with reduced loneliness among older adults (Sims et al., 2017). However, when social technologies are used for information or entertainment, this use is associated with higher loneliness for both younger and older cohorts (Nowland, Necka, & Cacioppo, 2018).

Both from popular media (e.g., Ducharme, 2019) and research (e.g., Beutel et al., 2017), we know that loneliness poses a significant health problem for older adults. Loneliness among older adults arises from the fact that their children have left home, often relocating and establishing their own families. Physical health put boundaries on social activities, and the spouse and close friends die (Nicolaisen & Thorsen, 2014). Loneliness may lead to different consequences based on an individual's personal preferences. Lonely individuals may rely on their smartphone more to get in touch with family, friends, or partner, alleviating negative feelings and gaining assurance (Bian & Leung, 2015; J.-H.; Kim, 2017; Lapointe, Boudreau-Pinsonneault, & Vaghefi, 2013). Additionally, they may become more reluctant to engage in face-to-face interactions preferring smartphone-mediated communication instead (J.-H. Kim, 2017). Several studies have confirmed that this behavior can, in turn, lead to PSU (e.g., Bian & Leung, 2015; J.-H.; Kim, 2018; Lapointe et al., 2013; Mahapatra, 2019) and that loneliness is higher in those who engage in PSU (Mosalanejad, Nikbakht, Abdollahifrad, & Kalani, 2019). However, some studies did not find any link between loneliness and PSU (e.g., Aktürk, Budak, Gültekin, & Özdemir, 2018). Furthermore, experiencing loneliness may lead to boredom and smartphone usage without any specific reason to relieve negative emotions. The more the smartphone is used without a particular purpose, the more likely it is for an individual to engage in PSU (Zhitomirsky-Geffet & Blau, 2016).

Even though most studies have investigated potential links between loneliness and PSU in younger people, we expect a link between loneliness as experienced by older adults and EG:

H1a: Loneliness is positively linked to EG.

2.5. *Social influence*

SI is the degree to which an individual perceives that significant others believe they should use the smartphone (cf., Venkatesh, Morris, Davis, & Davis, 2003). Older adults are often less technology and Internet literate than younger generations (e.g., Jokisch, Schmidt, Doh, Marquard, & Wahl, 2020). Therefore, they tend to rely on their families for advice on technology use. As younger generations experience smartphone use benefits, they might advise older adults to use them, mainly to keep in touch with family and friends. Research has shown that older adults are willing to adopt several technologies encouraged by their children and grandchildren (Luijkx et al., 2015). SI, however, may be context and technology-dependent. For example, Arenas-Gaitán et al. (2015) found that family and friends did not significantly impact the intentions to adopt mobile banking among older adults. Furthermore, older adults seem to be more confident with technology's informational features than connectivity-based features (Jokisch et al., 2020). Thus, we expect that the influence of family and friends on the older adults' use of connectivity-based features (e.g., social media) will lead to increased EG. Hence, we put forward the following hypothesis:

H1b: SI is positively linked to EG.

2.6. *Habit*

Habit is the extent to which people automatically perform behaviors because of learning (Limayem, Hirt, & Cheung, 2007). Habit has been found to positively influence behavioral intentions to use mobile technologies, such as smartphones, among older adults (Arenas-Gaitán et al., 2015). Research has found that smartphone accessibility can explain habitual behavior, where the primary motives for habits were entertainment and pastime (Oulasvirta, Rattenbury, Ma, & Raita, 2012; Zhitomirsky-Geffet & Blau, 2016). For example, when smartphone users find specific smartphone activities enjoyable, they are more likely to ignore any warnings or possible adverse outcomes (cf., Turel & Serenko, 2012). Thus, the EG perceived by a user will create a reinforcement effect; the user will seek to achieve EG from the smartphone creating habitual behavior. We, therefore, propose the following hypothesis:

H1c: Habit is positively linked to EG.

3. Method

We conducted a cross-sectional study of 154 older adults using smartphones to test our hypotheses.

3.1. *Procedure and participants*

We recruited participants from three different sources engaging older adults: a news magazine for older adults, a national association for retirees, and an interest organization for older adults in Norway. We contacted the administrators of their Facebook pages, informing them about the research project and inviting their subscribers to participate. The administrators distributed the survey link on their Facebook pages to the respondents on our behalf. To participate in the study, participants had to fulfill two criteria: (1) aged 60 years and older and (2) using a smartphone. Participants who met the eligibility criteria provided their informed consent and completed the survey hosted on an online data collection platform. To increase the likelihood of participation, we offered gift certificates that were given to two of the respondents after the data collection finished (after a draw). In total, 166 older adults completed the survey, of which 12 were removed because of incomplete responses or not fulfilling the inclusion criteria, ending up with 154 respondents. Of these, 115 (74.7%) respondents made use of the gift certificate option. The Norwegian Centre for Research Data approved the study.

3.2. *Measures*

We obtained data on the respondents' age, gender, marriage status, work status, and years of owning a smartphone. Whereas most scales employed in the study were from prior research, we developed a scale to measure smartphone usage and adapted FoMO to older adults' context. We measured PSU through the 10-item mobile phone problematic use scale (MPPUS-10) developed by Foerster, Roser, Schoeni, and Röösli (2015). MPPUS-10 highly reflects the original MPPUS-27 with a Cronbach's alpha of 0.85 (Foerster et al., 2015). Each question in MPPUS-10 is worth 7 points, and the maximum total score is 70. MPPUS-10 is a continuous scale, reflecting the level of PSU. Previous research has indicated a cutoff value to describe when smartphone usage becomes problematic. Based on a cutoff point of 160 in MPPUS-27 (Kalhori et al., 2015; Nahas et al., 2018), we used the extrapolated cut-off point of 41 in MPPUS-10. FoMO was measured by adapting a 10-item scale by Przybylski et al. (2013), adding family to the people they follow closely in addition to friends. EG was measured by using a 7-item instrument developed by Zhitomirsky-Geffet and Blau (2016). SC was measured with the 13-item Brief Self-Control Scale (BSCS) by Tangney et al. (2004). Loneliness was measured through the UCLA loneliness scale (UCLA-10) developed by Russell (1996). The UCLA loneliness scale measures individuals' subjective feelings of loneliness as well as feelings of social isolation. The scale measuring smartphone usage consists of 10 items and is based on a self-assessment of actual usage (in minutes) and the perception of this usage using a 3-point Likert scale. The items were based on the work by Elhai and Contractor (2018). By using short versions of measurement instruments, we sought to avoid questionnaire fatigue among the respondents. Appendices D and E list all and retained measurement scales respectively.

4. Data analysis and results

First, we analyzed descriptive data to understand more about the nature of smartphone usage of older adults. Moreover, we used structural equation modeling with the partial least squares estimation technique (PLS-SEM) to analyze our data and test the hypotheses. We followed best practices for reporting PLS-SEM results, as recommended by Hair, Hollingsworth, Randolph, and Chong (2017). PLS-SEM is considered suitable in research with relatively small samples (Hair et al., 2017). Using the ten times rule, where the minimum sample size should be greater than ten times the maximum number of structural paths directed at a particular construct (Hair et al., 2017), our sample size is well above the required minimum of 30 respondents. The data analysis was conducted using SmartPLS by following the two following steps: (1) assessment of the reliability of the PLS model (instrument validation) and (2) assessment of the hypothesized relationships in the research model (model validation).

4.1. Descriptives

Four (2.5%) of the 158 respondents completing the survey reported not using smartphones. Thus, 154 respondents met the inclusion criteria of this study. Table 1 presents the age distribution of the sample population.

The sample population consisted of 72.7% female and 27.3% male respondents with the following marital status: married (50.0%), unmarried (29.2%), widowed (14.9%), and registered partners (5.8%). 19.5% was still part of the active workforce, where the majority of these respondents (83.3%) were between 60 and 67 years.

The sample population had been using smartphones for 8.7 years on average (SD = 4.3 years). Table 2 presents the distribution of years of older adults using a smartphone. The vendors of the smartphones currently used by the respondents were Apple (52.8%), Samsung (29.9%), Huawei (12.5%), Sony (4.2%), and Motorola (0.7%).

Table 3 presents the different types of smartphone activities in the sample population. The first column of the table presents the average minutes used on each activity per day. For example, social media was the most used smartphone activity with 39.8 min on average per day. In sum, the sample population spent 159.4 min on average per day using their smartphones. Furthermore, the table presents the respondents' perception of the time spent on each activity. The self-assessed perception of use is measured in the intervals of 'very low', 'normal', and very high'. For example, 10.7% of the respondents reported that their use of social media on the smartphone was classified as 'very high'. Of the respondents reporting social media use as 'very high', the average time spent on this activity was 67.6 min per day.

The different types of uses can be classified into social and non-social use of the smartphone. The smartphone's social use (including social media, audio/video calling, and instant messaging) comprises 45.2% of the total smartphone use of older adults, whereas 54.8% was non-social use.

Table 4 presents the distribution of PSU in the sample population. Comparing the results with working and non-working respondents, we found no significant differences in the different PSU levels. As presented in Table 3, more than 10% of the sample population reported that their use of social media and reading news was 'very high'. However, by setting the PSU cutoff to 41, the PSU prevalence in the sample population was only 2.4%.

Table 1
Age distribution of respondents.

60–64 yrs.	64–69 yrs.	70–74 yrs.	75–79 yrs.	Over 79 yrs.
22.1%	29.2%	29.9%	13.6%	1.9%

n = 154; AVG = 69.0 yrs; SD = 5.7 yrs; MIN = 60 yrs; MAX = 89 yrs.

Table 2
Years using a smartphone.

1–4 yrs.	5–9 yrs.	10–14 yrs.	>15 yrs.
15.7%	39.9%	33.3%	11.1%

n = 153; AVG = 8.7 yrs; SD = 6.5 yrs; MIN = 1 yrs; MAX = 25 yrs.

Table 3
Self-assessed use of the smartphone.

Activity	Min/day (avg.)	Very low	Normal	Very high
Social media	39.8	18.6	42.2	67.6
		21.3%	68.0%	10.7%
Reading news	28.8	11.2	34.7	37.6
		26.0%	64.0%	10.0%
Audio/video calling	18.4	9.2	31.9	*
		57.3%	41.3%	1.3%
Gaming	16.0	2.8	32.3	106.4
		74.0%	18.7%	7.3%
Instant messaging	14.3	8.4	17.7	*
		36.0%	64.0%	1.3%
Emailing	14.2	6.5	19.0	30.0
		39.3%	58.7%	2.0%
Listening to music	8.4	2.3	19.7	105.0
		84.7%	11.3%	4.0%
Photo/video recording	7.6	4.6	11.0	21.4
		62.0%	32.0%	6.0%
Watching video	7.0	1.8	28.7	*
		84.0%	14.7%	1.3%
Navigating	6.0	2.8	13.3	15.4
		70.7%	26.0%	3.3%
Total (avg. mins.)	159.4	60.9	144.4	237.8

n = 150 (total); *insufficient data ($n \leq 2$)

Table 4
Distribution of PSU levels.

10-20	21–30	31–40	>40
50.4%	35.8%	11.4%	2.4%

4.2. Instrument validation

We conducted the instrument validation in four steps. First, we assessed indicator reliability for the reflective constructs included in the model. Our initial analysis revealed that indicator loadings were too low for several indicators. We subsequently modified the model by removing these indicators. After the modification, we found that all outer loadings were above the recommended level of 0.70 except for PSU4 and FoMO10, which is acceptable in exploratory research (Hair, Hult, Ringle, & Sarstedt, 2014).

In the second step, we assessed construct reliability by using the composite reliability (CR) measure since it is in line with the working principle of the PLS-SEM algorithm (Hair et al., 2014). The analysis showed that all CR values were above the recommended value of 0.70 (Hair et al., 2017).

In the third and fourth steps, we assessed construct validity (i.e., convergent and discriminant validity, respectively). We used the average variance extracted (AVE) of the constructs to assess convergent validity. All AVE values were above the recommended threshold value of 0.50 (Hair et al., 2017).

In the final step, we assessed the constructs' discriminant validity by checking cross-loadings (Chin, 1998) and using the Fornell-Larcker criterion (Fornell & Larcker, 1981). Our analysis showed no indicator loading higher on any other construct than the construct it was designed to measure. Moreover, the Fornell-Larcker's test showed that the square root of each construct's AVE was higher than the correlations between the construct and other constructs. Additionally, we assessed the newer heterotrait-monotrait ratio (HTMT) to assess discriminant validity. All values were below 0.85 (Hair et al., 2017). Appendix A presents the cross-loadings. Appendix B presents correlations between the latent variables with the AVE's square root (in bold) on the diagonal. The HTMT assessment results are presented in Appendix C. All survey measurement items are listed in Appendix D. Appendix E lists the retained items with reliability and validity metrics demonstrating measurement quality.

4.3. Model validation

Fig. 2 shows the research model with path coefficients (β), hypotheses, and explained variance of the endogenous variables (R2).

We used bootstrapping to assess the significance of the path coefficients (Hair, Ringle, & Sarstedt, 2011). As depicted in Table 5, all our hypotheses were empirically supported.

Loneliness is found to have a positive and significant impact on EG ($\beta = 0.402$, $t = 6.189$, $p \leq .001$). Social influence is found to have a positive and significant impact on EG ($\beta = 0.267$, $t = 4.355$, $p \leq .001$). Habit is found to have a positive and significant impact on EG ($\beta = 0.149$, $t = 2.194$, $p \leq .05$). EG is found to have a positive and significant impact on FoMO ($\beta = 0.517$, $t = 8.933$, $p \leq .001$). EG ($\beta = 0.285$, $t = 3.257$, $p \leq .001$) and FoMO ($\beta = 0.186$, $t = 2.063$, $p \leq .05$) are both found to have positive and significant effects on PSU. Self-control is found to have a positive and significant impact on PSU ($\beta = -0.233$, $t = 3.151$, $p \leq .01$). The structural model predicts 29.6% of the variance for PSU. It further predicts 26.8% and 24.7% of the variance for FoMO and EG respectively.

We continued our analysis by assessing the contributions of exogenous constructs have on endogenous constructs by simulating the inclusion and exclusion of exogenous constructs (Hair et al., 2014). This measure is called effect size (Cohen's f2). Investigating the effects on PSU, we found that FoMO (f2 = 0.036), EG (f2 = 0.078), and SC (f2 = 0.066) showed weak effects. Investigating the effect on FoMO, we found that EG (f2 = 0.365) showed a strong effect. Loneliness (f2 = 0.213) showed a moderate effect on EG whereas social influence (f2 = 0.091) and habit (f2 = 0.028) showed weak effects on EG (Hair et al., 2017). In exploratory studies, weak effect sizes are acceptable.

The final assessment was to examine the exogenous constructs' predictive relevance (using Stone-Geisser's Q2 value) and its related effect size (q2). We performed a blindfolding procedure (omission distance = 8) suggesting that PSU (Q2 = 0.135), FoMO (Q2 = 0.144), and EG (Q2 = 0.150) have sufficient predictive relevance (Hair et al., 2014, 2017). The effect size q2 was calculated manually for each construct. Table 6 presents the results from the f2 and q2 assessments.

These calculations revealed a strong effect for H2, moderate effect for H1a, and weak effects for the other hypotheses. The calculations also showed moderate predictive relevance for H2, weak predictive relevance for H1a, H1b, and H5, and unsatisfactory values for H1c, H3, and H4 (Hair et al., 2017).

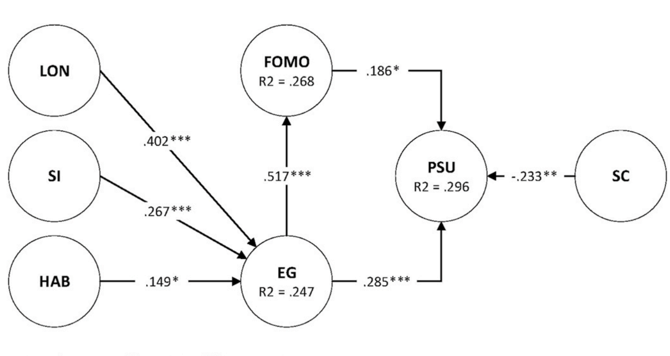

Fig. 2. Results of hypotheses tests.

Table 5
Summary of hypotheses tests.

Hypothesis	Path	Support
H1a	LON - > EG	Yes
H1b	SI - > EG	Yes
H1c	HAB - > EG	Yes
H2	EG - > FoMO	Yes
H3	EG - > PSU	Yes
H4	FoMO - > PSU	Yes
H5	SC - > PSU	Yes

Table 6
Effect size and relative prediction relevance values.

Hypothesis	Path	f^2	q^2
H1a	LON - > EG	.213	.12
H1b	SI - > EG	.091	.05
H1c	HAB - > EG	.028	.01
H2	EG - > FoMO	.365	.17
H3	EG - > PSU	.078	.01
H4	FoMO - > PSU	.036	.01
H5	SC - > PSU	.066	.02

5. Discussion

This research has explored how older adults use their smartphones. Our results are among the first to discuss smartphone usage among older adults (cf., Busch & McCarthy, 2021). This study suggests that loneliness is the strongest predictor of EG among older adult smartphone users. EG further predicts FoMO among older adults. Social media is the most prevalent type of smartphone usage (averaging 23% of daily usage), explaining the strong correlation between EG and FoMO. Our findings further suggest a low prevalence of PSU among older adult smartphone users. However, 20.8% of the respondents perceived their smartphone usage to be "very high". Among those who assessed their usage as normal, they spent, on average, slightly more than two hours per day. Those who considered their usage as very high spent on average four hours per day. Whereas SI and habit were strong predictors of smartphone usage among older adults, loneliness was not. FoMO was not prevalent among older adults. Also, as we expected, the findings suggest that higher self-control reduce PSU behavior among older adults. Our findings contribute to research by providing knowledge within a context of smartphone usage, which is scarcely researched in the literature.

We hypothesized that loneliness, habit, and social influence are related to the perception of EG among older adults. Our findings supported all hypothesized relationships. The study findings further suggest that loneliness is the strongest indicator of EG. This finding is congruent with the literature, which has found loneliness to be a strong indicator of PSU behavior (e.g., Mahapatra, 2019). Loneliness is more prevalent among older adults than other age groups (Nicolaisen & Thorsen, 2014). Attachment theory suggests that emotional and physical bonding is vital for people to retain emotional health for both younger adults (Trub & Barbot, 2016) and older adults (Shunqin, 2015). Furthermore, with its internet connectivity, the smartphone has been identified as a device that can fulfill social needs (Mahapatra, 2019) and contribute to maintaining a sense of belonging in old age (Singh & Kiran, 2013). Thus, we expected individuals in this age group to alleviate feelings of loneliness by using the smartphone. The smartphone is a convenient device to reduce social distance and give older adults a sense of social interaction. According to the respondents' usage statistics, older adults in this study spent most of their smartphone time on social interaction activities such as social networking, calling, instant messaging, and emailing.

As an explanation for technology adoption, social influence has been thoroughly researched in the IS literature (Venkatesh et al., 2003). The literature identifies three sources of influence for technology adoption among older adults above 60 years of age. These sources are social networks (friends), family, and organizations (Tsertsidis, Kolkowska, & Hedström, 2019). Whereas the literature has found that adolescents are heavily influenced to use various technologies, our findings suggest that also older adults experience a considerable amount of social influence to use their smartphones. We did not specify the sources of influence, but considering the societal interest in and development of digital solutions, older adults may feel pressure to use a smartphone. Our findings indicated that almost 62% of our respondents experienced a strong social influence using smartphones. This group also owned a smartphone for the longest time. This finding can be explained by the fact that smartphone use expectations increase as older adults become more familiar with their smartphones. For example, family and friends may have encouraged their older adult family members to use applications such as Snapchat. Furthermore, as older adults become more smartphone literate, they may experience more EG from smartphone usage. Our findings suggest that older adults who experienced the most EG also used the smartphone the longest time.

Our findings suggest that EG is a predictor of both FoMO and PSU behavior. Whereas FoMO is a well-known phenomenon among adolescents, older adults seem to be significantly less impacted by FoMO on information about social events. Whereas adolescents are digital natives where social interaction is mainly by digital channels, older adults are digital immigrants whose social interactions are more hybrid; they use digital and analog channels. This distinction can explain the low prevalence of EG and FoMO among older adults in our study (high scores were found for 7.4% and 2.0% of the respondents, respectively) even though we have surveyed older adult smartphone users only. Older adults may be more confident in themselves and have already established social networks, not having the same need for using the smartphone for social interaction. Unlike older adults, the younger experience a heightened desire for connectedness with peers during adolescence. Thus, FoMO is more prevalent in adolescents due to the digital nature of communications among adolescents (Barry, Sidoti, Briggs, Reiter, & Lindsey, 2017).

Much of the technology acceptance and use literature in IS has presupposed that technology use is a positive and desired outcome. However, the premise for PSU research is that this is not always the case since PSU behavior is undesired and irrational. Perceived usefulness has been used to explain technology acceptance in terms of rational behavior, e.g., smartphone use to increase job performance. On the other hand, the EG is intrinsic and explains the more irrational spectrum of smartphone use. Since PSU behavior is undesired and irrational, the behavior is influenced by the level of self-control. Our findings suggest that self-control is a negative predictor of PSU among older adults. This finding is expected and per existing literature, since the nature of PSU is associated with a loss of control in their lives. Our respondents reported medium to high levels of self-control, which can explain the low prevalence of PSU in this study. This finding can also be associated with the fact that they experience less pressure (social influence) to use the smartphone, and thus, they do not experience smartphone use as pervasive as adolescents.

Our findings further suggest a low prevalence of PSU (2.4%) among older adults. However, approximately 20% of our respondents characterized their smartphone use as 'very high', averaging four hours per day. Existing literature indicates that hourly smartphone usage is not a clear determinant of PSU. However, users associated with PSU behavior are, in general, high users. Comparing early (e.g., Oulasvirta et al., 2012) and more recent studies (e.g., Bragazzi et al., 2019), there seems to be a change in the understanding of what constitutes normative smartphone usage. Whereas Oulasvirta et al. (2012) indicate that three hours of daily usage can be considered as heavy smartphone usage, Bragazzi et al. (2019) found that more than 50% of the respondents (averaging 28 years old) used the smartphone more than three hours per day. This change can be attributed to a higher tolerance for smartphone usage and increased areas for usage. Whereas 29% of our respondents used the smartphone for more than three hours per day, only 40% reported this as very high. Furthermore, our findings suggest that 2.4 hours of daily usage is normal for older adults considering normative smartphone usage. However, considerations about high and normative smartphone usage must account for factors such as work situation and relationship status since our respondents mainly were retired and have fewer daily obligations than work active and younger users. Thus, they can spend more time on the smartphone without impacting professional and social performance. Hence, high smartphone usage among older and younger cohorts cannot necessarily be compared - and categorizations of low, normative, and high usage must be differentiated between age groups.

Another important distinction is between the different types of use areas, as identified by the literature (Davazdahemami et al., 2016). Our findings show that older adults mainly used the smartphone for non-social purposes, comprising 54.8% of the total usage. Within this category, 'reading news' was most frequent. Social use was found to comprise 45.2% of the total usage among older adults. Within social use, 'social network' was the most frequent use area in our sample population. As illustrated in Table 3, our findings suggest diverse smartphone usage among older adults. Given this diversity of use (varying from social interaction to information retrieval and hedonic purposes), these findings strengthen our argument that normative use must distinguish between age cohorts and usage types.

Moreover, existing research has found that online technologies for social interactions are associated with a higher level of loneliness among younger cohorts and lower levels among older adults. Other uses (e.g., information retrieval and hedonic use) are associated with a higher level of loneliness among all age cohorts (Nowland et al., 2018). One reason for the difference between the age cohorts in social interactions is attributed to the changing intentions of use throughout life (Sims et al., 2017). SST explains these changing intentions by emphasizing how social networks reconstruct as people age (Carstensen et al., 1999). In contrast, younger individuals maintain large and often peripheral social networks online. Older adults prefer to cultivate smaller and more intimate online networks (Nicolaisen & Thorsen, 2014) that reinforce their offline network (Nowland et al., 2018). While we did not investigate the direct link between loneliness and social use of smartphones, we observed high social media usage and low prevalence of loneliness. This finding resonates with SST and previous studies on loneliness and social use of technology (e.g., Sims et al., 2017). Thus, we recommend increased use of smartphones to strengthen existing social relations to reduce loneliness and prevent PSU.

Whereas our findings suggest a low prevalence of PSU (2,4%), indicating that the use of smartphones is less problematic among older adults, the analysis revealed higher scores on the following two items; “If I don't have a smartphone, my friends and family would find it hard to get in touch with me” (PSU3), and “I find myself engaged on the smartphone for longer periods of time than intended” (PSU6). This finding could reflect the high usage among some older adults and their dependence on family and peers, indicating that loneliness and the need to connect with other contribute to PSU. Despite the current low prevalence, our finding raises the question of whether smartphone use among older adults will become a problem for the next generation of older adults. Will the next generation of older adults bring their PSU into their retirement, or are there characteristics among older adults that influence their perceptions of 'problematic use'? For example, different age cohorts have various characteristics such as curiosity, engagement, and how social networks are established and maintained (e.g., Nicolaisen & Thorsen, 2014). Whether such differences may result in a more consistent lower smartphone usage among older adults (compared to younger cohorts) also when more digitally capable users become older adults is a potential avenue for future research.

5.1. Limitations and future research

We recognize that our study has some limitations. First, our sample consists of smartphone users residing in Norway only, which may influence our findings' generalizability. Whereas we acknowledge this shortcoming, we argue that Norwegian older adults reside in a country that ranks highly on digitalization indexes, and thus, are highly exposed to digital services serving as a good illustrative case of how older adult smartphone users may be engaged in PSU. Future research should investigate PSU among older adults in other contexts. Second, since our respondents were recruited through Facebook, they are probably higher in internet self-efficacy than other older adults. However, when investigating smartphone usage and PSU, we were interested in older adults who use their smartphones more often. Future research could take a broader approach to examine the prevalence of smartphone usage and PSU among older adults. Third, our model's validation shows low values on some metrics suggesting that the used scales in this study are not entirely fit to the context of older adults. However, we argue that our study is among the first to study PSU behavior among older adults, representing an exploratory study where lower values are common and acceptable (Hair et al., 2017). Future studies could refine our measurement instrument by adapting our scales on FoMO, EG, and PSU. Regarding PSU, we suggest future qualitative studies investigating better adapted candidate items of PSU in the context of older adults.

6. Conclusion

This study has explored how older adults use their smartphones. While most of the current literature investigates smartphone usage and PSU among adolescents (Busch & McCarthy, 2021), this study focuses on smartphone usage among older adults. Our findings reveal that older adults use smartphones for various social and non-social reasons and that social media and news reading are the most common use areas. However, smartphone usage was found to be associated with a low prevalence of PSU among older adults.

Smartphone usage holds the potential for both positive and adverse effects. On the one hand, used for social interactions, smartphone use can prevent loneliness, PSU, and cognitive decline. On the other hand, we know that digital technologies become increasingly important in modern society, where the next generation of older adults experiences more problematic use. Thus, we suggest that researchers adopt a balanced approach that accounts for both the positive and adverse effects of smartphone use among older adults. We contribute to the literature by providing knowledge about smartphone usage and PSU for an age group with a very different starting point than the adolescents most frequently examined in the literature.

Declaration of competing interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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APPENDICES.

Appendix A. Crossloadings

	EG	FOMO	HAB	LON	PSU	SC	SI
EG3	**0.761**	0.352	0.268	0.258	0.313	−0.218	0.237
EG4	**0.841**	0.376	0.158	0.388	0.390	−0.415	0.215
EG5	**0.848**	0.404	0.117	0.278	0.381	−0.271	0.219
EG6	**0.775**	0.525	0.048	0.271	0.414	−0.267	0.188
FoMO10	0.318	**0.611**	0.372	0.072	0.394	−0.223	0.287
FoMO2	0.380	**0.806**	−0.098	0.255	0.194	−0.162	0.169
FoMO3	0.461	**0.839**	−0.012	0.247	0.285	−0.182	0.146
HAB1	0.091	0.045	**0.902**	−0.089	0.160	−0.031	0.198
HAB2	0.159	0.109	**0.920**	−0.054	0.249	−0.077	0.179
HAB3	0.175	0.141	**0.948**	−0.061	0.227	−0.095	0.168
HAB4	0.191	0.126	**0.899**	−0.033	0.245	−0.049	0.187
LON1	0.263	0.204	0.075	**0.710**	0.172	−0.394	−0.036
LON10	0.208	0.158	−0.044	**0.741**	0.316	−0.346	−0.130
LON2	0.323	0.185	−0.088	**0.855**	0.201	−0.339	−0.124
LON6	0.305	0.160	−0.019	**0.824**	0.231	−0.365	−0.022
LON7	0.344	0.238	−0.130	**0.816**	0.290	−0.384	−0.048
LON8	0.312	0.231	−0.033	**0.812**	0.265	−0.426	0.015
LON9	0.302	0.229	−0.067	**0.845**	0.237	−0.421	−0.120
PSU4	0.413	0.333	0.169	0.194	**0.651**	−0.194	0.201
PSU6	0.294	0.249	0.250	0.286	**0.806**	−0.374	0.073
PSU9	0.319	0.282	0.128	0.186	**0.752**	−0.282	0.092
SC12	−0.315	−0.192	0.028	−0.448	−0.275	**0.714**	0.060
SC2	−0.297	−0.226	−0.149	−0.331	−0.370	**0.863**	0.149
SC7	−0.224	−0.151	−0.003	−0.341	−0.204	**0.717**	0.108
SI1	0.212	0.195	0.175	−0.086	0.107	0.123	**0.924**
SI2	0.293	0.305	0.183	−0.045	0.184	0.143	**0.954**
SI3	0.232	0.236	0.200	−0.103	0.173	0.130	**0.952**

Appendix B. Discriminant validity (Fornell-Larcker criterion)

	Variable	1	2	3	4	5	6	7
1	SI	.944						
2	**LON**	-.079	**.802**					
3	**HAB**	.197	-.060	**.917**				
4	**EG**	.265	.372	.178	**.807**			
5	**FoMO**	.266	.252	.124	.517	**.759**		
6	**SC**	.141	-.476	-.072	-.366	-.253	**.768**	
7	**PSU**	.168	.302	.249	.467	.393	-.384	**.739**

Appendix C. Discriminant validity (HTMT)

	EG	FOMO	HAB	LON	PSU	SC
FOMO	0.715					
HAB	0.197	0.288				
LON	0.423	0.336	0.094			
PSU	0.670	0.644	0.324	0.420		
SC	0.487	0.385	0.117	0.627	0.596	
SI	0.298	0.341	0.212	0.100	0.220	0.172

Appendix D. Survey measurement items (all)

Item	Wording	Mean	SD
SI1	People who are important to me think that I should use a smartphone.	5.66	1.79
SI2	People who influence my behavior think that I should use a smartphone.	5.27	1.91
SI3	People whose opinions that I value prefer that I use a smartphone.	5.37	1.93
LON1	I feel unhappy doing so many things alone.	3.14	1.84
LON2	I feel I have no one to talk to.	2.75	1.83
LON3	I feel I cannot tolerate being so alone.	2.32	1.51
LON4	I feel as if no one understands me.	2.01	1.34
LON5	I find myself waiting for people to call or write.	2.46	1.56
LON6	I feel completely alone.	2.23	1.63
LON7	I feel unable to reach out and communicate with those around me.	1.94	1.30
LON8	I feel starved for company.	2.93	1.66
LON9	I feel it is difficult for me to make friends.	2.31	1.66
LON10	I feel shut out and excluded by others.	1.83	1.40
HAB1	Smartphone use is part of my daily routines.	6.48	1.10
HAB2	I use my smartphone without reflection.	6.25	1.35
HAB3	It's a habit to use my smartphone.	6.41	1.17
HAB4	When I need to complete a certain task then the use of my smartphone is an obvious choice.	5.94	1.44
EG1	I enjoy my smartphone.	6.36	1.12
EG2	My smartphone makes me feel calm and self-confident.	5.55	1.59
EG3	When I am busy with my smartphone I am able to forget about my sorrows.	3.52	1.75
EG4	I look at my smartphone when I am irritated, so that I won't have to deal with what is bothering me.	3.11	1.89
EG5	I use my smartphone to relieve boredom, irritability, anger, loneliness, or sadness.	2.84	1.69
EG6	I think my life would be boring and lacking fun without my smartphone.	2.24	1.39
EG7	I feel depressed and stressed when my smartphone is out of reach.	2.99	1.81
FOMO1	I fear others have more rewarding experiences than me	2.27	1.41
FOMO2	I fear my friends and family have more rewarding experiences than me	2.17	1.33
FOMO3	I get worried when I find out my friends and family are having fun without me.	1.92	1.23
FOMO4	I get anxious when I don't know what my friends and family are up to.	1.97	1.25
FOMO5	It is important that I understand my friends and family "in jokes''.	4.23	1.90
FOMO6	Sometimes, I wonder if I spend too much time keeping up with what is going on.	3.85	1.88
FOMO7	It bothers me when I miss an opportunity to meet up with friends and family.	3.11	1.58
FOMO8	When I have a good time it is important for me to share the details online (e.g. updating status).	2.97	1.70
FOMO9	When I miss out on a planned get-together it bothers me.	3.12	1.79
FOMO10	When I go on vacation, I continue to keep tabs on what my friends and family are doing.	4.24	1.91
SC1	I am good at resisting temptation.	4.96	1.40
SC2	I have a hard time breaking bad habits. (R)	4.53	1.55
SC3	I am lazy. (R)	4.85	1.66
SC4	I say inappropriate things. (R)	5.73	1.46
SC5	I do certain things that are bad for me, if they are fun. (R)	4.34	1.69
SC6	I refuse things that are bad for me.	4.08	1.66
SC7	I wish I had more self-discipline. (R)	4.57	1.81
SC8	People would say that I have iron self- discipline.	4.16	1.49
SC9	Pleasure and fun sometimes keep me from getting work done. (R)	3.29	1.67
SC10	I have trouble concentrating. (R)	5.42	1.64
SC11	I am able to work effectively toward long-term goals.	5.36	1.53
SC12	Sometimes I can't stop myself from doing something, even if I know it is wrong. (R)	5.60	1.40
SC13	I often act without thinking through all the alternatives. (R)	5.10	1.47
PSU1	I have used my smartphone to make myself feel better when I was feeling down.	2.13	1.69

(*continued on next page*)

(*continued*)

Item	Wording	Mean	SD
PSU2	When out of range for some time, I become preoccupied with the thought of missing a call.	1.95	1.32
PSU3	If I don't have a smartphone, my friends and family would find it hard to get in touch with me.	3.56	2.05
PSU4	I feel anxious if I have not checked for messages or switched on my smartphone for some time.	2.27	1.52
PSU5	My friends and family complain about my use of the smartphone.	1.88	1.40
PSU6	I find myself engaged on the smartphone for longer periods of time than intended.	3.14	1.87
PSU7	I am often late for appointments because I'm engaged on the smartphone when I shouldn't be.	1.10	0.45
PSU8	I find it difficult to switch off my smartphone.	2.36	1.88
PSU9	I have been told that I spend too much time on my smartphone.	1.68	1.27
PSU10	I have received phone bills I could not afford to pay.	1.05	0.49
SU1	On average, how many minutes per day do you spend on … voice/video calls?	22.81	55.78
SU1a*	I consider this use to be …	1.45	0.52
SU2	On average, how many minutes per day do you spend on … text/instant messaging?	17.19	28.84
SU2a*	I consider this use to be …	1.68	0.51
SU3	On average, how many minutes per day do you spend on … reading and writing e-mail?	22.56	76.83
SU3a*	I consider this use to be …	1.64	0.53
SU4	On average, how many minutes per day do you spend on … social networking?	46.70	69.78
SU4a*	I consider this use to be …	1.90	0.56
SU5	On average, how many minutes per day do you spend on … listening to music?	22.54	165.78
SU5a*	I consider this use to be …	1.21	0.49
SU6	On average, how many minutes per day do you spend on … gaming?	16.14	41.89
SU6a*	I consider this use to be …	1.34	0.61
SU7	On average, how many minutes per day do you spend on … taking pictures and/or making videos?	8.19	13.36
SU7a*	I consider this use to be …	1.44	0.60
SU8	On average, how many minutes per day do you spend on … watching TV series and movies?	9.18	28.76
SU8a*	I consider this use to be …	1.19	0.43
SU9	On average, how many minutes per day do you spend on … reading news etc.?	33.55	43.64
SU9a*	I consider this use to be …	1.85	0.58
SU10	On average, how many minutes per day do you spend on … map navigation?	6.59	12.81
SU10a*	I consider this use to be …	1.33	0.54
SU11	Overall, I consider my smartphone use to be …	4.51	1.40

* 3-point Likert scale.

Appendix E. Survey measurement items and construct validity metrics

Variable	AVE	CR	Item	Wording	OL	Mean	SD
SI	.891	.961	SI1	People who are important to me think that I should use a smartphone.	.924	5.66	1.79
			SI2	People who influence my behavior think that I should use a smartphone.	.954	5.27	1.91
			SI3	People whose opinions that I value prefer that I use a smartphone.	.952	5.37	1.93
LON	.643	.926	LON1	I feel unhappy doing so many things alone.	.710	3.14	1.84
			LON2	I feel I have no one to talk to.	.855	2.75	1.83
			LON6	I feel completely alone.	.824	2.23	1.63
			LON7	I feel unable to reach out and communicate with those around me.	.816	1.94	1.30
			LON8	I feel starved for company.	.812	2.93	1.66
			LON9	I feel it is difficult for me to make friends.	.845	2.31	1.66
			LON10	I feel shut out and excluded by others.	.741	1.83	1.40
HAB	.842	.955	HAB1	Smartphone use is part of my daily routines.	.902	6.48	1.10
			HAB2	I use my smartphone without reflection (adapted).	.920	6.25	1.35
			HAB3	It's a habit to use my smartphone.	.948	6.41	1.17
			HAB4	When I need to complete a certain task then the use of my smartphone is an obvious choice.	.899	5.94	1.44
EG	.652	.882	EG3	When I am busy with my smartphone I am able to forget about my sorrows.	.761	3.52	1.75
			EG4	I look at my smartphone when I am irritated, so that I won't have to deal with what is bothering me.	.841	3.11	1.89
			EG5	I use my smartphone to relieve boredom, irritability, anger, loneliness, or sadness.	.848	2.84	1.69
			EG6	I think my life would be boring and lacking fun without my smartphone.	.775	2.24	1.39
FoMO	.576	.800	FoMO2	I fear my friends and family have more rewarding experiences than me (adapted).	.806	2.17	1.33
			FoMO3	I get worried when I find out my friends and family are having fun without me (adapted).	.839	1.92	1.23
			FoMO10	When I go on vacation, I continue to keep tabs on what my friends and family are doing (adapted).	.611	4.24	1.91
SC	.590	.811	SC2	I have a hard time breaking bad habits (R)	.863	4.53	1.55
			SC7	I wish I had more self-discipline (R)	.717	4.57	1.81
			SC12	Sometimes I can't stop myself from doing something, even if I know it is wrong (R)	.714	5.60	1.40
PSU	.546	.782	PSU4	I feel anxious if I have not checked for messages or switched on my mobile phone for some time.	.651	2.27	1.52
			PSU6	I find myself engaged on the mobile phone for longer periods of time than intended.	.806	3.14	1.87
			PSU9	I have been told that I spend too much time on my mobile phone.	.752	1.68	1.27

(R) = Items are reversed, CR = Composite reliability, AVE = Average Variance Extracted, OL = Outer loadings, SD = Standard deviation.

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