



The bidirectional relationships between fear of missing out, problematic social media use and adolescents' well-being: A random intercept cross-lagged panel model

Yan-Yu Li^{a,*}, Ina M. Koning^b, Catrin Finkenauer^a, Maartje Boer^c, Regina J.J.M. van den Eijnden^a

^a Department of Interdisciplinary Social Science, Utrecht University, the Netherlands

^b Clinical Child and Family Studies, Faculty of Behavioural and Movement Sciences, Vrije Universiteit Amsterdam, the Netherlands

^c National Institute for Public Health and the Environment, the Netherlands

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ABSTRACT

Problematic social media use (PSMU) is a societal problem, which impacts adolescents' well-being. Fear of missing out (FoMO) has been suggested as a core risk factor predicting both PSMU and adolescents' well-being. However, longitudinal research on the directionality of these relationships is scarce. The present study aims to fill this knowledge gap by testing the bidirectional relationships between FoMO, PSMU and adolescents' life satisfaction in the total sample, as well as for girls and boys separately. This study used four-waves annual longitudinal data collected from 2015 to 2019 among Dutch adolescents aged 11–15 years ($n = 1419$, $M_{age} = 12.5 \pm 0.60$, 45.9% girls). We applied random intercept cross-lagged panel model(s) to separate within-person level effects from between-person level effects. On the within-person level, findings suggested a unidirectional relationship whereby FoMO increased PSMU during mid-adolescence, but not vice versa. Moreover, low life satisfaction predicted an increase in FoMO during early adolescents. These findings underline that FoMO can be considered a risk factor of PSMU, and that low life satisfaction may be a risk factor for developing FoMO. These insights should be considered in intervention programs developed to effectively prevent unhealthy internet use in adolescents.

1. Introduction

Social media platforms such as Facebook, Instagram, and Snapchat have become an integral aspect of adolescents' daily lives worldwide (Keles et al., 2019). However, concerns have been raised by families and schools when adolescents use social media problematically. Problematic social media use (PSMU) can be defined as uncontrollable, addictive-like social media use that persists over a longer period of time (van den Eijnden et al., 2016). This behavior always comes at the expense of important life domains for adolescents (Banyai et al., 2017; Paakkari et al., 2021; Shannon et al., 2022). There is a growing body of empirical evidence indicating that adolescents who have developed PSMU subsequently report lower levels of well-being (Boer, Stevens, Finkenauer, de Looze, & van den Eijnden, 2021; Chang et al., 2022; Li et al., 2018; Marttila et al., 2021; Raudsepp, 2019; van den Eijnden et al., 2021), for instance life satisfaction (Boer, Stevens, Finkenauer, & van den Eijnden,

2021; Marttila et al., 2021; van den Eijnden et al., 2018).

Meanwhile, scholars have suggested that fear of missing out (FoMO) may be a core risk factor that is associated with both higher levels of PSMU (Fioravanti et al., 2021; Gul et al., 2021; Çelik et al., 2022) and lower levels of life satisfaction among adolescents (Deniz, 2021; Çelik et al., 2022). Yet, there is a scarcity of empirical studies investigating the interrelationships between FoMO, PSMU, and life satisfaction. The Differential Susceptibility to Media Effects Model (DSMM; Valkenburg & Peter, 2013) provides a comprehensive theoretical framework elucidating that media use factors predict media response states (i.e., state variables originating from media use), which in turn predict media effects (i.e., cognitive, emotional, attitudinal, and behavioral effects of media on individuals), whereby it is assumed that preexisting individual and social context factors may predict media use, but may also influence the relationships between media use and media response states/media effects. When applying the DSMM, PSMU can be considered a media use

* Corresponding author. Padualaan 14, PO Box 80140, 3584 CH, Utrecht, the Netherlands.

E-mail address: y.li4@uu.nl (Y.-Y. Li).

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factor, whereas life satisfaction a media effect. Furthermore, FoMO could serve as both a predictor (i.e., preexisting individual factor) of PSMU and an outcome (i.e., media response state) resulting from PSMU. However, because most of the existing studies on the relationships between FoMO, PSMU, and life satisfaction have used cross-sectional designs (Çelik et al., 2022), we know little about the assumed temporal associations between these variables. In other words, the directionality of the relationships between these variables remains unclear. In addition, cross-sectional data only allow for inferences at the between-person level (Curran & Bauer, 2011), thereby providing insufficient information regarding within-person dynamics over time which is crucial for comprehending temporal changes.

To address these gaps, the present study aims to enhance our understanding of the longitudinal associations between PSMU, FoMO, and life satisfaction at a within-person level, while also exploring potential gender differences in these relationships. By addressing these research gaps, this study provides a better understanding of the relationships between PSMU, FoMO, and life satisfaction, thereby providing potential leverage points for the development of prevention and intervention efforts aimed at reducing FoMO and PSMU and improving adolescent well-being. Meanwhile, the current study also enriches the existing literature by bridging the gap in understanding the long-term effects between FoMO, PSMU, and life satisfaction through the lens of the DSMM.

1.1. The impact of PSMU on life satisfaction

PSMU is negatively associated with adolescents' life satisfaction, as was shown by a large number of cross-sectional studies (Buda et al., 2021; Huang, 2022). Moreover, several longitudinal studies suggest that PSMU predicts a decrease in life satisfaction (Boer, Stevens, Finkenauer, & van den Eijnden, 2021; van den Eijnden et al., 2018). For instance, a recent longitudinal study found a direct unidirectional association between PSMU and life satisfaction (Boer, Stevens, Finkenauer, & van den Eijnden, 2021), suggesting that PSMU predicts a decrease in adolescents' life satisfaction one year later, but not vice versa. Although the mechanisms involved in this association are not fully understood yet, there are theoretical reasons to believe that several processes may account for this association. For instance, PSMU may come at the expense of other important life domains, such as mental health (Chang et al., 2022; Li et al., 2018; Marttila et al., 2021; Raudsepp, 2019), school performance (Ali, 2022), sleep (Raudsepp, 2019; van den Eijnden et al., 2021), and may lead to more conflict with parents (White-Gosselin & Poulin, 2022). Therefore, we hypothesize that higher levels of PSMU will predict lower levels of life satisfaction (Hypothesis 1).

1.2. The mediating role of FoMO

FoMO refers to a general apprehension that others may have more rewarding experiences that one is deprived of, characterized by a strong desire to stay connected with others (Przybylski et al., 2013). FoMO has often been related to adolescents' social media use, and particularly to PSMU (Fioravanti et al., 2021; Zhang, Li, et al., 2021). According to the social comparison theory (Festinger, 1954), individuals tend to evaluate themselves and their lives by comparing their own situation with that of others, such as their peers. Particularly among adolescents, idealized images are often shared on social media platforms (Vogel & Rose, 2016), showcasing enjoyable leisure activities and fun moments with friends. Consequently, exposure to highly positive online content may lead adolescents to perceive that others have more fulfilling social lives than they do, thereby triggering FoMO (Burnell et al., 2019). Adolescents with higher levels of PSMU are more likely to engage in social comparison (Boer, Stevens, Finkenauer, & van den Eijnden, 2021; Burnell et al., 2019), which may result in higher levels of FoMO (Servidio et al., 2021; Wang et al., 2023).

There are also reasons to assume that FoMO may predict a decrease

in adolescents' life satisfaction. Individuals with higher levels of FoMO tend to have a stronger inclination to maintain social connections and compare themselves to others (Przybylski et al., 2013). This constant need to stay connected and up to date on social media platforms, coupled with upward social comparison tendencies, may result in depression over missing out on social events or experiences that others are having (Leung et al., 2021; Park, 2022). Such feelings can lead to the perception of inadequacy and dissatisfaction with one's own life (Deniz, 2021; Przybylski et al., 2013). Furthermore, by definition, a key component of FoMO is a relatively high level of negative affect. Several studies have shown that FoMO is associated with other negative feelings, such as envy (Yin et al., 2021), loneliness (Tatli & Ergin, 2022), and boredom (Liang et al., 2022), which in turn can lead to lower life satisfaction (Marttila et al., 2021; Mujcic & Oswald, 2018; Spruyt et al., 2016). Cross-sectional studies also found that FoMO was negatively associated with life satisfaction (Blachnio & Przepiorka, 2018; Deniz, 2021; Przybylski et al., 2013). Based on the above, it can be hypothesized that higher levels of PSMU will predict higher levels of FoMO, which, in turn, will predict lower levels of life satisfaction (Hypothesis 2).

1.3. The mediating role of PSMU

It should be noted, however, that, as most studies on the relationship between PSMU and FoMO have used cross-sectional designs. Consequently, it is plausible to consider that the association between FoMO and PSMU may also be bidirectional in nature. While there exist theoretical grounds to support that PSMU leads to higher levels of FoMO, as described above, in light of the DSMM (Valkenburg & Peter, 2013) it should also be acknowledged that FoMO could potentially serve as a risk factor (i.e., dispositional-susceptibility factor) for the development of PSMU. According to the self-determination theory (Ryan & Deci, 2000), relatedness, which refers to the desire for interpersonal closeness and connection, is identified as one of the basic psychological needs contributing to individuals' well-being. Relatedness is particularly important for adolescents, because, during early adolescence, they tend to spend more time with peers of their own age, have less adult supervision, and place more value on peers' opinions and expectations (Brown & Larson, 2009). Therefore, it is expected that when adolescents have higher levels of FoMO, they will have a stronger urge to stay connected with their peers. In order to fulfill this need and alleviate feelings of FoMO, adolescents may be inclined to use social media to stay connected with their peers, for instance by checking their peers' profile pages on social media without time and place constraints and may also be more likely to engage in addictive-like social media use (Zhu & Xiong, 2022; Çelik et al., 2022). Indeed, a recent study found that FoMO enhanced adolescents' state of self-presentation on social media and further led to PSMU (Zhu & Xiong, 2022). Therefore, in addition to Hypothesis 2, it is hypothesized that higher levels of FoMO will predict higher levels of PSMU, which, in turn, will predict lower levels of life satisfaction (Hypothesis 3).

1.4. The current study

Building on the theories and the previous studies, the current study aimed to understand the longitudinal associations between PSMU, FoMO, and life satisfaction among adolescents. In order to do this, we used four annual waves of longitudinal data collected from Dutch secondary school adolescents aged 11–15 years between 2015 and 2019. We used a novel modeling technique, the Random-Intercept Cross-lagged Panel Model (RI-CLPM, see Fig. 1), to disentangle within-person effects from between-person effects. This approach allows us to examine the relationships at the within-person level. Moreover, to make sure that the found associations were specific to PSMU and not social media use behaviors in general, we controlled for the social media use intensity. Meanwhile, we also included a number of demographic

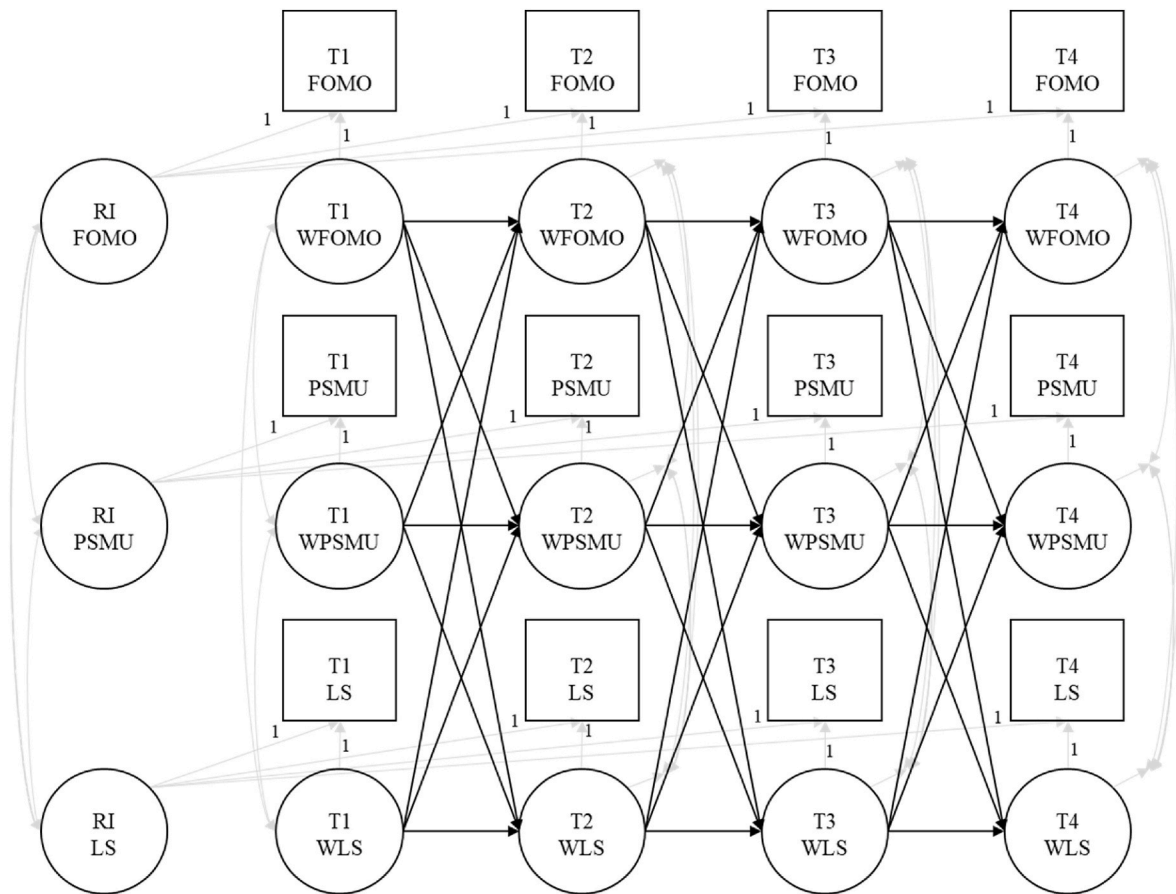


Fig. 1. Conceptual RI-CLPM for FoMO, PSMU, and Life Satisfaction Across Four Waves. *Note.* Observed variables are represented by squares; latent variables at both between- and within-level are represented by circles; RIs indicate the between-person variance. Correlations between RIs and correlations between the within-person values from the same measurement occasion were specified by gray double arrows. Diagonal black arrows represent the cross-lagged paths. Horizontal arrows represent the auto-regressive paths. Gender, educational level, and social media use intensity have been inserted into the model as control variables, but they are not shown in the figure for clarity. FoMO, Fear of Missing Out; PSMU, Problematic Social Media Use; LS, Life Satisfaction.

variables as covariates to control for possible confounding effects. Finally, as both FoMO and PSMU, as well as life satisfaction showed significant gender differences in previous studies (Chen et al., 2019; Gong et al., 2022; van den Eijnden et al., 2018). Therefore, in the current study, we also conducted RI-CLPMs in multigroup analysis to provide more insight into the relationship between FoMO and PSMU and its influence on life satisfaction between genders.

2. Method

2.1. Participants and procedure

The study used data from the Digital Youth (DiYo) project. The DiYo project is an ongoing self-report longitudinal study that aims to investigate the relationship between online behaviors and mental health among secondary students in the Netherlands. The project collected annual data in February and March from 2015 to 2019. Two weeks prior to the survey assessment, letters were sent to parents that explained the topic and purpose of the research, emphasized that participation was voluntary and anonymous, and notified them of the option to refuse participation for their child. A week after informing the parents, students were also informed about the same information, and given the right to withdraw from the survey at any point, even after it had started. The assessments were conducted in the classroom, using digital self-completion, with the monitoring of researcher assistants who were available to provide help if necessary. The students completed the online survey during school hours. The research procedure was identical across

waves. The research procedures abide by the Declaration of Helsinki and were reviewed and approved by the ethical committee of Utrecht University (protocol number: FETC16-076 Eijnden).

In the current study, we selected data from four waves of the DiYo project, specifically from adolescents who were in 7th grade at the time of the survey assessments in either 2015 or 2016, resulting in a sample of 1419 adolescents eligible for analysis (Boer, Stevens, Finkenauer, & van den Eijnden, 2021). The waves that were included in the current study are further referred to as T1, T2, T3, and T4. Of this sample, participating students were between 11 and 15 years old ($M_{age} = 12.5, SD = 0.60$) at T1, and 45.9% were girls. Furthermore, the students were in different educational levels, with 57.8% in pre-vocational, 28.5% in intermediate, and 13.7% in the pre-university level, respectively.

At T1, 782 participants, accounting for 55.1% of the whole analysis sample, joined the investigation. One year later (T2), due to new participants entering the investigation at this time point, there was a total of 1327 participants, accounting for 93.5% of the whole analysis sample. At T3, there were 1077 participants, accounting for 75.9% of the whole analysis sample, and at T4, there were only 495 participants, accounting for 34.9% of the whole analysis sample. The incomplete data in T1 was because some participants entered the investigation in T2 or T3 for the first time. The high dropout at T4 was a result of the discontinuation of participants in entire pre-vocational schools, school years (e.g., final exam year) or school classes (e.g., difficulties in arranging the survey assessment due to practical reasons), and not due to individual selection.

Attrition analysis was conducted by doing Little's MCAR tests and by predicting dropout at T2, T3, and T4 with the studied measures at the

previous waves using binary logistic regressions. Results of the Little's MCAR test showed that at T1, T3, and T4, the missing values were completely at random (T1: $\chi^2(6) = 6.221, p = .399$; T3: $\chi^2(6) = 6.541, p = .365$; T4: $\chi^2(6) = 9.530, p = .146$), whereas at T2 these values were not missing completely at random ($\chi^2(5) = 13.001, p = .023$). Additional binary logistic regressions, however, showed that social media use intensity, FoMO, PSMU, life satisfaction, age or gender at T1 did not significantly predict dropout at T2 ($OR_{\text{range}} = -0.14$ to $0.21, p = .405$ to $.761$). Thus, the results suggest that although there was attrition over time, associations between our studied variables and dropout were limited.

2.2. Measures

2.2.1. Fear of missing out (FoMO)

FoMO was measured using the Fear of Missing Out scale, which was developed by Przybylski et al. (2013). The scale originally consists of 10 items, however, in the current study, only five items were used, for example, "I fear others have more rewarding experiences than me". Adolescents rated the items on a 5-point Likert scale (1 = *not true to me at all* to 5 = *extremely true to me*). An exploratory factor analysis revealed that the five items loaded onto one factor, with all factor loadings above 0.5. In addition, overall Kaiser-Meier-Olkin measure (0.8) indicated good sampling adequacy. A mean score was computed, where higher scores indicating higher levels of FoMO. Cronbach's α (T1 = 0.83; T2 = 0.82; T3 = 0.83; T4 = 0.83) suggested adequate internal consistency in the present study.

2.2.2. Problematic social media use (PSMU)

PSMU was measured using the 9-item Social Media Disorder Scale (van den Eijnden et al., 2016). The scale consists of items measuring symptoms of addiction regarding social media, including preoccupation, withdrawal, tolerance, persistence, displacement, conflict, deception, escape, and problems. Adolescents were asked: "During the past year, have you (...)", followed by, for example, "often felt bad when you could not use social media?" (withdrawal). Response scales were dichotomous (0 = *no*, 1 = *yes*). A sum score was computed that denoted adolescents' number of present criteria, where a higher score indicating higher levels of PSMU. Due to the dichotomous nature of the items, internal consistency was calculated using the tetrachoric correlation matrix (Gadermann et al., 2012). Ordinal α (T1 = 0.83; T2 = 0.85; T3 = 0.84; T4 = 0.86) suggested adequate internal consistency in the present study.

2.2.3. Life satisfaction

Life satisfaction was measured using the 7-item Student's Life Satisfaction Scale (Huebner, 1991). This scale includes items on student's satisfaction with their own life, for example "My life is going well", "My life is just right". Adolescents rated the items on a 6-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). Relevant items were recoded reversely, so that a higher mean score indicated a higher level of life satisfaction. Cronbach's α (T1 = 0.81; T2 = 0.83; T3 = 0.84; T4 = 0.83) suggested adequate internal consistency.

2.2.4. Social media use intensity (SMUI)

SMUI was assessed by six items, which measured the frequency of different social media activities (van den Eijnden et al., 2018). The first four items included "How many times *per day* do you view social network sites", "How many times *per week* do you post a message, photo, or video on social network sites", "How many times *per week* do you 'like' messages, photos, or videos of others on social network sites", "How many times *per week* do you respond to messages, photos, or videos of others on social network sites", rated on a 7-point Likert scale from 1 (never or less than once) to 7 (more than 40 times). Two additional items included "How many times *per day* do you send a message, photo or video via your smartphone, for example a WhatsApp, Chat, SnapChat, or SMS" and "How many times *per day* do you check your

smartphone to see whether you have received a message, photo, or video, for example a WhatsApp, Chat, SnapChat, or SMS?". Answer categories included a 7-point Likert scale (1 = *less than once* to 7 = *more than 80 times*). A mean score was obtained, where higher scores indicated higher levels of SMU intensity. Cronbach's α (T1 = 0.87; T2 = 0.86; T3 = 0.83; T4 = 0.80) suggested adequate internal consistency in the present study.

2.2.5. Demographic variables

Respondents' gender was measured by asking whether they were boy or girl (0 = *boy*, 1 = *girl*). Also, they reported their educational level (1 = *pre-vocational*, 2 = *intermediate*, 3 = *pre-university*). Adolescents' educational level was defined as their most recent reported educational level. Moreover, respondents' age was also included at T1.

2.3. Analytic strategy

We performed descriptive statistics and bivariate correlation analyses in SPSS 26 to capture the mean levels of the main study variables and their inter-relationships, both within and across different time points. According to Cohen (1992), Pearson correlation coefficients of 0.10, 0.30, and 0.50 indicate small, medium, and large effect sizes, respectively. Subsequently, we performed measurement invariance using Mplus 8.0 to ensure that significant effects found in the structural model would not be likely due to the differences in the measurement model. Measurement invariance was established when applying equality constraints to the item factor loadings and intercepts (or thresholds) did not substantially deteriorate model fit in terms of change in comparative fit index ($\Delta CFI = \text{decrease of } \leq 0.010$) and root mean square error of approximation ($\Delta RMSEA = \text{increase of } \leq 0.015$; Chen, 2007).

To examine the longitudinal relationships between FoMO, PSMU, and life satisfaction at the within-person level, we fitted a random intercept cross-lagged panel model (RI-CLPM, see Fig. 1), in which between-person level associations can be separated from within-person level associations and be controlled to have more accurate estimates of relationships between studied variables.

In the between-person part, we tested correlations between random intercepts (RIs), which are latent variables extracted from four repeated values with all factor loadings constrained to 1 to denote the trait-like deviations from the temporal group means. In the within-person part, after controlling the correlations between RIs, we tested autoregressive associations and cross-lagged associations established by within-person values, which are latent variables extracted from their respective value with factor loading constrained to 1. Specifically, the autoregressive associations represent the amount of within-person carry-over effect over time, whereas cross-lagged associations represent the extent to which the within-person changes in preceding, for example, PSMU would predict subsequent within-person changes in, for example, life satisfaction. Meanwhile, we also tested and controlled the correlations between within-person values within the same year. In addition, we included social media use intensity as a time-variant variable into the model, meanwhile, we regressed the adolescents' gender and educational levels on the observed scores of FoMO, PSMU, life satisfaction, and social media use intensity to control for their possible confounding effects following guidelines of Mulder and Hamaker (2021).

In our first model, we fitted a RI-CLPM with four repeated measures of FoMO, PSMU, life satisfaction, and social media use intensity (M1). In our second model, we fitted a multi-group RI-CLPM, where all parameters were free to vary across boys to girls, to examine the gender difference (M2). Missing data were estimated using full information maximum likelihood (FIML) with robust errors default settings, because FIML has been shown to perform better than data deletion-based methods in reducing bias in longitudinal studies even with high rates of missing data (Lee & Shi, 2021). Furthermore, model fit was evaluated using the root mean square error of approximation (RMSEA; acceptable < 0.08 , good < 0.05), the comparative fit index (CFI; acceptable > 0.90 ;

good >0.95), and standardized root mean square residual (SRMR; acceptable <0.08, good <0.05). The standardized results (STDYX) of the models were used for the interpretation of the effect sizes. Analyses were conducted using Mplus 8.0 (Muthén & Muthén, 2017).

3. Results

3.1. Preliminary analyses

As shown in Table 1, the results of the bivariate associations showed that nearly all variables were significantly related across time points, with effect sizes from moderate to large. To examine whether PSMU, FoMO, life satisfaction, and social media use intensity were invariant over time, we carried out longitudinal measurement invariance test to examine configural, metric, and scalar invariance for the four constructs separately. Results, as shown in Table 2, suggested that the configural, metric, and scalar invariance were established for PSMU, FoMO, and life satisfaction. Meanwhile, the configural, metric, and partial scalar invariance were established for social media use intensity, where the intercept of 2 items were released to be freely estimated. Additionally, to examine whether PSMU, FoMO, life satisfaction, and social media use intensity would be invariant across gender, we carried out measurement invariance for each construct over time and across gender. Specifically, we fit models including T1, T2, T3, and T4 for each variable, separately, as four latent variables, with each latent variable constructed by items of the scale at each time point. Results, as shown in Table 2, suggested that the configural, metric, and scalar invariance were established for PSMU, and life satisfaction. Meanwhile, the configural, metric, and partial scalar invariance were established for social media use intensity (intercepts of item 1 and item 2 were freely estimated), and FoMO (intercept of item 5 was freely estimated).

3.2. Main analyses

After controlling for demographic variables and adolescents' social media use intensity, the RI-CLPM (M1) had a good model fit ($\chi^2(38) = 38.049$, RMSEA = 0.001, CFI = 1.000, TLI = 1.000, SRMR = 0.024). At the between-person level, PSMU was positively related to FoMO ($b = 0.21$, $p < .001$, $\beta = 0.61$), but negatively related to life satisfaction ($b = -0.09$, $p < .001$, $\beta = -0.40$). FoMO was negatively related to life satisfaction ($b = -0.16$, $p < .001$, $\beta = -0.35$). At the within-person level, autoregressive and cross-lagged associations between FoMO, PSMU, and life satisfaction are reported in Table 3 and Fig. 2.

Firstly, the cross-lagged associations between PSMU and life satisfaction were non-significant. This means that adolescents whose PSMU changed did not report associated changes in life satisfaction one year later. Thus, Hypothesis 1 was not confirmed.

Secondly, with regards to the cross-lagged associations between PSMU and FoMO, we only observed a unidirectional association from FoMO at T3 to PSMU at T4 ($b_{T3-T4} = 0.29$, $p = .026$, $\beta = 0.15$). This finding indicates that adolescents whose FoMO increased reported increases in PSMU one year later, specifically in late adolescence, but not the other way around. No significant cross-lagged relations between FoMO and PSMU at other time points were found.

Finally, with regards to the cross-lagged associations between FoMO and life satisfaction, we did not find any significant effects of FoMO on life satisfaction at any time point. Thus, the findings did not confirm Hypothesis 2 but partially supported Hypothesis 3.

Even though we did not find that adolescents' increases in FoMO predicted decreases in their life satisfaction one year later, we did find a reverse relation: Increases in adolescents' life satisfaction were associated with decreases in their FoMO on year later ($b_{T1-T2} = -0.15$, $p = .040$, $\beta = -0.14$), yet only during early adolescents (age 12–13).

Table 1
Means, standard deviations, and bivariate association of study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Covariates																			
1 Gender ^a																			
2 Educational level ^b	.13***																		
3 age T1	-.10***	1																	
4 SMUI T1	.12**	-.21***	1																
5 SMUI T2	.21***	-.15***	.01	1															
6 SMUI T3	.12***	-.16***	.01	.52***	1														
7 SMUI T4	.10*	-.16***	.03	.42***	.60***	1													
Key variables																			
8 PSMU T1	-.05	-.25***	.11**	.35***	.28***	.24***	.10	1											
9 PSMU T2	.06*	-.15***	.05	.28***	.34***	.22***	.22***	.45***	1										
10 PSMU T3	.07*	-.11***	.03	.26***	.27***	.29***	.18***	.45***	.46***	1									
11 PSMU T4	.05	-.10*	.08	.23**	.20***	.17***	.30***	.34***	.28***	.48***	1								
12 FoMO T1	.06	.08*	-.04	.11**	.06	.12*	.08	.32***	.24***	.21***	.18**	1							
13 FoMO T2	.12***	.09**	-.05	.13***	.18***	.19***	.11*	.22***	.35***	.26***	.25***	.47***	1						
14 FoMO T3	.12***	.14***	-.04	.08	.08*	.13***	.10*	.15**	.15***	.26***	.32***	.35***	.44***	1					
15 FoMO T4	.12**	.12**	.02	.10	.08	.14**	.19***	.17**	.16**	.19***	.24**	.30***	.36***	.49***	1				
16 LS T1	-.08*	.06	-.03	-.10**	-.11**	-.06	-.06	-.28***	-.22***	-.18***	-.15**	-.34***	-.27***	-.14**	-.14**	1			
17 LS T2	-.09**	.01	.02	-.11**	-.09**	-.07*	-.05	-.21***	-.31***	-.21***	-.16**	-.21***	-.39***	-.16**	-.17**	.51***	1		
18 LS T3	-.03	.03	-.03	-.12*	-.07*	-.06	-.09	-.26***	-.22***	-.20**	-.20**	-.25***	-.22***	-.19***	-.29***	.47***	.52***	1	
19 LS T4	-.04	.05	-.06	-.13	-.06	-.03	-.07	-.15*	-.17**	-.13**	-.24***	-.12	-.16**	-.16**	-.23***	.51***	.45***	.55***	1
M			12.51	3.68	3.89	3.91	3.90	1.13	1.29	1.15	1.47	1.75	1.72	1.77	1.92	4.93	4.69	4.54	4.48
SD			0.60	1.38	1.37	1.29	1.20	1.49	1.62	1.46	1.63	0.70	0.71	0.73	0.79	0.76	0.87	0.88	0.88

Note. ^a gender is a category variable (0 = boy, 1 = girl). ^b educational level is a category variable (1 = pre-vocational level, 2 = intermediate level, 3 = pre-vocational level). SMUI = social media use intensity, PSMU = problematic social media use, FoMO = fear of missing out, LS = life satisfaction. T1 = at time 1, T2 = at time 2, T3 = at time 3, T4 = at time 4. Same as below.

Table 2
Measurement invariance.

	CFI	ΔCFI	RMSEA	ΔRMSEA
Measurement Invariance (longitudinal)				
SMUI	0.925	–	0.048	–
Configural invariance				
Metric invariance	0.921	–0.004	0.047	–0.001
Partial scalar invariance ^a	0.915	–0.006	0.048	0.000
PSMU				
Configural invariance				
Metric invariance	0.926	–	0.018	–
Scalar invariance	0.937	0.011	0.016	–0.002
Scalar invariance	0.927	–0.010	0.017	0.001
FoMO				
Configural invariance				
Metric invariance	0.905	–	0.050	–
Scalar invariance	0.904	–0.001	0.048	–0.002
Scalar invariance	0.900	–0.004	0.047	–0.001
Life satisfaction				
Configural invariance				
Metric invariance	0.924	–	0.041	–
Scalar invariance	0.922	–0.002	0.040	–0.001
Scalar invariance	0.917	–0.005	0.041	0.001
Measurement Invariance (across gender)				
SMUI				
Configural invariance				
Metric invariance	0.910	–	0.053	–
Partial scalar invariance ^b	0.904	–0.006	0.053	0.000
Partial scalar invariance ^b	0.897	–0.007	0.053	0.000
PSMU				
Configural invariance				
Metric invariance	0.935	–	0.016	–
Scalar invariance	0.938	0.003	0.015	–0.001
Scalar invariance	0.934	–0.004	0.016	0.001
FoMO				
Configural invariance				
Metric invariance	0.911	–	0.049	–
Partial scalar invariance ^c	0.904	–0.007	0.050	0.001
Partial scalar invariance ^c	0.895	–0.009	0.050	0.000
Life satisfaction				
Configural invariance				
Metric invariance	0.915	–	0.045	–
Scalar invariance	0.905	–0.010	0.047	0.002
Scalar invariance	0.899	–0.006	0.048	0.001

Note. ^a Equality constraints of item 1 and item 2 were released for partial scalar invariance. ^b Equality constraints of item 1 and item 2 were released for partial scalar invariance. ^c Equality constraints of item 5 was released for partial scalar invariance.

3.3. Additional findings

The RI-CLPM also included correlations between (the residuals of the) within-person values of our measures within the same year, as shown in Table 4. Although we did not find any significant cross-lagged associations between PSMU and life satisfaction, we found concurrent associations between PSMU and life satisfaction. More specifically, adolescents whose PSMU increased at T1, T2, and T3 reported decreases in life satisfaction within the same year. Moreover, adolescents whose FoMO increased at T1, T2, and T3 also reported increases in PSMU within the same year. With regards to the correlations between FoMO

Table 3
RI-CLPM, within-person (Cross-)Lagged effects of FoMO, PSMU and LS.

	FoMO T2				PSMU T2				LS T2			
	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β
FoMO T1	0.17	0.08	.033	.16	0.17	0.15	.271	.07	–0.12	0.08	.172	–.10
PSMU T1	0.01	0.04	.978	.002	0.12	0.11	.286	.10	–0.03	0.04	.452	–.05
LS T1	–0.15	0.08	.040	–.14	–0.22	0.17	.193	–.09	0.10	0.12	.418	.07
	FoMO T3				PSMU T3				LS T3			
	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β
FoMO T2	0.20	0.08	.014	.20	0.02	0.13	.889	.01	–0.04	0.07	.562	–.03
PSMU T2	–0.03	0.03	.300	–.07	0.17	0.07	.013	.20	–0.04	0.03	.107	–.09
LS T2	0.01	0.05	.973	.002	–0.15	0.11	.182	–.09	0.18	0.07	.011	.18
	FoMO T4				PSMU T4				LS T4			
	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β	<i>b</i>	<i>SE</i>	<i>p</i>	β
FoMO T3	0.26	0.08	.001	.23	0.29	0.13	.026	.15	0.01	0.07	.891	.01
PSMU T3	–0.02	0.05	.704	–.03	0.21	0.08	.010	.22	0.09	0.05	.059	.15
LS T3	–0.05	0.07	.502	–.05	0.06	0.11	.622	.03	0.33	0.09	<.001	.33

Note. Significant effect(s) is in bold.

and life satisfaction, increases in FoMO co-occurred with decreases in life satisfaction across all waves.

We examined whether our results were robust to gender. Gender differences were investigated using multi-group RI-CLPM (M2), model fit was good ($\chi^2(76) = 97.661$, RMESA = 0.020, CFI = 0.994, TLI = 0.979, SRMR = 0.0400). The results (see Appendix 1) showed that although the strength and significance of the cross-lagged parameters differed slightly between boys and girls, yet these differences were not significant in any of the waves.

4. Discussion

The current study investigated long-term associations between PSMU, FoMO, and life satisfaction at the within-person level, using longitudinal data collected among Dutch secondary school students aged 12–16 years. Findings showed that, during mid-adolescence (14–15 years), adolescents whose FoMO increased reported an increase in PSMU one year later. However, increased PSMU did not predict lowered life satisfaction one year later, neither directly nor indirectly via FoMO. Moreover, during early adolescence (12–13 years), decreased life satisfaction appeared to predict an increase in FoMO one year later. No gender differences were found.

Our expectation that higher levels of FoMO would predict higher levels of PSMU, which, in turn, would predict lower levels of life satisfaction (Hypothesis 3) was only partially supported. The findings indicated that higher levels of FoMO in adolescents predicted increased levels of PSMU one year later, although only among mid-adolescents, but did not translate into a subsequent decrease in life satisfaction. This is consistent with previous longitudinal studies on FoMO predicting later problematic smartphone use (Geng et al., 2021; Gong et al., 2022; Lin et al., 2021; Yuan et al., 2021; Zhang, Zhou, et al., 2021). The finding suggests that FoMO may be an important reason for adolescents to engage in social media use with an increased risk of developing PSMU. In other words, the negative emotions associated with FoMO may prompt an adolescent to engage in more compulsive social media activities such as endless browsing through posts or looking for possibilities to chat with peers. Thus, social media platforms may be used as a coping strategy for assuaging feelings of FoMO, which may consequently contribute to PSMU. The finding is in line with the compensatory internet use theory (Kardefelt-winter, 2014), which suggests that using social media to alleviate negative feelings and worries about peers having rewarding experiences that one does not participate in could lead to uncontrollable social media use. At this point we can only speculate why these mechanisms mainly seem to operate among 14–15-year-old adolescents, and not among younger adolescents aged 12–14 year. Perhaps, FoMO may evolve into a more serious condition as young people grow older. After all, as adolescents age, it becomes increasingly common for them to meet up with each other in real life, outside of

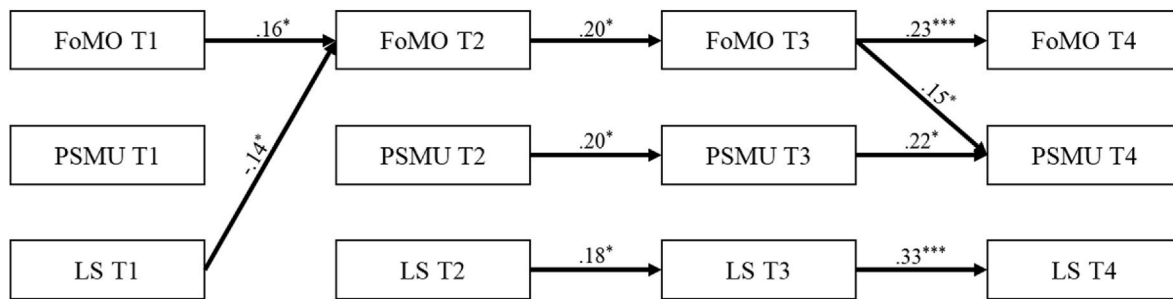


Fig. 2. Significant Associations from the RI-CLPM (M1)Note. The figure displays the significant auto-regressive and (cross-) lagged associations between the within-person values of the measures. Standardized solutions are reported. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4
RI-CLPM, within-person (residuals) correlations within same year.

	<i>b</i>	<i>SE</i>	<i>p</i>	β
FoMO T1 ↔ PSMU T1	0.15	0.05	.002	.23
FoMO T2 ↔ PSMU T2	0.17	0.04	<.001	.23
FoMO T3 ↔ PSMU T3	0.08	0.04	.022	.12
FoMO T4 ↔ PSMU T4	0.06	0.05	.264	.08
FoMO T1 ↔ LS T1	-0.09	0.02	<.001	-.31
FoMO T2 ↔ LS T2	-0.14	0.02	<.001	-.36
FoMO T3 ↔ LS T3	-0.10	0.02	<.001	-.24
FoMO T4 ↔ LS T4	-0.08	0.03	.011	-.19
PSMU T1 ↔ LS T1	-0.14	0.05	.004	-.22
PSMU T2 ↔ LS T2	-0.24	0.05	<.001	-.27
PSMU T3 ↔ LS T3	-0.17	0.04	<.001	-.23
PSMU T4 ↔ LS T4	-0.13	0.07	.056	-.18

Note: Significant effect(s) is in bold.

school hours. This is in line with the higher number of symptoms of PSMU at age 14–15 (Boer et al., 2022). Hence, experiencing FoMO during mid-adolescence may result in a stronger inclination to compensate through compulsive searching for social information and/or engaging in online social interactions. However, follow-up research should first show that the age effects we found are generalizable.

Additionally, the finding also provides valuable insights into the nuanced nature of FoMO and its relationship with PSMU. Notably, our findings indicate that, within the DSMM framework (Valkenburg & Peter, 2013), FoMO functions as a predictive factor (i.e., dispositional-susceptibility variable), rather than an outcome (i.e., media response state), of PSMU. In the DSMM (Valkenburg & Peter, 2013), dispositional-susceptibility variables encompass preexisting traits that influence responses to media, while media response states originate from media engagement. This particular finding highlights the trait-like nature of FoMO, suggesting that despite the emergence of the FoMO concept in media outlets in the early 2010s when social media use experienced exponential growth (Elhai et al., 2020; Przybylski et al., 2013), it appears to be a trait-like construct rather than a state-like direct consequence of media use. However, it's important to acknowledge that our longitudinal design with annual measurements limits the immediate assessment of FoMO after social media use, potentially hindering a definitive assertion that FoMO lacks a state-like nature as a media response state. Prior research employing experimental designs has suggested an immediate increase in FoMO following social media engagement, indicating that FoMO (also) encompasses state-like characteristics (David & Roberts, 2023).

Moreover, contrary to our Hypothesis 1, the results of the current study show that an increased level of PSMU did not decrease life satisfaction one year later. This finding is challenging previous research (Boer, Stevens, Finkenauer, de Looze, & van den Eijnden, 2021; van den Eijnden et al., 2018), although these studies used different designs and tested different theoretical models. For example, Boer, Stevens, Finkenauer, and van den Eijnden (2021) used a comparable analytical approach and showed that adolescents' increased PSMU did predict a

decrease in life satisfaction. However, Boer, Stevens, Finkenauer, and van den Eijnden (2021) used a larger analysis sample, which was twice the size of our sample, and included only 3 waves of data, instead of 4 waves as we did. Adding more measurement waves is generally better to increase precision because it allows for a more accurate estimation of change over time (Arndt et al., 2000). Yet, more longitudinal research is needed to disentangle the relationship between PSMU and life-satisfaction.

In addition, contrary to Hypothesis 2, PSMU did not predict later life satisfaction, neither directly nor indirectly via FoMO. This finding is consistent with a recent paper, which did not find support for a longitudinal association between problematic smartphone use and subsequent FoMO one year later (Lo Coco et al., 2020). Also, the current findings did not support the idea that increased levels of FoMO would decrease subsequent life satisfaction. The finding is inconsistent with previous studies suggesting that FoMO is a negative predictor of life satisfaction (Blachnio & Przepiorka, 2018; Deniz, 2021; Przybylski et al., 2013). One possible explanation is that, rather than decreasing life satisfaction, as a positive indicator of well-being, the experience of FoMO is more likely to increase negative indicators of well-being, for instance depressive feelings (Gupta & Sharma, 2021). However, given that we observed a positive concurrent association between PSMU and FoMO, as well as a negative concurrent association between FoMO and life satisfaction, we speculate that the potential effects of PSMU on FoMO and that of FoMO on life satisfaction may also be short-term. To investigate this suggestion, future studies could use shorter time intervals than the current one (e.g., 3 months).

Finally, although we found no evidence to support our hypothesis that higher levels of FoMO predicted lower levels of life satisfaction, we surprisingly found that life satisfaction acted as a predictor of FoMO in early adolescence. The results suggest that lower levels of life satisfaction may act as a risk factor for the development of FoMO and/or higher levels of life satisfaction may act as a protective factor against FoMO. This finding is consistent with a recent study (Chung, 2022) and the self-determination theory (Ryan & Deci, 2000), suggesting that FoMO can be seen as an expression of unmet basic psychological needs. Therefore, early adolescents who have lower levels of life satisfaction, are more likely to experience FoMO, probably due to the unmet basic psychological needs (e.g., relatedness). That particularly these young adolescents develop FoMO in response to lowered levels of life satisfaction may relate to the fact that these adolescents aged 12–13 have just entered schools for secondary education. In these new surroundings with new peers, those who are unhappy can be expected to also have more peer problems and thereby more reasons to experience FoMO. However, as stated before, follow-up research first must confirm the present age effects.

Moreover, the findings suggest that FoMO may act as an adaptive mechanism among adolescents who perceive engagement in social groups as an approach to ameliorate their unfavorable circumstances (e.g., low life satisfaction in the current study). FoMO may stimulate adaptive behaviors that may lead to more peer connectedness,

consequently resulting in a higher level of life satisfaction. Similarly, prior research has indicated that adolescents experiencing greater loneliness, increased boredom, diminished sense of belongingness, along with heightened exposure to bullying, are more prone to developing FoMO (Alabri, 2022; Gao et al., 2023; Marengo et al., 2021). Therefore, increased FoMO could serve as a viable means for them to learn more about their peers and sustain social connections (albeit through negative channels), helping them to better fit into social groups whenever opportunities arise.

4.1. Strengths, limitations, and future directions

The present study has important strengths related to the research design. First, by disentangling between- and within-person effects, we controlled for all possible confounding time-invariant traits, providing more accurate estimates of directionality. Second, we also controlled for the possible confounding variable of social media use intensity to obtain a purer and clearer picture of the relationships between the study variables. As the number of studies in this area with a longitudinal design is limited, this study contributes to important insights into the direction of change and influences for prevention.

However, several limitations should also be noted. First, the data of the current study were self-reported data that were collected in the Netherlands, where most adolescents have smartphones and social media account(s) at an early age, before they enter secondary education. This limits our ability to draw firm conclusions and generalize the present findings to adolescents living in other countries. Second, our longitudinal design with annual time intervals provides a better understanding of possible long-term effects. However, this design does not provide insight into possible over-time influences of factors that impact each other within shorter time periods. Future studies could use more intensive measurement approaches to capture the dynamic interplay between variables over a shorter period of time (e.g., 3 or 6 months). Finally, particularly at the last measurement wave there was a high dropout rate. Although dropout in the present study was not selective, and the associations between our study variables and dropout were minimal, it still represents a limitation. We aimed to mitigate the bias typically associated with dropout by including all adolescents in the analyses.

4.2. Conclusion

To conclude, the present study provides initial evidence on the cross-lagged effects between FoMO, PSMU, and life satisfaction among Dutch secondary school students aged 12–16 years. The results highlight two unidirectional effects: (1) more FoMO predicted more PSMU over time during mid-adolescence (14–15 years), and (2) lower life satisfaction predicted more FoMO over time during early adolescence (12–13 years). The findings suggest that FoMO may contribute to increased PSMU among Dutch adolescents, while higher levels of life satisfaction may act as a protective factor against FoMO, highlighting the importance of decreasing FoMO and promoting life satisfaction in interventions aimed at reducing excessive social media use and enhancing well-being in Dutch adolescents.

CRediT authorship contribution statement

Yan-Yu Li: Conceptualization, Data curation, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. **Ina M. Koning:** Conceptualization, Supervision, Writing – review & editing. **Catrin Finkenauer:** Conceptualization, Supervision, Writing – review & editing. **Maartje Boer:** Conceptualization, Methodology, Writing – review & editing. **Regina J.J.M. van den Eijnden:** Conceptualization, Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing.

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.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.chb.2024.108160>.

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