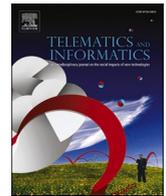


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# Does excessive social media use decrease subjective well-being? A longitudinal analysis of the relationship between problematic use, loneliness and life satisfaction

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## ABSTRACT

Current literature suggests problematic social media use (PSMU) predicts reduced social and psychological well-being. Lonely people are more prone to experience the negative outcomes of PSMU, but only few studies have focused explicitly on how loneliness affects the relationship between PSMU and subjective well-being experiences. In this paper, we examine if loneliness influences the association between PSMU and life satisfaction. We used nationally representative cross-sectional data from Finnish social media users (N = 2991) and follow-up panel data (N = 2021). First, we tested if PSMU affects satisfaction with life indirectly through loneliness while controlling for a set of background variables. Next, we examined whether changes in PSMU and loneliness affect life satisfaction over time. First analyses showed that PSMU was associated with life satisfaction negatively, but the effect was largely confounded by loneliness. Longitudinal analysis revealed increased PSMU did not predict decreased satisfaction with life within individuals, but increased PSMU predicted increased loneliness, and increased loneliness predicted decreased satisfaction with life. The analyses indicate that loneliness is a crucial element that contributes to the relationship between PSMU and life satisfaction. In addition, earlier observations that PSMU might increase loneliness over time were confirmed.

## 1. Introduction

The use of social media has increased dramatically over the last decade, and the number of daily users has almost doubled in several western countries (Eurostat, 2019a; Pew Research, 2019). Social media is present everywhere, all the time and it is constantly evolving with the proliferation of mobile devices and applications. As people's lifestyles are becoming increasingly technology-mediated, there are also more grounds for a variety of excessive and compulsive online behaviours (Kuss et al., 2014; Panova and Carbonell, 2018; Sarmiento et al., 2020). This progress has also incited public and scholarly debate on the possible negative effects of social media use (SMU) on users' health and well-being. A large body of research indicates that excessive or problematic social media use<sup>1</sup> (PSMU) is often associated with lower levels of well-being (e.g., Brooks, 2015; Wheatley and Buglass, 2019). However, SMU is also linked to positive social and psychological outcomes, such as improved social connectedness and life satisfaction, and particularly active SMU might increase subjective well-being experiences (e.g., Kim and Kim, 2017; Pang, 2018b; Verduyn et al., 2017).

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<sup>1</sup> We use abbreviations SMU and PSMU for social media use and problematic social media use throughout the article.

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Existing literature provides several explanations for different outcomes of SMU. For example, active SMU could strengthen social ties and create new connections, which in turn increases social and psychological well-being (e.g., Bano et al., 2019; Chen and Li, 2017; Pang, 2018a). Passive use, however, can lead to upward social comparison and envy (Appel et al., 2016; Wang et al., 2017) and decrease well-being. Also, previous research has shown that PSMU could affect individuals differently depending on life situation and phase of life. In particular, certain socio-demographic groups, such as those who feel lonely (Arampatzi et al., 2018) or are unemployed (Wheatley and Buglass, 2019) are more prone to experience the negative effects of excessive use.

In this research we are interested in the relationship between PSMU, loneliness and satisfaction with life. Loneliness is a growing public health problem in industrialised countries (Cacioppo and Cacioppo, 2018), and earlier studies have demonstrated that loneliness might predict higher levels of PSMU (Kim et al., 2009) and reduced life satisfaction (Salimi, 2011). Furthermore, the relationship between PSMU and loneliness appears to be bidirectional, and people who overuse social media are more likely to be lonely (Nowland et al., 2018). Building on these notions and findings of recent studies (e.g., Arampatzi et al., 2018; Satici, 2019), we suggest that loneliness might influence the relationship between PSMU and life satisfaction.

We addressed this topic using a longitudinal research design, which enabled us to estimate the effects using a fifteen-month time scale. Our data come from a unique postal and online panel sample representing Finns ages 16–74. We first explored whether the association between PSMU and satisfaction with life is confounded by loneliness. Next, we examined if changes in PSMU predict increased loneliness, and if changes in loneliness predict increased PSMU within and between subjects. Before empirical analyses, we conducted a short review of earlier research to clarify existing knowledge regarding the relationship between SMU, loneliness, and life satisfaction.

## 2. Literature review

### 2.1. Problematic use of social media and subjective wellbeing

Subjective well-being is a concept aimed at capturing the qualitative evaluation of an individual's current life condition. A high level of well-being offers positively valuated descriptions of an individual's life situation, whereas a low level offers negative descriptions. There are various alternative dimensions of well-being. For instance, we can refer to financial, physical, mental and social levels of satisfaction and wellbeing (Suldo and Huebner, 2004). The most common general conceptions, which address multiple dimensions at the same time, are life satisfaction and happiness. Researchers often use these concepts to identify such issues as differences in the experienced enjoyment of life or content with life as whole (e.g. Diener et al., 1985, 2005). Life satisfaction is often considered distinct from happiness because the former involves a more holistic view of life, rather than focusing solely on individual moments that produce positive feelings and emotions (Suldo and Huebner, 2004). In this study, we use life satisfaction as a general measure of subjective wellbeing.

Currently, findings on the relationship between SMU and subjective well-being are contradictory and ambiguous. SMU might have a positive effect on users' subjective well-being (Kim and Lee, 2011; Valenzuela et al., 2009; Verduyn et al., 2017), but SMU has also been associated with several adverse effects, such as depression (Bá Nyai et al., 2017; Shensa et al., 2017), and reduced subjective well-being (Balcerowska et al., 2020; Duradoni et al., 2020; Hawi and Samaha, 2017; Kross et al., 2013; Satici, 2019). However, a recent comprehensive review found only a weak negative linear association between well-being and SMU (Appel et al., 2020), and another noted a small, positive association between self-reported depressive symptoms and SMU (Vahedi and Zannella, 2019).

However, several studies have demonstrated that the link between excessive use and reduced subjective well-being is more robust (e.g., Raudsepp and Kais, 2019; Wheatley and Buglass, 2019). Consequently, researchers have developed new concepts, such as the problematic use of social media (Bá Nyai et al., 2017) and social networking addiction (Griffiths et al., 2014; Kuss and Griffiths, 2017), to assess the excessive use of social media platforms and services. Estimates of the proportion of users who engage in PSMU in various populations have varied significantly, but in recent nationally representative samples, 2.6% of German Internet users (Reer et al., 2020) and 4.5% of Hungarian adolescents (Bá Nyai et al., 2017) were considered problem users.

Besides excessive use, several other components might affect the outcomes of SMU. It is well-known that high-quality and gratifying social relationships are essential for life satisfaction and well-being of individuals (e.g., Diener et al., 2018). Some researchers have suggested that social media platforms could offer users a way to increase their social capital and connectedness, which, in turn, has a positive impact on subjective well-being (Clark et al., 2018). However, others have noted that SMU may also generate upward social comparison and envy, which have a negative impact on subjective well-being (Verduyn et al., 2017).

A sizeable body of research supports these assumptions, and increased social connectedness (Bano et al., 2019; Chen and Li, 2017; Wei and Gao, 2017; Wheatley and Buglass, 2019), accumulated gains in social capital (Pang, 2018a; Valenzuela et al., 2009), and enhanced intimacy with peers (Pang, 2018b; Pittman and Reich, 2016) might indeed moderate the relationship between SMU and increased well-being. Similarly, there is evidence that social comparison (Appel et al., 2016; Tromholt, 2016; Verduyn et al., 2015; Wang et al., 2017) moderates the association between SMU and reduced well-being.

### 2.2. Problematic social media use, loneliness, and life satisfaction

Although SMU might bring benefits, such as new social connections and strengthened existing social ties, sometimes time spent in social media might also aggravate feelings of loneliness and perceived social isolation. Loneliness is a common human experience of perceived social isolation that is linked to several negative outcomes for both physical and mental health (e.g., VanderWeele et al., 2012). Recently, loneliness has become a widespread problem particularly in Western societies (Cacioppo and Cacioppo, 2018;

Eurostat, 2019b), and some accounts have argued that digital technologies are contributing to the increased levels of loneliness among populations (Caplan, 2007). Past research has implied a stable positive association between problematic use of digital technologies and loneliness (Moretta and Buodo, 2020; Savolainen et al., 2020; Youssef et al., 2020), and PSMU has been linked to increased loneliness among adolescents (Primack et al., 2017), young adults (Yang, 2016), and older adults (Meshi et al., 2020).

Loneliness is also associated with reduced life satisfaction (e.g., Salimi, 2011; Tu and Zhang, 2015), and some researchers have recently hypothesized that loneliness could contribute to the relationship between PSMU and well-being. In a recent study on Turkish university students, Satici (2019) examined the relationship between Facebook addiction, loneliness and subjective well-being, and found out that the indirect effects of Facebook addiction on subjective well-being were fully mediated by feelings of loneliness. Similarly, and Ponnusamy et al. (2020) confirmed that Instagram addiction is negatively associated with loneliness, and that loneliness negatively predicts life satisfaction among Malaysian university students. Finally, in their study on Dutch young adults, Arampatzi et al. (2018) found out that excessive SMU predicts decreased happiness for those young adults who felt socially disconnected and lonely, but not for those who are satisfied with their social contacts.

To conclude, earlier research implies that loneliness increases the risk of experiencing negative outcomes of SMU (Nowland et al., 2018), and that PSMU predicts lower subjective well-being for those who are lonely (e.g., Arampatzi et al., 2018; Satici, 2019). However, there is currently a gap in research concerning the temporal associations between PSMU, loneliness and life satisfaction. Most of the previous research on the relationship between PSMU, loneliness and well-being are based on cross-sectional designs, and the few longitudinal studies have returned mixed results (Moretta and Buodo, 2020). For example, two longitudinal studies have indicated that problematic use might predict increased loneliness over a 4–12-month period (Yao and Zhong, 2014; Zhang et al., 2018), and third found a bidirectional link between problematic use and loneliness (Tian et al., 2018). More longitudinal studies are needed in order to understand how do temporal changes in PSMU and loneliness relate to each other and to well-being of social media users.

### 3. The current study

In this study, we examined the associations between PSMU, loneliness and satisfaction with life over a 15-month period. Previous research has suggested that both PSMU (Verduyn et al., 2017) and feelings of loneliness (VanderWeele et al., 2012) reduce life satisfaction. Also, researchers have shown that there's a negative association between PSMU and satisfaction with life for those who feel lonely (Arampatzi et al., 2018), and that the indirect effect of PSMU on life satisfaction is mediated by loneliness (Satici 2019). Furthermore, socio-demographic factors, such as gender, age and socioeconomic status, often correlate with SMU and its outcomes (Ertiö et al., 2020; Wheatley and Buglass, 2019; Vidal et al., 2020).

Based on these findings, we deployed three hypotheses (analytical model illustrated in Fig. 1):

- H1: Problematic use of social media has a negative association with life satisfaction
- H2: Loneliness has a negative association with life satisfaction
- H3: Problematic use of social media is associated with life satisfaction indirectly through loneliness

We provide answers to the hypotheses by dividing an empirical analysis into two stages. In the first stage, we examined the associations between PSMU, loneliness and life satisfaction using a cross-sectional design and between-subject tests. In the second stage, we examined how changes in PSMU and loneliness are linked to each other and to satisfaction with life over a 15-month period. More specifically, we tested the confounding role of loneliness using longitudinal design and within-subjects tests.

## 4. Method

### 4.1. Data

In the first stage, we used a wide cross-sectional data set from the first round of the Finland in the Digital Age survey (N = 3724) collected in Finland from December 2017 to January 2018 (Sivonen et al., 2018). The original data were derived from two sources: a postal survey and an online panel. The former is the probability sample that consisted of the postal survey respondents (N = 2470) sampled randomly from a population register of Finnish citizens. The latter is the non-probability sample that consisted of respondents

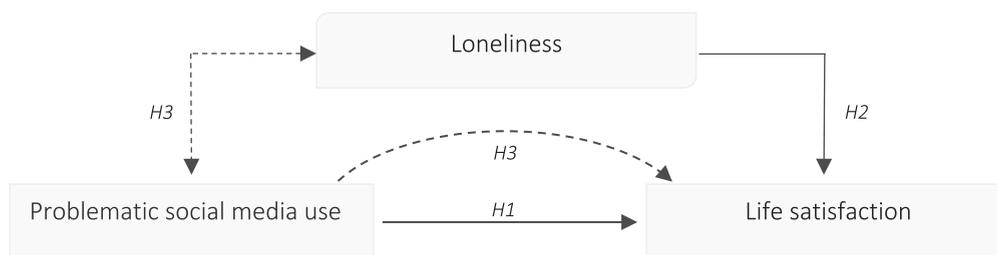


Fig. 1. Analytical model.

(N = 1254) from online panel administered by a Finnish market research company.

The analyses of first stage were based on the social media users (N = 2991), who accounted for 77% of the original data. Of the respondents, 64% (N = 1917) were from the probability sample, and 36% (N = 1074) were from the nonprobability sample. We filtered social media users from the original data by selecting only those cases that reported at least some level of SMU (see the variable description for *social media use* below).

In the second stage, we utilised panel data derived from the first and second rounds of the Finland in the Digital Age survey. During the first round, respondents were asked if they were willing to participate in the follow-up survey and provide personal information for this purpose. A total of 1708 respondents expressed that they were willing to participate in the follow-up survey. In connection with the question of personal information necessary for the follow-up survey, respondents were promised to be contacted within the next year (in 2018). The first inquiry of the follow-up survey was sent to the respondents in December 2018, confirming their address details and participation in the survey. Finally, the survey was conducted three months later, meaning the second round was conducted 15 months after the first round. A total of 1134 participants responded to the follow-up survey, so the response rate for the second round was 66.8% of the total sample.

The question form was essentially the same for both data collection rounds. In the second round, the data were highly biased towards higher education, as 44.5% of participants had obtained at least a bachelor's degree. However, gender (females 49.2%) and age (M = 49.9, SD = 16.2) were evenly distributed compared to the population characteristics. The structure of data also shows that it is relatively difficult to get employees and entrepreneurs to participate in follow-up surveys (working participants 50.5%). A more detailed description of data collection and its representativeness is available online (Sivonen et al., 2019).

## 4.2. Measures

### 4.2.1. Life satisfaction

We measured satisfaction with life using the respondents' subjective evaluations of their life satisfaction, which we defined as individuals' subjective feelings about their lives (Diener et al., 1985). Self-reported satisfaction with life has been found to have a high test-retest reliability in longitudinal studies (e.g. Krueger and Schkade, 2008).

Life satisfaction was assessed using a single-item measure that asked 'How satisfied are you with your life?' Respondents rated their subjective feelings on a scale from 0 (*extremely dissatisfied*) to 10 (*extremely satisfied*). Even though life satisfaction can be measured with multiple statements by utilising, for example, the Satisfaction with Life Scale, a single-item measure produces results similar to those achieved with longer scales (Cheung and Lucas, 2014).

### 4.2.2. Problematic social media use

In the construction of PSMU, we utilized the Compulsive Internet Use Scale (CIUS) validated by Meerkerk et al. (2009). The CIUS is highly used measurement for psychometric properties of internet addictions in different contexts (e.g. Sarmiento et al. 2020) and among different populations (Vondráčková and Gabrhelík, 2016). The original measurement of CIUS contains 14 items that are rateable on a 5-point Likert scale (Meerkerk et al., 2009). Our shorter measurement assesses whether the respondents have experienced the lack of control, inter- and intra-personal conflicts, impaired mood and cognitive preoccupation due to social media usage. We measured PSMU using five items on a 4-point scale (1 = *Never*, 2 = *Less than weekly*, 3 = *Weekly*, 4 = *Daily*) based on how often respondents experienced or did the following: (a) 'Have difficulty stopping social media use', (b) 'Have been told by others you should use social media less', (c) 'Have left important work, school, or family related things undone due to social media use', (d) 'Used social media to alleviate feeling bad or stress', and (e) 'Planned social media use beforehand'. The scale showed decent internal consistency (Cronbach's  $\alpha = 0.69$ ).

We used all five items to create a new four-level variable to assess the intensity of respondents' PSMU. If the respondent experienced at least one of the signs of problematic use daily, we coded PSMU as high. Correspondingly, if the respondent experienced at least one of the signs of problematic use weekly, we coded PSMU as medium, and if the respondent experienced at least one of the signs of problematic use less than weekly, we coded PSMU as low. Finally, if the respondent experienced no signs of problematic use, we coded PSMU as none.

### 4.2.3. Loneliness

We used a single self-labelling item to measure loneliness. Participants were asked the question 'Are you lonely?' and the answers were measured on a 5-point scale (1 = *Never*, 2 = *Rarely*, 3 = *Sometimes*, 4 = *Often*, 5 = *Always*). A single-item measure is a straightforward technique to address loneliness and it has commonly been used in past research (e.g., Victor and Yang, 2012). However, methodological literature has pointed out that the use of single-item measures has certain limitations, such as biased estimates of loneliness by socio-demographic groups (Shiovitz-Ezra and Ayalon, 2012). This may lead to difficulties when comparing different studies with each other. While acknowledging this, it is important to note that the use of alternative items does not affect the population estimates of loneliness prevalence (Nicolaissen and Thorsen, 2014).

### 4.2.4. Social media use

To measure the frequency of SMU, we asked respondents to use a 5-point scale (1 = *Never*, 2 = *Less than weekly*, 3 = *Weekly*, 4 = *Daily*, 5 = *Many hours per day*) to report how often they do the following: (a) 'Spend time on social media platforms (e.g., Facebook, Twitter)' and (b) 'Use instant messenger applications (e.g., WhatsApp, Facebook Messenger)'. We first filtered out non-users, which included those cases that had answered 1 (*Never*) to both questions. After this, all respondents in our data set reported at least some

level of SMU.

For analysis, we used both items to create a new four-level variable to assess respondents' SMU activity. If a respondent reported using social media platforms, instant messengers, or both for many hours per day, we coded activity as high. In addition, we coded the activity of respondents who reported using social media platforms, instant messengers, or both daily as medium. If they reported weekly use, we coded their activity as low. For those respondents who reported using platforms or instant messengers less than weekly, we coded their activity as very low.

#### 4.2.5. Sociodemographic factors

Respondent's gender (1 = *Male*, 2 = *Female*), age (in years), level of education, and economic activity were measured. We recorded education using eight levels and recoded it into three categories: primary, secondary, and bachelor's degree or higher. In addition, we measured economic activity using six items and recoded it into five categories: employed, unemployed, student, retired, and other.

Descriptive statistics for all measurements for cross-sectional and panel data are provided in [Table 1](#).

#### 4.3. Analytical strategy

The first stage of analysis proceeded in three steps and included ordinary least squares (OLS) regression models to test the association between PSMU and life satisfaction. First, we constructed a simple regression model for each independent variable. Next, we performed three multiple regression models. We first controlled for respondents' SMU. The second model controlled for the possible confounding effects of sociodemographic factors, and the third for the confounding effect of loneliness. We computed and visualised marginal effects for each multiple regression model to measure the change in the mean of the response variable as the regressor changed by one unit. Finally, we also considered the potential bias related to the probability and non-probability samples by providing a robustness check for the main effects by analyzing separately the two samples used in the first stage.

In the second stage of analysis, we used the balanced longitudinal data to analyse the relationships between PSMU, loneliness and life satisfaction over time by considering within- and between-person effects. The data were nested: the level-one units were person-time observations, and the level-two units were individuals. We used the hybrid mixed and the correlated random effects (CRE) models to distinguish two time-varying factors: between-person random effects and within-person fixed effects. Previous research has argued that the hybrid and CRE models combine the strengths of random and fixed effects models ([Schunck and Perales 2017](#)).

First, we examined if increased PSMU predicted decreased life satisfaction. Then, we examined how increased loneliness affected

**Table 1**  
The Descriptive Statistics of Independent Variables for the Cross-sectional and Panel Data.

Variable	Cross-sectional (N = 2991)		Panel (N = 2021)	
	N	%( )	N	%( )
<i>Life satisfaction (mean)</i>	2975	(7.46)	2016	(7.34)
<i>Problematic social media use (mean)</i>	2701	(1.96)	1870	(2.01)
None	1066	39.5	685	36.6
Low	887	32.8	626	33.5
Medium	527	19.2	414	22.1
High	221	8.2	145	7.8
<i>Social media use (mean)</i>	2991	(2.80)	2021	(2.88)
Very low	241	8.1	121	6.0
Low	480	16.0	300	14.8
Medium	1893	63.3	1313	65.0
High	377	12.6	287	14.2
<i>Gender</i>				
Male	1417	47.6	983	48.6
Female	1563	52.4	1033	51.1
<i>Age (mean)</i>	2895	(48.8)	2013	(48.1)
<i>Education</i>				
Primary education	268	9.2	112	5.6
Secondary education	1541	52.7	993	49.9
Bachelor or higher education	1117	38.2	884	44.4
<i>Main activity</i>				
Employed	1586	54.2	1119	49.7
Unemployed	192	6.6	154	6.8
Student	248	8.5	181	8.0
Retired	814	27.8	716	31.8
Other	86	2.9	73	3.2
<i>Feeling of loneliness (mean)</i>	2927	(2.20)	1998	(2.26)
Never	665	22.7	421	21.1
Rarely	1234	42.2	822	41.1
Sometimes	811	27.7	568	28.4
Often/always	217	7.4	187	9.4

life satisfaction. Afterwards, we considered whether increased PSMU predicted loneliness. Finally, we tested how increased loneliness increased PSMU. When predicting life satisfaction, we used identity-linked regression models with the gaussian distribution. In terms of PSMU and loneliness, we constructed the models based on the ordinal distribution and the logit links.

In the first stage, we presented the results as tables and average marginal effects plots (Table 1, Fig. 2). We performed the statistical analyses in R 3.6.3 (R Core Team, 2020), and we calculated and visualised average marginal effects using the ggeffects package (Lüdtke, 2018). The second-stage models were compiled with Stata 16 using the xthybrid command (Schunck and Perales, 2017).

## 5. Results

### 5.1. First stage: Analysis of cross-sectional data

The findings of the first stage of analyses appear in Table 2 and Fig. 2. We began our analysis by inspecting the direct effects of each explanatory variable on the response variable subjective well-being. PSMU negatively predicted life satisfaction ( $B = -0.33$ ), but SMU did not have a significant effect. Female gender ( $B = 0.34$ ), age ( $B = 0.02$ ), and bachelor's degree or higher education ( $B = 0.50$ ) were positively associated with life satisfaction, whereas being unemployed ( $B = -1.71$ ), being a student ( $B = -0.92$ ), and other economic activity status ( $B = -0.68$ ) had a negative effect. Our confounding variable, loneliness, also negatively predicted life satisfaction ( $B = -1.11$ ). According to the robust check, we did not find significant differences between the used samples in the main effects. PSMU predicted negatively life satisfaction in probability sample ( $B = -0.32$ ,  $SE = 0.04$ ) and non-probability sample ( $B = -0.35$ ,  $SE = 0.07$ ). Also, loneliness was negatively associated with life satisfaction in both probability ( $B = -1.06$ ,  $SE = 0.04$ ) and non-probability sample ( $B = -1.04$ ,  $SE = 0.06$ ).

In Model 1, we regressed life satisfaction on PSMU and SMU. Here, PSMU continued to be significantly and negatively ( $B = -0.33$ ) associated with life satisfaction. The effect of SMU, however, was positive and significant ( $B = 0.16$ ). Controlling for gender, age, education, and economic activity (Model 2) only slightly altered the effect of PSMU ( $B = -0.29$ ) and SMU ( $B = 0.20$ ), and both remained significant. Gender ( $B = 0.29$ ), age ( $B = 0.02$ ) and bachelor's degree or higher education ( $B = -0.33$ ) positively and significantly predicted life satisfaction, whereas being unemployed ( $B = -1.47$ ), being a student ( $B = -0.37$ ), being a pensioner ( $B = -0.52$ ), and other economic activity status ( $B = -0.56$ ) had a significant negative effect.

Finally, we examined the confounding effect of loneliness (Model 3). In the fully adjusted model, PSMU's on life satisfaction decreased, but it remained significant ( $B = -0.09$ ), whereas SMU's positive effect decreased only slightly and remained significant ( $B = 0.15$ ). Gender ( $B = -0.09$ ), age ( $B = -0.09$ ), and bachelor's degree or higher education continued to positively and significantly predict life satisfaction, and the effect of unemployment remained negative and significant, though at reduced level ( $B = -0.95$ ).

**Table 2**

Ordinary least squares (OLS) regression models for explanatory variables predicting life satisfaction.

Variables	Simple regression		Multiple regression		
	Model	N	Model 1	Model 2	Model 3
<i>Problematic social media use</i>	-0.33 *** (0.04)	2690	-0.36 *** (0.04)	-0.29 *** (0.04)	-0.09 * (0.04)
<i>Social media use</i>	0.01 (0.05)	2975	0.16 ** (0.06)	0.20 ** (0.06)	0.15 ** (0.05)
<i>Gender (reference Male)</i>					
Female	0.34 *** (0.07)	2965		0.29 *** (0.07)	0.37 *** (0.07)
<i>Age (continuous)</i>	0.02 *** (0.00)	2969		0.02 *** (0.00)	0.01 ** (0.00)
<i>Education (reference Primary education)</i>		2910			
Secondary education	0.16 (0.14)			0.02 (0.14)	0.13 (0.13)
Bachelor/higher education	0.50 *** (0.14)			0.36 * (0.15)	0.42 ** (0.13)
<i>Economic activity (reference Employed)</i>		2910			
Unemployed	-1.71 *** (0.13)			-1.47 *** (0.14)	-0.95 *** (0.12)
Student	-0.92 *** (0.11)			-0.37 ** (0.12)	-0.20 (0.11)
Retired	-0.11 (0.09)			-0.52 *** (0.13)	-0.17 (0.12)
Other	-0.68 *** (0.19)			-0.56 ** (0.21)	-0.34 (0.18)
<i>Feeling of loneliness</i>	-1.11 *** (0.03)	2918			-1.01 *** (0.04)
N			2690	2585	2534
R2			0.03	0.12	0.31

Note: \*\*\*  $p < 0.001$ ; \*\*  $p < 0.01$ ; \*  $p < 0.05$ .

Unstandardized coefficients and standard errors in parentheses.

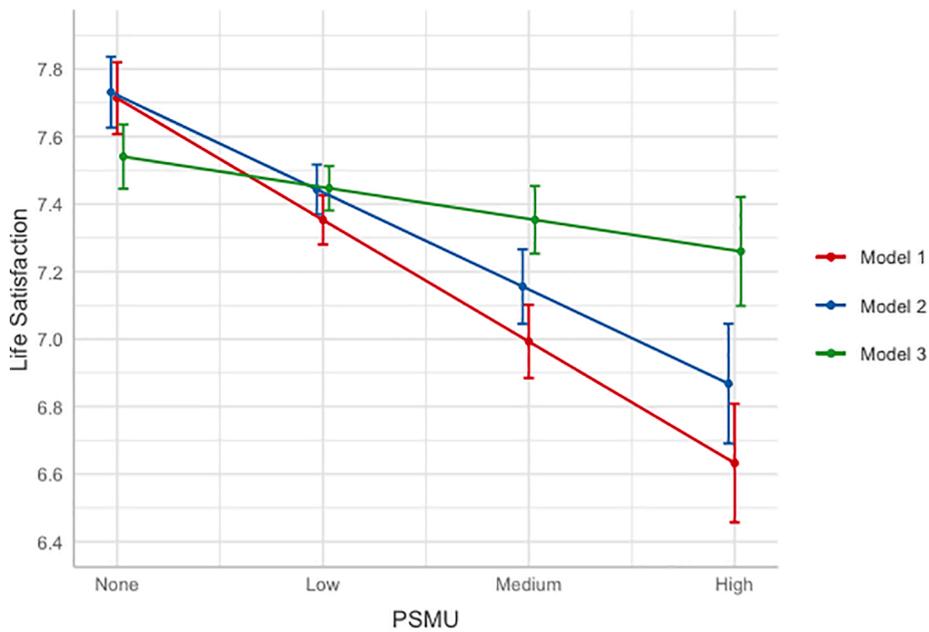


Fig. 2. Life satisfaction at various problematic social media use levels. Estimated means with 95% confidence intervals.

Loneliness, which was negatively and significantly ( $B = -1.01$ ) associated with life satisfaction, rendered the effects of other variables statistically insignificant.

The effect of controlling for loneliness is clearly visible in Fig. 2. In Models 1 and 2, especially medium or high PSMU levels predicted significantly reduced life satisfaction. It is also noteworthy, that controlling for demographic factors did not alter the effect of PSMU on satisfaction with life. Model 3, instead, shows that after controlling for loneliness, PSMU’s predicted effect on life satisfaction is much weaker. This seems to indicate that PSMU might have adverse effects on health and life satisfaction, but the effect is possibly confounded by other factors (in this case, loneliness).

5.2. Second stage: Panel data analysis

In the second stage, we examined the relationship between PSMU, loneliness and life satisfaction more closely using panel data from Finnish social media users. We controlled for the effect SMU, but we did not include the demographic factors on the models, because they did not affect the relationships of interests in the first stage. Moreover, they are usually static over a short observation

Table 3

Linear regression coefficients for subjective well-being according to PSMU and loneliness from hybrid mixed models (HYB) and correlated random effect models (CRE).

	Model 1				Model 2			
	HYB		CRE		HYB		CRE	
W_PSMU	-0.06	(0.06)	-0.06	(0.06)	-0.06	(0.06)	-0.06	(0.06)
B_PSMU	-0.30***	(0.07)			0.01	(0.06)		
D_PSMU			-0.24**	(0.09)			0.07	(0.09)
W_Loneliness					-0.17*	(0.08)	-0.17*	(0.08)
B_Loneliness					-1.28***	(0.06)		
D_Loneliness							-1.11***	(0.10)
W_SMU	0.04	(0.09)	0.04	(0.09)	0.06	(0.09)	0.06	(0.09)
B_SMU	-0.04	(0.10)			0.03	(0.08)		
D_SMU			-0.08	(0.13)			-0.03	(0.12)
Constant	8.05***	(0.28)	8.05***	(0.28)	10.11***	(0.26)	10.11***	1.76***
Observations	1,866		1,866		1,847		1,847	1,847
Number of groups	994		994		993		993	993

Standard errors in parentheses.

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

W = Within individuals effects.

B = Between individuals effects.

D = Between individuals effects.

period and thus their effect is generally captured by the fixed effect panel models.

Table 3 shows the results of the first hybrid models. The within effects of the first model revealed that increased PSMU did not decrease individuals' life satisfaction during the observation period ( $B = -0.06$ ). Instead, the between effect was significant ( $B = -0.30$ ), indicating that increased PSMU was associated with individuals' lower life satisfaction over the observation period.

The second model indicated that the between effect of PSMU was associated with the effect of loneliness. After controlling for the between and within effects of loneliness, the between effect of PSMU decreased significantly. Moreover, we found that loneliness also had a negative within effect on life satisfaction among the individuals during the observation period ( $B = -0.17$ ). In addition, loneliness had a strong negative association ( $B = -1.28$ ) with life satisfaction between individuals over the observation period.

Table 4 contains the results of models when predicting the between and within effects of social media users' loneliness. Notably, the within effects revealed that increased PSMU across the observation period had a slight but statistically significant ( $B = 0.27$ ;  $p < 0.05$ ) effect on individuals' loneliness. The between effects indicate that PSMU had a notable association with loneliness ( $B = 1.14$ ) over the observation period.

Finally, Table 5 shows the ordinal logit coefficients when predicting changes in PSMU with respect to loneliness. The within effects indicate that increased loneliness ( $B = 0.29$ ) did increase likelihood of PSMU, but the effect was not statistically significant (at level  $p < 0.05$ ). Notably, the between effect of loneliness ( $B = 0.78$ ) was remarkable when predicting PSMU. The model also revealed that the general use of social media was highly contributing PSMU when examining the between-subjects effects ( $B = 1.16$ ), but the within-subjects effect was not significant (at level  $p < 0.05$ ).

In each multilevel hybrid models, the formal tests of the random-effects assumption indicated that that the within-cluster effects were statistically different from the between-cluster effects. Accordingly, we performed robust checks using correlated random effect models in which within-cluster effects were identical to those found in the hybrid model, but the between effects varied across the models. However, the relationships between individuals were quite similar to those found in the hybrid models.

## 6. Discussion and conclusion

In this study, we examined how PSMU connects to life satisfaction, with a focus on the confounding effect of loneliness. In the first stage of analysis, we used cross-sectional data from Finnish social media users, and discovered that although PSMU is negatively associated with life satisfaction, the confounding effect of loneliness largely explains the association. In the second stage, we used follow-up panel data to predict the direction of the effects among PSMU, loneliness, and satisfaction with life. We found that increased PSMU did not predict a decrease in life satisfaction over a 15-month period. However, increased PSMU predicted increased loneliness, and increased loneliness predicted decreased life satisfaction, which indicates that PSMU is connected to decreased life satisfaction over time through loneliness.

Our analysis produced several important findings that clarify the relationship between PSMU and subjective well-being experiences. Consistent with hypotheses 1 (H1) and 2 (H2), as well as earlier research (e.g., Verduyn et al., 2017; Wheatley and Buglass, 2019), cross-sectional analysis indicated that PSMU and loneliness are negatively associated with life satisfaction. Additionally, the first stage of the analysis confirmed the hypothesis 3 (H3) that PSMU is associated with reduced life satisfaction through loneliness, which is in line with findings from earlier studies (Arampatzi et al., 2018; Satici, 2019). Results from the analysis of the panel data validated this finding over the 15-month observation period: PSMU directly predicted decreased life satisfaction between subjects, but the effects diminished after loneliness were taken into account. Our results are in contrast with earlier research that has implied PSMU has a strong, independent effect on subjects' well-being experiences (e.g., Shensa et al., 2017), and support the notions (e.g., Verduyn et al., 2017) that PSMU is a multidimensional phenomenon that could produce varying outcomes depending on users' background and type of use.

Findings from the panel data provide further information on how loneliness affects the relationship between PSMU and life satisfaction. Within-subject tests confirmed that increased PSMU predicts increased individuals' loneliness over time, as well as that increased loneliness predicts decreased life satisfaction, a result that supports the findings from earlier studies (Ponnusamy et al., 2020). However, despite the expected direction of the relationship (Kim et al., 2009; Moretta and Buodo, 2020), we could not confirm that loneliness would predict increased PSMU over time. This finding from the within-subject tests shows that PSMU significantly contributes to the development of loneliness, but loneliness does not necessarily lead to PSMU. This appears to be the case, although PSMU and loneliness show significant effect with each other in the between-subjects tests. These findings add to the existing research and provide more proof that those who feel lonely are in more vulnerable position when it comes to negative outcomes of PSMU.

In addition, our analysis found no significant association between SMU and life satisfaction, and controlling for PSMU transformed the relationship into a moderately strong, positive and significant in the cross-sectional data. According to the panel data analysis, increased SMU did not decrease life satisfaction or vice versa. Moreover, the panel data did not reveal a statistically significant within effect of the SMU on PSMU during the observation period. These results contribute to earlier studies that found a positive relationship between overall SMU and subjective well-being (Valenzuela et al., 2009; Verduyn et al., 2017), and they indicate that overall SMU itself does not increase the risk of negative life outcomes.

To conclude, the results of both analyses indicate that loneliness is a crucial underlying element that contributes to the relationship between PSMU and subjective well-being. Although PSMU does not appear to affect the well-being of individuals directly over time, its negative impact on an individuals' social relationships is quite clear. In the longer term, increased loneliness naturally also affects subjective well-being, and this is confirmed by the results of within-subjects tests. In this respect, we can conclude that PSMU may trigger a decline in subjective well-being that is mainly associated with deteriorating social relationships. This notion is important when considering the current social media applications for mobile devices, which require constant logging on and frequent activity

**Table 4**

Ordinal logit coefficients for loneliness according to PSMU from hybrid generalised mixed models (HYB) and correlated random effects models (CRE).

Variables	HYB		CRE	
	B	SE	B	SE
W_PSMU	0.27*	(0.13)	0.27*	(0.13)
B_PSMU	1.14***	(0.16)		
D_PSMU			0.87***	(0.21)
W_SMU	0.12	(0.20)	0.12	(0.20)
B_SMU	0.27	(0.22)		
D_SMU			0.14	(0.29)
Observations	1850		1850	
Number of groups	993		993	

Standard errors in parentheses.

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

W = Within individuals effects.

B = Between individuals effects.

D = Between individuals effects.

**Table 5**

Ordinal logit coefficients for PSMU according to loneliness from hybrid generalised mixed models (HYB) and correlated random effects models (CRE).

Variables	HYB		CRE	
	B	SE	B	SE
W_Loneliness	0.29	(0.15)	0.29	(0.15)
B_Loneliness	0.78***	(0.11)		
D_Loneliness			0.49***	(0.18)
W_SMU	0.29	(0.18)	0.29	(0.18)
B_SMU	1.61***	(0.16)		
D_SMU			1.31***	(0.24)
Observations	1850		1850	
Number of groups	993		993	

Standard errors in parentheses.

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

W = Within individuals effects.

B = Between individuals effects.

D = Between individuals effects.

from their users (Panova and Carbonell, 2018). Such applications can easily create problematic use patterns for many, and especially for the lonely, who are already among the most vulnerable segments of online users.

It is unclear why do those who are lonely experience the effects of PSMU differently. Earlier research (e.g., Bano et al., 2019; Chen and Li, 2017; Pang, 2018a; Verduyn et al., 2017) have suggested that active SMU strengthens social ties and increases well-being, and passive use generates social comparison and decreases life satisfaction. Also, according to previous studies (e.g., Nowland et al., 2018) lonely people might be more likely to use digital technologies in a way that does not promote new social connections, and there is an association between SMU, loneliness and social comparison. Consequently, it is possible that in some cases PSMU might initiate a cycle of social comparison, isolation, and decreased life quality, happiness and life satisfaction. Unfortunately, our data and analysis do not capture these differences, such as social comparison orientation, within and between individuals.

Our research also comes with other limitations. As our study comes from one country alone, we should keep in mind that there may also be cultural differences in how SMU patterns connect with life satisfaction and loneliness. Moreover, our data covered only two time-points with relatively short 15-month timespan, and studies covering at least three time-points are needed to offer more plausible analysis on the directionality of the effects and interplay among the associated factors of SMU. Last, we measured loneliness with single self-rated item, which could lead to biased estimates.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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