Fear of missing out and fear of not being up to date: investigating different pathways towards social and process problematic smartphone use

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Abstract

The present study introduces a new construct potentially associated with problematic smartphone use, that is the fear of not being up to date, and tests two serial mediation models, in which it was hypothesised that: (i) metacognitions and social smartphone use would be serial mediators of the relationship between the fear of missing out (FoMO) and problematic smartphone use (PSU); and (ii) metacognitions and process smartphone use would be serial mediators of the relationship between and the fear of not being up to date and PSU. A sample of 364 participants ($F = 72.8\%$; mean age $= 36.80 \pm 15.32$ years; age range: 18–75 years), recruited online, were administered a battery of self-report measures assessing FoMO, the fear of not being up to date, metacognitions about smartphone use, process and social smartphone use, and PSU. The serial mediation effect of metacognitions about smartphone use and process use on the relationship between the fear of not being up to date and PSU was significant (indirect effect $= 0.004$; 95% CI: [0.0006, 0.009]). Conversely, the serial mediation effect of metacognitions about smartphone use and social use on the relationship between FoMO and PSU was not significant (indirect effect $= 0.002$; 95% CI: [-0.003, 0.009]). Smartphone social use did not predict PSU. The current study highlights a possible pathway towards process smartphone use via a relatively new phenomenon termed "fear of not being up to date" within a metacognitive framework.

Keywords Fear of not being up to date · Fear of missing out · Metacognitions · Need for control · Problematic smartphone use · Process use · Social use

Introduction

Over the last decade, worldwide smartphone use has increased rapidly because it provides near-permanent Internet access (Statista, 2020). The number of mobile devices operating worldwide was 14.02 billion in 2020 and is expected to reach 17.72 billion by 2024, an increase of 3.7 billion devices compared to 2020 levels (Statista, 2021). Recent scholarship has noted growing interest in the negative potential of excessive smartphone use. The excessive frequency of smartphone use combined with impairment in scholastic or academic, occupational and/or social functioning has been termed problematic smartphone use (PSU), and involves some features and symptoms observed in established behavioral addictions (e.g., gambling disorder), such as craving under abstinence conditions (Wilcockson et al., 2019), and harmful behaviors (e.g., using the smartphone while driving; Kim et al., 2017). Empirical evidence has also provided initial evidence of the commonality between the neural mechanisms underlying substance use disorder and PSU (e.g., Horvath et al., 2020). Despite these initial results, evidence supporting PSU as an addictive behavior is scarce, and PSU is not currently recognized as a mental disorder by the American Psychiatric Association. It has also been repeatedly argued that most of the studies in this field share a methodological bias in that they tend to adopt a confirmatory approach in which PSU is *a priori* considered an addictive behavior, with the presumption that it shares

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the core symptoms of substance addictions (Billieux et al., 2015). Consequently, most prominent authors in the field suggest adopting the expression PSU as opposed to smartphone addiction.

The frequency of smartphone use can involve a variety of uses and features, and the relationship between types of use and PSU has received growing scientific attention. The distinction between process and content use was first applied to the Internet (Song et al., 2004). Process-oriented use is related to enjoyment of the act of using the medium itself, whilst content-oriented use entails the application of the messages or content conveyed by the Internet into the real world. According to this perspective, content use would be a more outcome-oriented approach as people access the Internet looking for a specific item of information, whilst a process-oriented use might be exemplified by users who spend time browsing for something that catches their interest. In the context of smartphone use research, the distinction entails process (also named "non-social" use) and social use, even if there may be a degree of overlap between social and process use (Elhai et al., 2020). Whereas process smartphone use primarily involves non-social motivations and purposes (e.g., news consumption, entertainment, relaxation), thus indicating the gratifying effects of consuming media, social use involves mainly social purposes (e.g., communication, social networking) (van Deursen et al., 2015). Findings on the association between the two forms of smartphone use and PSU are conflicting, with some research indicating that PSU severity is related to process use (Elhai et al., 2017a, b, 2020), whilst other research showing it is more related to social use (Panova et al., in press). As already suggested (Elhai et al., 2020), the difference in measurement strategy may account for these mixed findings, since some studies assessed motivations for use, whilst others inquired into the specific features and applications on a user's smartphone. Taken as a whole, the findings are consistent in showing that both process and social use are positively correlated with PSU, but they also suggest the need to focus on process use as it is more closely related to mental health factors (see Rozgonjuk & Elhai 2019).

An important variable for understanding PSU is the fear of missing out (FoMO) – i.e., the apprehension of missing out on rewarding experiences, and a corresponding need to always stay connected with one's social network (Przybylski et al., 2013). Numerous studies have found moderate to large positive correlations between FoMO and both self-reported (e.g., Elhai et al., 2018b, 2020; Oberst et al., 2017; Servidio et al., 2021; Wolniewicz et al., 2018) and objectively measured PSU (Sela et al., 2020). There is no doubt that FoMO is related to both process and social smartphone use, although the magnitude of thfear of not knowing or missing oe correlation is less clear (Elhai et al., 2018a,

2020; Wolniewicz et al., 2018). However, there is abundant evidence on the positive robust correlations between FoMO levels and problematic social networking site use (PSNSU; see for a meta-analysis, Fioravanti et al., 2021), which might suggest that high levels of apprehension concerning missing friends' rewarding experiences leads to using the smartphone mainly as a vehicle to keep in touch with significant others (i.e., social smartphone use).

Conversely, other factors might be called into question to explain process-driven PSU use within a motivation-based perspective. It has been repeatedly argued that the need for control is not only desirable, but is also a psychological necessity, and converging evidence from diverse areas of research provides increasing evidence for a biological explanation for our need for control. It has also been argued that organisms have adapted to find control rewarding (and its absence aversive) because the perception of control plays a role in buffering an individual's response to environmental stress (Leotti et al., 2010). Since the smartphone provides increasingly abundant forms of information, smartphone use might be not just a means for checking on what significant others are doing, but also a vehicle to satisfy a wider need to obtain information and exert control over the environment (or, at least, have the perception to meet it). Indeed, the Internet has made it easier than ever to know about a wide array of events occurring around the world and relevant new items. Intensive process smartphone use might be explained by another albeit less investigated apprehension clearly distinguishable from FoMO, i.e., the fear that one is either not in the know or is missing out on relevant new information. This "Fear of not being up to date" (FoBU) reflects the anxious arousal that accompanies the unmet need for control over relevant information and events occurring around in the world. Whilst FoMO is explicitly linked to concerns that one might be missing an opportunity for *social* interactions and is characterized by a desire to stay continually connected with what significant others are doing, FoBU might be linked to concerns to find out belatedly—or not at all—a relevant news item. Since process smartphone use indicates the gratifying effects of consuming or 'prosuming' media, and also involves primarily non-social motivations and purposes (e.g., news consumption), we hypothesise that the need to stay constantly 'tuned in' might be associated with process smartphone use—to a similar degree and for similar reasons as those claimed for the link between FoMO and social smartphone use. That is, for those who fear missing out, participation in social media is especially attractive. For those who fear not staying abreast with relevant information, participation in online activities related to non-social motives and behaviours such as trawling the news might be more appealing.

In the following section, we will introduce the potentially explanatory mechanisms of these links.

Explaining the link between fears, different types of use and problematic usage through a metacognitive lens

In recent years, a growing body of research has emphasized that metacognitions are involved in addictive behaviors (see Spada et al., 2015), including PSU (Akbari et al., 2021a; Casale et al., 2020, 2021a, b; Throuvala et al., 2021; Shi et al., 2021). Metacognitions refer to the implicit or explicit information individuals hold about their own cognition and about coping strategies that have an impact on it (Brown, 1987; Wells & Matthews, 1994). Either positive (i.e., a specific form of expectancy relating to smartphone use as a means of controlling and regulating cognitions and emotions) and negative metacognitions (i.e., beliefs concerning the uncontrollability and dangers of thoughts concerning smartphone use) have been found to predict PSU independently of anxiety and depressive symptoms (Akbari et al., 2021b; Casale et al., 2020). Moreover, as metacognitions play a central role in motivating individuals to engage in addictive behavior, they appear to be excellent candidates in the role of mediators in the relationship between cognitive-affective states that need to be regulated (e.g., the fear of missing out) and PSU. In keeping with this perspective, a number of empirical studies have highlighted that negative emotions play a role in predicting addictive behaviors through beliefs concerning the usefulness of the substance/object use with respect to emotion regulation (Akbari, 2017; Spada & Marino, 2017), including one's smartphone usefulness (Casale et al., 2021a). The more intense the negative emotion experienced, the stronger the beliefs that using the smartphone will help in managing these emotions, which, in turn, predict PSU (Akbari et al., 2021b).

However, there is a lack of research into the potential role of metacognitions as a potential mediating variable in the link between negative emotions (i.e., fear of missing out, fear of not being up to date) and different types of smartphone use (i.e., social and process smartphone use) and how such use may contribute to PSU. On the one hand, we know that PSU is linked to both social and non-social use (Elhai et al., 2017a, b, 2020; van Deursen et al., 2015). On the other hand, we know that metacognitions appear to be involved in the perpetuation of smartphone use (Akbari et al., 2021b) and have a mediating role in the negative emotions-PSU link (Casale et al., 2021a).

The present study

In summary, previous studies have shown mixed findings about the association among FoMO, process and social use of the smartphone, and PSU (Elhai et al., 2017a, b, 2018a, 2020; Panova et al., in press; Wolniewicz et al., 2018). In the current study we suggest that previous conflicting findings might be clarified—at least in part—by including in the developmental pathways other potentially relevant psychological factors. The fear of not knowing or missing out on relevant new information, that we called fear of "not being up to date", might be linked to a process-driven PSU, whilst high levels of apprehension concerning missing friends' rewarding experiences might lead to problematically use the smartphone for social purposes. Furthermore, in keeping with the well-known central role of metacognitions in motivating individuals' engagement in PSU (Akbari et al., 2021a; Casale et al., 2020, 2021a, b; Throuvala et al., 2021; Shi et al., 2021), we also suggest that these links are mediated by the beliefs concerning the usefulness of the smartphone in regulating the above-mentioned fears. Therefore, the present study aimed at integrating results from these different lines of research, in an effort to clarify the pathways towards PSU. More specifically, it has been hypothesized that social smartphone use might be motivated by FoMO through metacognitions (Model 1), while process smartphone use may be driven by an as yet unexplored need—the fear of not being up to date—via metacognitions (Model 2). Both social and process use are expected to predict PSU. In detail, the present study tested two serial mediation models, whereby it was hypothesised that:

a) metacognitions and social smartphone use would be serial mediators of the relationship between FoMO and PSU.
b) metacognitions and process smartphone use would serial mediators of the relationship between and the Fear of not being up to date (FoBU) and PSU.

Due to the use of cross-sectional data (rather than longitudinal data), the hypothesized model will be compared with two hypothesized alternative models, which will be discussed in the statistical analysis section.

Methods

Participants

Adopting opportunity and snowball sampling methods, participant recruitment was conducted online in the autumn of 2020 by sharing the questionnaire link in various online

communities, online groups, and thematic forums. A sample of 364 central Italian participants (F = 72.8%; mean age = 36.80 ± 15.32 years; age range: 18–75 years) agreed to participate in the study. Participants were required to have a smartphone and give their consent to participate in the study. The majority of the sample (98.4%) self-reported as Caucasian. Participants were informed that participation was voluntary and anonymous. No payments were made for participation. An online study format was used to collect data. The first page of the study website outlined the general aims of the study: "To investigate the psychological predictors of smartphone use". Participants were then redirected, if providing their consent to participate in the study, to a second page containing basic demographic questions and the self-report questionnaires. The study protocol was approved by the institutional review board of the last author's university.

Measures

Fear of missing out. The Italian version of the FoMO Scale (Casale & Fioravanti, 2020) contains 10 items involving anxiety from missing rewarding social events and experiences, in accordance with the parent version (Przybylski et al., 2013). A sample item is "I fear others have more rewarding experiences than me". Participants give their answer on a Likert-scale from "*1* = Not at all true of me" to "*5* = Extremely true of me". Higher scores indicate higher levels of FoMO. The psychometric properties of the Italian version of the FoMO scale are good (Casale & Fioravanti, 2020). In the current sample, the alpha coefficient was 0.89.

Fear of not being up to date. Taking inspiration from the FoMO scale, we developed the following six items to assess the fear of not keeping up to date with relevant information: (1) It annoys me when others are more up to date than I am on important news; (2) It annoys me when I find out that others know something important I do not know; (3) Sometimes, I wonder if I spend too much time keeping up with the news; (4) It annoys me when I miss some important information online; (5) It is important for me to always be aware of what is happening in the world; and (6) I like to have a lot of control on what is going on around. Principal axis factor analysis was used. According to the Kaiser Mayer-Olkin Measure of Sampling Adequacy criterion KMO, sampling adequacy was adequate for the number of items on the scale and factor analysis was appropriate for this data set (KMO = 0.84). Bartlett's test of sphericity showed that the correlation matrix was suitable for factor analysis (χ^2 = 1049.55, df = 15, $p < 0.001$). Using the conventional criterion for retaining factors with eigenvalues > 1.0 and the scree plot, a one-factor solution was identified explaining 60.74% of the total variance. A Confirmatory Factor Analysis revealed that the unidimensional factor structure of the fear of not being up to date scale produced a good fit to these data: $\chi^2(7)$ = 15.94 p = 0.02; χ^2/df = 2.27; *RMSEA [90% CI]* = 0.05 [0.02, 0.08]; *CFI* = 0.99; *SRMR* = 0.02. Factor loadings ranged from 0.59 to 0.90, all of which were significant at the 0.001 level as well as the estimated correlations among errors. In the current sample, the alpha coefficient was 0.89.

Metacognitions about Smartphone use. The Metacognitions about Smartphone use Questionnaire (MSUQ; Casale et al., 2020) was used to assess positive and negative metacognitions about smartphone use. This self-report measure comprises 24 items and a three-factor structure: positive metacognitions about emotional and cognitive regulation (e.g., "Using a Smartphone helps me to relax when I am agitated"), positive metacognitions about social advantages ("Using my Smartphone makes me more sociable when I feel alone"), and negative metacognitions about uncontrollability and cognitive harm ("I continue to use my Smartphone although I think it would be better to stop"). The MSUS has been found to have good psychometric properties in the Italian context. The three dimensions of the scale can be collapsed because, taken together, they tap into the construct of metacognitions about smartphone use. In the current sample, the alpha coefficient was 0.86.

Process and social smartphone use. To determine the process and socially oriented uses of the smartphone, we adapted items proposed by van Deursen et al., (2015). The social smartphone use subscale (5 items) includes: "I use my smartphone to call other people" and "I use my smartphone to preserve relationships" (the alpha coefficient was 0.67 in the current study). The process smartphone use subscale (5 items) includes: "I use my smartphone in order to stay up to date on the latest news" and "I use my smartphone in order to find the places, products and services I need" (the alpha coefficient was 0.82 in the current study).

Problematic smartphone use. The Italian version of the Smartphone Addiction Scale-Short Version (SAS-SV; De Pasquale et al., 2017) includes 10 items measuring PSU severity on a 6-point Likert scale (from "*1* = Strongly disagree" to "*6* = Strongly agree"). Reliability and validity are adequate in both the Italian (De Pasquale et al., 2017; Servidio, 2019) and the original version (Kwon et al., 2013). Sample items include "I use my smartphone longer than I had intended". Higher scores indicate higher PSU. In the current sample, the alpha coefficient was 0.83.

Statistical analyses

All statistical analyses have been performed using the Statistical Package for Social Sciences SPSS (Version 26 for Windows). Shapiro-Wilk test has been carried out revealing that normality was met for all the study variables.

Thus, descriptive statistics and Pearson's correlations were computed. Before running the serial mediation models, multicollinearity was checked, revealing no indication of multicollinearity as tolerance statistics were above 0.20 and variance influence factors were well below 10 (Bowerman & O'Connell, 1990). Therefore, we used Model 6 from PRO-CESS (Hayes, 2018) to test the two serial mediation models. We estimated 5000 bootstrap samples in which the independent variable was FoMO (in Model 1; FoBU, in Model 2) the mediators were metacognitions about smartphone use and social smartphone use (in Model 1; process smartphone use, in Model 2), and the dependent variable was PSU. This method generated 95% confidence intervals (CI) of the indirect effects. Bootstrapped 95% CIs not straddling zero were considered statistically significant (Hayes, 2018). As previous evidence showed a negative link between age and PSU, and women tend to report higher levels of PSU (Elhai et al., 2017a; Rozgonjuk et al., 2016; van Deursen et al., 2015), we included gender and age as covariates in the models. As suggested by Kline (2011), we tested alternative models. Firstly, we tested the direct and indirect effect of FoMO on PSU via metacognitions about smartphone use and process use. Then, we tested the direct and indirect effect of FOBU on PSU via metacognitions about smartphone use and social use.

We estimated the minimum sample size required by using Tabachnick and Fidell's (2014) formula [N > (50 + 8 m), where N is the required sample size and m is the highest possible number of paths (N > 50 + 8*12)]. The final sample should have guaranteed at least 146 subjects. A total of 364 participants were involved.

Results

Table 1 shows descriptive statistics and correlations between the study variables. The correlation between FoMO and fear of not being up to date was 0.64, thus suggesting a moderate-to-strong link but not to the extent of being redundant. The correlation with social smartphone use was higher for FoMO, whilst the correlation with process smartphone use was higher for the fear of not being up to date, as expected. Significant positive strong correlations were found between these two variables, metacognitions, and PSU.

Table 1 Descriptive and zero-order correlations among the study variables

Variables	M	SD	1	2	3	4	5	6
1. FoMO	20.75	8.13	--					
2. FoBU	18.99	8.11	0.64**	--				
3. MSUQ	43.85	12.26	0.52**	0.41**	--			
4. Social Use	19.60	3.54	0.21**	0.19**	0.22**	--		
5. Process Use	22.14	3.37	0.17**	0.24**	0.25**	0.39**	--	
6. SAS-SV	27.73	9.36	0.50**	0.56**	0.65**	0.19**	0.28**	--

Note. **p < 0.001, FoMO = Fear of Missing Out; FoBU = Fear of not Being Up to date; MSUQ = Metacognitions about Smartphone Use Questionnaire; SAS = Smartphone Addiction Scale—Short Version
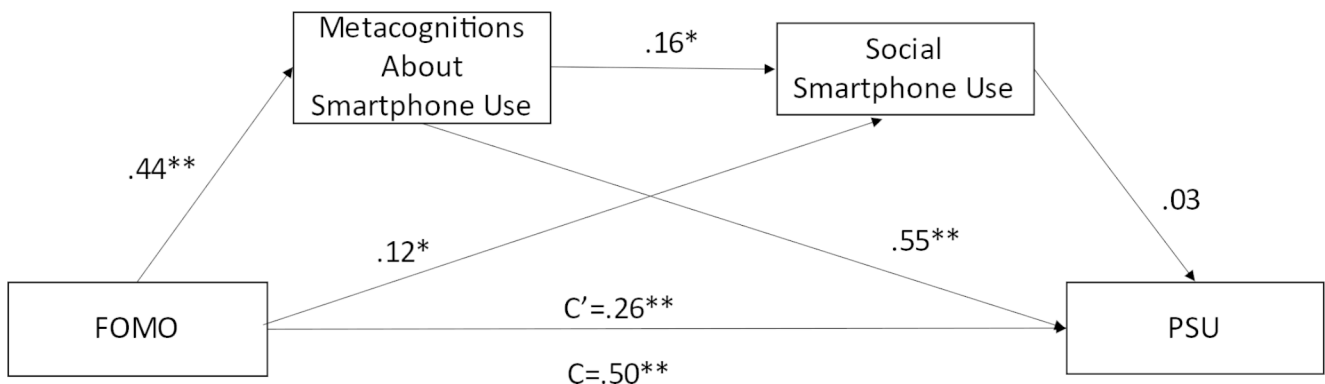

Fig. 1 Serial mediation model linking FoMO and PSU. Standardized effects are presented. C'= direct effect C = total effect; *p < 0.05, **p < 0.001

Testing model 1: FoMO→Metacognitions→Social use→Problematic smartphone use

After controlling for participants' gender (women coded as 1, men coded as 2; β =-0.01 p=0.79) and age (β = -0.09, p=0.03), the results indicated that metacognitions about smartphone use and social use partially mediated the relationship between FoMO and PSU (total indirect effect=0.24; 95% CI: [0.17, 0.32]; direct effect=0.26, 95% CI: [0.19, 0.40]; see Fig. 1). Specifically, metacognitions about smartphone use mediated the relationship between FoMO and PSU (indirect effect t=0.24; 95% CI: [0.17,0.31]); social use did not mediate the relationship between FoMO and PSU (indirect effect=0.003; 95% CI: [-0.006, 0.02]); and the serial mediation effect of metacognitions about smartphone use and social use on the relationship between FoMO and PSU was not significant (indirect effect=0.002; 95% CI: [-0.003, 0.009]). Smartphone social use did not predict PSU. Therefore, the serial mediation hypothesis was not supported. The model explained 47% of the PSU variance.

Testing model 2: fear of not being up to date→Metacognitions→Process use→Problematic smartphone use

After controlling for participants' gender (women coded as 1, men coded as 2; β =-0.03 p=0.48) and age (β =-0.06, p=0.48), the results indicated that metacognitions about smartphone use and process use partially mediated the relationship between fear of not being up to date and PSU (total indirect effect=0.19; 95% CI: [0.13, 0.25]; direct effect=0.35, 95% CI: [0.31, 0.49]; see Fig. 2). Specifically, metacognitions about smartphone use mediated the relationship between the fear of not being up to date and PSU (indirect effect=0.17; 95% CI: [0.11,0.23]); process

use mediated the relationship between fear of not being up to date and PSU (indirect effect=0.01; 95% CI: [0.002, 0.03]); and the serial mediation effect of metacognitions about smartphone use and process use on the relationship between the fear of not being up to date and PSU was significant (indirect effect=0.004; 95% CI: [0.0006, 0.009]). Therefore, the serial mediation hypothesis was supported. The model explained 53% of the variance of PSU.

When it comes to the alternative models, we firstly tested the direct and indirect effect of FoMO on PSU via metacognitions about smartphone use and process use. This model explained 48.7% of the variance of PSU, but it showed lower path coefficients compared with Model 1. After controlling for participants' gender (women coded as 1, men coded as 2; β=0.05 p=0.52) and age (β=0.01, p=0.02), the results indicated that metacognitions about smartphone use and process use partially mediated the relationship between FoMO and PSU (total indirect effect=0.03; 95% CI: [0.02, 0.04]; direct effect=0.03, 95% CI: [0.02, 0.04]). Specifically, metacognitions about smartphone use mediated the relationship between FoMO and PSU (indirect effect=0.03; 95% CI: [0.02,0.02]); process use did not mediate the relationship between FoMO and PSU (indirect effect=0.0003; 95% CI: [-0.002, 0.002]); and the serial mediation effect of metacognitions about smartphone use and process use on the relationship between FoMO and PSU was significant (indirect effect=0.001; 95% CI: [0.0005, 0.003]).

We then tested the direct and indirect effect of FOBU on PSU via metacognitions about smartphone use and social use. Again, this alternative model explained 48.7% of the variance of PSU, but it showed lower path coefficients. After controlling for participants' gender (women coded as 1, men coded as 2; β =-0.003 p=0.97) and age (β=0.005, p=0.06), the results indicated that metacognitions about smartphone use and social use partially mediated the relationship between FoMO and PSU (total indirect effect=0.02; 95% CI: [0.01, 0.03]; direct effect=0.04, 95%
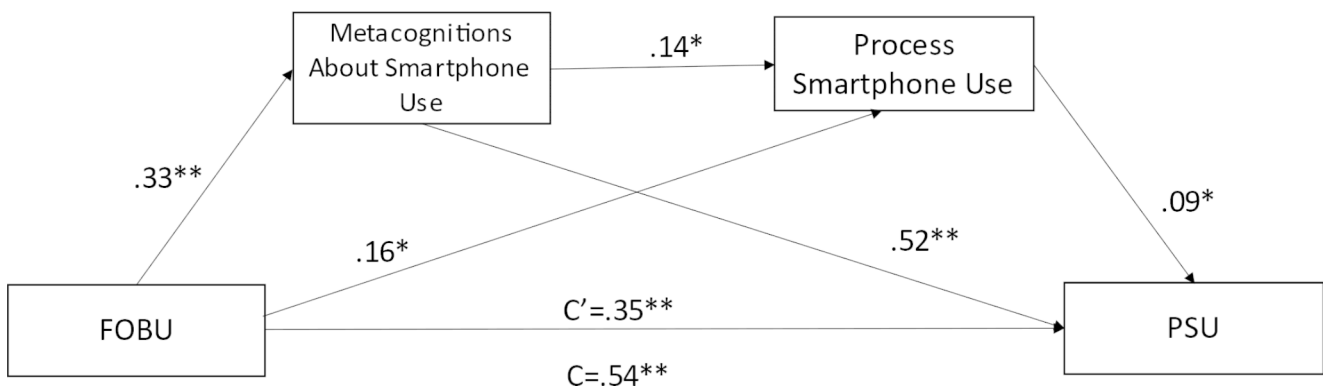

Fig. 2 Serial mediation model linking the fear of not being up to date and PSU. Standardized effects are presented. C' = direct effect C = total effect; *p < 0.05, **p < 0.001

CI: [0.03, 0.05]). Specifically, metacognitions about smartphone use mediated the relationship between FOBU and PSU (indirect effect = 0.02; 95% CI: [0.01,0.03]); social use did not mediate the relationship between FOBU and PSU (indirect effect = 0.0002; 95% CI: [-0.0008, 0.0013]); and the serial mediation effect of metacognitions about smartphone use and social use on the relationship between FOBU and PSU was not significant (indirect effect = 0.0001; 95% CI: [-0.0004, 0.0007]).

Discussion

As previous studies have shown that process and social smartphone use might be involved in PSU, there has been a call for further research into the pathways that might lead to PSU through one type of use or another. Especially process smartphone use warrants further scientific attention, as very recent studies have shown that it is closely related to PSU relative to social use (Rozgonjuk & Elhai, 2019). Based on previous findings derived from different lines of research, the current study hypothesized that social smartphone use may be mainly motivated by the fear of missing out (FoMO) through metacognitions (Model 1), while process smartphone use may be driven by an as yet unexplored need—the fear of not being up to date—via metacognitions (Model 2). Both social and process use were then expected to predict PSU.

Overall, our results provide: (a) promising initial results regarding the introduction of the FoBU construct in explaining developmental pathways towards PSU via intense process use; (b) further evidence for the scarce contribution of social smartphone use in predicting PSU whilst they confirm the detrimental effect of process use; (c) further support to the role of metacognitions in explaining the link between unsatisfied needs and PSU. We will describe each result in detail below.

The first intriguing and promising result is that the correlation between FoMO and the fear of not being up to date was moderate-to-strong, thus suggesting that these two fears were significantly associated with each other but not to the extent of being redundant. Moreover, the fear of not being up to date strongly correlates with process use than FoMO does, whilst FoMO strongly correlates with social use than the fear of not being up to date does (as expected). These preliminary results support the hypothesis that process and social smartphone use might be driven by different motivations. Subsequent analyses have shown that Model 2 was supported in that the serial mediation effect of metacognitions concerning smartphone use and process use on the relationship between the fear of not being up to date and PSU, was significant. The greater the fear of not being up to

date, the greater the process smartphone use via metacognitions, which in turn predicts PSU. Results concerning the positive correlation between process smartphone use and PSU are not surprising, as this is a well-established finding in the literature (Elhai et al., 2017a, b, 2020; Rozgonjuk & Elhai, 2019; van Deursen et al., 2015). The current study builds upon the previous findings by showing that intense process smartphone use might be driven by the need for control over information and events *and* this is mediated by expectancies related to smartphone use as a means of controlling cognitions and emotions. That is, individuals showing an intense fear of not staying up to date with important information report high process smartphone use at least in part due to their belief that the smartphone is a useful tool for regulating their cognition (i.e., fears). Similarly, metacognitions about smartphone use mediate the relationship between FoMO and PSU. On the one hand, this result lends further support to the already well-established link between FoMO and PSU (Elhai et al., 2018a, 2020; Oberst et al., 2017; Servidio et al., 2021; Wolniewicz et al., 2018). On the other hand, it highlights a potential explanatory mechanism for this link. In this respect, an additional contribution to the literature was provided in that FoMO has been typically considered as a mediator in the link between mental health variables or personality traits and PSU (e.g., Geng et al., 2021; Yuan et al., 2021), without considering that its effect on PSU might in turn be explained by cognitive processes.

This said, social use did not predict PSU. Moreover, it did not mediate the relationship between FoMO and PSU, and the serial mediation effect of metacognitions about smartphone use and social use on the relationship between FoMO and PSU was not significant (Model 1 was not supported). The fact that smartphone social use did not predict PSU confirms previous findings reporting PSU is more related to process use (Elhai et al., 2017a, b, 2020; Rozgonjuk et al., 2019). Excessive smartphone use might not be driven necessarily by communicative purposes, such as using social networking, messaging, and phone calls. Indeed, smartphones allow for the use of a number of other non-social oriented applications and potentially problematic activities such as news consumption, and web surfing (smartphone process use). These considerations draw attention to the current debate on the overlap between the problematic use of smartphones and the problematic use of specific activities available on smartphones, such as social media apps (for a systematic review, see Marino et al., 2021).We did not find support for the hypothesis that high levels of apprehension of missing friends' rewarding experiences leads to using the smartphone as a vehicle to stay in touch with significant others—FoMO predicts PSU, but not via intense social smartphone use. One possible explanation related to the measure we used for measuring social smartphone use.

This self-report measure refers to an active smartphone use for social purposes (i.e., calling other people, maintaining relationships), which is likely to allow higher experiences of closeness to others with no consequent problematic usage (Gioia et al., 2021). Moreover, FoMO may also be implicated in PSU via process use, as has already been suggested (Elhai et al., 2018a, 2020), since the individual may engage in process smartphone use to regulate the fear of missing out when social engagement becomes fear-inducing (Elhai et al., 2020). The alternative model tested in the current study supports that FoMO is somehow linked to process use, as it predicts PSU through the serial mediating role of metacognitions about smartphone use and process use.

The current study does have some limitations, however. Firstly, given its correlational design, inferences about causal directions are not warranted. A recent study (Lo Coco et al., 2020) has suggested caution when causal links between FoMO and PSU are inferred, because no cross-lagged associations between them were longitudinally supported. Similarly, the fear of not being up to date might not be longitudinally associated with PSU—or PSU might reinforce, in the course of time, one's own fear of not being up to date. Secondly, we use self-report measures to assess the study variables, and this is a problem especially when it comes to PSU, as self-report measures may not be reliable and accurate enough to assess smartphone usage (Elhai et al., 2018b). Moreover, our sample was mainly comprised of young people from Italy and was not well-balanced for gender. As age and gender differences emerged in this field (Elhai et al., 2017a; Rozgonjuk et al., 2016; van Deursen et al., 2015), future studies should involve a more representative sample.

The present study has both theoretical contributions and clinical implications. From a theoretical perspective, the current results add a further layer of knowledge to pathways towards PSU, for the first time highlighting the role of another variable—the fear of not being up to date—which might explain the additional amount of variance in PSU levels, especially when it comes to excessive process smartphone use. In fact, our results suggest that scientific attention in this field should be focused on process use since it predicts PSU in each tested model. Moreover, our findings show that the intuitive link between the fear of missing reward experiences and the use of the smartphone for social purposes ought to be questioned. Whilst there is no doubt that a link between FoMO and PSU exists, it is less clear which smartphone functions or motivations are more involved in accounting for this association. Following Elhai et al.'s reasoning (2020), we cannot exclude that the binary distinction between process and social smartphone use is not helpful when it comes to FoMO. High levels of FoMO might motivate towards smartphone use for satisfying the need to belong in the first place, but when social engagement becomes distressing the same individual may engage in process smartphone use to regulate his/her negative feelings. In terms of clinical implications, our results suggest that providing interventions to people with high levels of FoMO and not being up to date might be important not only for directly targeting these painful experiences but also indirectly to prevent PSU. Moreover, metacognitions may exacerbate these negative affective states, in turn leading to increased engagement with the smartphone. Developing interventions aimed at the modification of metacognitions that lead to problematic smartphone use could well be precious, in keeping with previous evidence showing that metacognitive interventions are beneficial for dealing with addictive behaviours (e.g., Caselli et al., 2016, 2018).

Conflict of interest The authors declare no conflict of interest.

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