Full length article

Social media use intensity, social media use problems, and mental health among adolescents: Investigating directionality and mediating processes

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ABSTRACT

Social media have become increasingly integrated into the daily lives of adolescents. There are concerns about the potential detrimental effects of adolescents' social media use (SMU) on their mental health. Using a three-wave longitudinal study among 2109 secondary school adolescents ($M_{age} = 13.1$, $SD_{age} = 0.8$), the present study examined whether high SMU intensity and addiction-like SMU problems were bidirectionally associated with low mental health, and whether these associations were mediated by increased levels of upward social comparisons, cybervictimization, decreased subjective school achievements, and less face-to-face contact with friends. In doing so, mental health was measured by depressive symptoms and life satisfaction. Findings from random intercept cross-lagged panel models showed a direct unidirectional association between SMU problems and mental health: SMU problems were associated with decreased mental health one year later, but not vice versa. SMU problems also predicted increased levels of upward social comparisons and cybervictimization one year later. Yet, these processes did not mediate the observed effect of SMU problems on decreased mental health. Over time, SMU intensity and mental health were not associated in any direction; neither directly, nor indirectly through any of the mediators. Findings of our study suggest that harmful effects of SMU intensity may be limited and highlight the potential risk of SMU problems to adolescent mental health.

1. Introduction

Social media, such as Instagram and Snapchat, are immensely popular among adolescents (Anderson & Jiang, 2018; Vannucci & McCauley Ohannessian, 2019). Concerns have been raised about adolescents' social media use (SMU) and its impact on their mental health, in particular on their life satisfaction and depressive symptoms (Primack & Escobar-Viera, 2017; Underwood & Ehrenreich, 2017). The present study investigated the relationship between SMU and mental health in adolescents. In doing so, we distinguished between *SMU intensity* and *SMU problems* as two separate dimensions of SMU. SMU intensity refers to the frequency of SMU, whereas SMU problems indicate addiction-like SMU, such as loss of control over SMU or neglecting hobbies or other activities due to SMU (Van den Eijnden, Lemmens, & Valkenburg, 2016). Although adolescents with SMU problems tend to also display high SMU intensity, high SMU intensity does not necessarily imply loss of control over SMU or interference with important life domains. Yet,

research suggests that both types of SMU are negatively related to adolescents' mental health, including their life satisfaction, happiness, and other emotional problems (e.g., Mérelle, Kleiboer, Schotanus, Cluitmans, & Waardenburg, 2017; Twenge, Martin, & Campbel, 2018). Given that SMU intensity and SMU problems differ conceptually, they may have differential associations with mental health. However, research that investigates this hypothesis is scarce. Also, we know little about the directionality of these associations and their underlying processes. Using three waves of longitudinal data among adolescents, the present study addressed these gaps in the literature by investigating bidirectional associations between both types of SMU and mental health, and possible mediators in these associations. The study thereby aims to advance current knowledge on the potential link between social media behaviors and mental health, which is essential given the prominent role social media play into the daily lives of adolescents.

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1.1. SMU intensity and mental health

Cross-sectional research suggests that adolescents' SMU intensity is associated with lower life satisfaction and more depressive symptoms, although the strength of these associations was often small (Kelly, Zilanawala, Booker, & Sacker, 2018; Twenge, Martin, & Campbel, 2018; Twenge, Joiner, Rogers, & Martin, 2018). Researchers argue that this link could be bidirectional: On the one hand, adolescents who use social media intensively may be sensitive to such mental health problems because they spend less time on offline activities that are important to their mental health (Primack & Escobar-Viera, 2017; Underwood & Ehrenreich, 2017). On the other hand, adolescents with more mental health problems may be more inclined to use social media more intensively to find emotional and social support for their problems (Radovic, Gmelin, Stein, & Miller, 2017). Some longitudinal studies support these propositions (Frison & Eggermont, 2017; Heffer, Good, Daly, MacDonell, & Willoughby, 2019; Riehm et al., 2019), whereas others found no or only a very small bidirectional association between SMU intensity and mental health (Coyne, Rogers, Zurcher, Stockdale, & Booth, 2019; Houghton et al., 2018; Orben, Dienlin, & Przybylski, 2019). The few studies that examined both adolescents' SMU intensity and SMU problems and their associations with mental health in one model repeatedly show that SMU intensity was not or only weakly associated with lower mental health, whereas SMU problems were consistently related to lower mental health (Boer, Van den Eijnden, et al., 2020; Shensa et al., 2017; Van den Eijnden, Koning, Doornwaard, Van Gurp, & Ter Bogt, 2018). These findings imply that previously found negative associations between high SMU intensity and mental health were possibly driven by a confounding effect of SMU problems.

High SMU intensity may not necessarily harm mental health, because frequent SMU may not interfere with life domains that are relevant to adolescents' mental health, such as offline socializing with friends or family (Boer, Van den Eijnden, et al., 2020). In other words, adolescents who engage in high SMU intensity may be well able to regulate their SMU and to combine it with a healthy lifestyle. Reversely, low mental health may not increase SMU intensity because nowadays, many adolescents use social media intensively to maintain and enhance their social involvement with peers (Anderson & Jiang, 2018; Boyd, 2014; Vannucci & McCauley Ohannessian, 2019). Therefore, high SMU intensity may rather be normative adolescent behavior than a behavior that is specific to adolescents with low mental health. Accordingly, we expected that high SMU intensity would not be associated with mental health in any direction.

1.2. SMU problems and mental health

In contrast, cross-sectional studies repeatedly showed that adolescents with SMU problems report mental health problems, such as depressive symptoms and other emotional problems, with moderate to large effect sizes (Bányai et al., 2017; Mérelle et al., 2017; Pontes, 2017). However, it is unclear whether SMU problems precede or follow from poor mental health. The presence of SMU problems may lead to lower mental health, because, as compared to adolescents who solely show high SMU intensity by using social media very frequently, adolescents with SMU problems show addiction-like SMU. That is, adolescents with SMU problems often have a diminished ability to regulate their SMU impulses, perceive SMU as more important than other activities, are preoccupied with social media, feel a constant urge to go online, and/or experience discomfort such as stress or anxiety when SMU is not possible (Apaolaza, Hartmann, D'Souza, & Gilsanz, 2019; Griffiths, 2013; Griffiths, Kuss, & Demetrovics, 2014). In other words, they have a diminished control over their thoughts, emotions, and behaviors, and social media dominates their daily lives. This loss of agency, that is typical to SMU problems, may harm adolescents' mental health. Therefore, we expected that SMU problems would decrease mental health.

Reversely, low mental health may also elicit SMU problems. The cognitive behavioral model posits that pre-existing psychopathology, such as depression, drive maladaptive cognitions about social media (Caplan, 2003; Davis, 2001; Griffiths, 2013). Adolescents with such cognitions may feel, for example, that their offline life is less meaningful than their online life, or that SMU alleviates their sorrows (Davis, 2001). To feel positive about themselves, or to forget their problems, they may become dependent on SMU, and therefore develop addiction-like SMU problems (Griffiths, 2013). Thus, we also expected that poorer mental health would increase SMU problems.

1.3. Mediating processes

The proposed bidirectional pathways between SMU problems and mental health may be driven by several underlying behaviors (Marino, Gini, Vieno, & Spada, 2018a, 2018b), yet these have received little empirical attention. The present study considers four mediating processes that could explain the effect of SMU problems on low mental health (Fig. 1). First, adolescents with SMU problems typically attach excessive importance to social media, and may therefore perceive the online world, which is heavily biased toward idealist self-presentations, as social reality. They may therefore not be able to place the overly flattered portrayals of others into perspective. As a result, they may engage in upward social comparisons. That is, they may perceive their peers' appearances as superior to their own (Pera, 2018). Second, driven by their cravings for the potential social reward afforded by SMU, such as the reassurance to be noticed and appreciated by others (Veissière & Stendel, 2018), adolescents with SMU problems may engage in high levels of self-disclosure on social media (Blau, 2011). This, in turn, may make them vulnerable to cybervictimization (Weber, Ziegele, & Schnauber, 2013). Finally, given that adolescents with SMU problems typically perceive SMU as their most important activity and that abstaining from it may cause stress or anxiety, they may displace offline social activities with peers and schoolwork activities with SMU. This may, third and fourth, go at the expense of face-to-face contact and school achievement (Salmela-Aro, Upadyaya, Hakkarainen, Lonka, & Alho, 2017; Underwood & Ehrenreich, 2017; Wallsten, 2013). These four adverse processes that may result from SMU problems, in turn, may decrease mental health. Accordingly, we expected that SMU problems would decrease mental health through upward social comparisons, cybervictimization, decreased face-to-face-contact, and decreased school achievements.
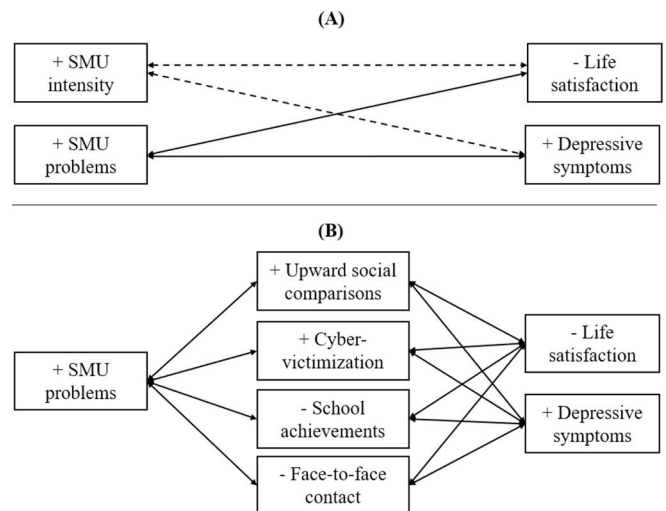

Fig. 1. Path diagram of hypothesized direct and indirect associations. The double-headed arrows denote that associations were examined bidirectionally. Solid arrows indicate the expected significant associations. Dashed arrows indicate that no associations were expected. Diagram A displays the hypothesized direct effects. Diagram B displays the hypothesized mediations.

These four processes may also underlie the reverse proposed effect, that is, the effect of lower mental health on SMU problems (Fig. 1). First, the negative self-perceptions that adolescents with poorer mental health typically have may reinforce upward social comparisons after exposure to their peers' idealized appearances on social media (Nesi, Miller, & Prinstein, 2017). Second, adolescents with mental health impairments may face a higher risk of cybervictimization, as their vulnerabilities may make them an easy target for aggressive peers (Rose & Tynes, 2015; Van den Eijnden, Vermulst, van Rooij, Scholte, & van de Mheen, 2014), Third, they may also have less face-to-face contact with peers, because peers may perceive them as less attractive to be friends with (Connolly, Geller, Marton, & Kutcher, 1992). Fourth, poor mental health may also be a source of decreased schoolwork achievements (Brännlund, Strandh, & Nilsson, 2017). In order to compensate and/or find relief for these additional adversities that may stem from poor mental health, adolescents may become more dependent upon and preoccupied with SMU. This maladaptive coping strategy may ultimately elicit SMU problems (Griffiths et al., 2014). We therefore expected that poorer mental health would increase SMU problems through upward social comparisons, cybervictimization, decreased face-to-face-contact, and decreased school achievements.

1.4. Current study

Using three waves of longitudinal data among Dutch adolescents in their first two years of secondary school, the present study examined bidirectional associations between adolescents' SMU intensity as well as SMU problems and mental health. In this study, mental health was defined by the presence of wellbeing as well as the absence of mental illnesses (Herrman, Saxena, & Moodie, 2005). We therefore focused on two aspects of mental health: the presence of life satisfaction and the absence of depressive symptoms. Based on recent findings that refute the alleged negative link between SMU intensity and mental health and because high SMU intensity is considered normative in adolescence, we expected that SMU intensity would be unrelated to mental health in any direction; neither directly nor indirectly. Rather, we expected that addiction-like SMU problems would decrease mental health. We also expected, reversely, that lower mental health would increase SMU problems. We also examined whether these proposed bidirectional associations were mediated by upward social comparisons, cybervictimization, decreased face-to-face contact with peers, and worsened school achievements (Fig. 1).

2. Methods

2.1. Sample

Data were obtained from the Digital Youth-project: a self-report longitudinal study on online behaviors and mental health among Dutch secondary school students (Van den Eijnden et al., 2018). We used data from the second, third, and fourth wave, which took place in February and March of 2016, 2017, and 2018, respectively. Data from the first wave were excluded because depressive symptoms were not measured in this wave. The waves that were included in the current study are further referred to as T1, T2, and T3. In order to study developments of adolescents from a similar age category, we selected students who were in the first two school years of secondary school at T1 ($n = 2228$). Students for whom data were missing on all study measures were excluded from the sample, which yielded a final analysis sample of 2109 adolescents from 9 schools. From this sample, 77.9% participated in T1, 75.0% participated in T2, and 40.5% participated in T3. The nonresponse was mainly due to dropout of schools and classes, because teachers were absent or not able to schedule the survey assessments at participating schools. Hence, we considered the dropout as not selective.

At T1, participating students from the analysis sample were between 10 and 16 years old ($M = 13.1$, $SD = 0.8$) and 43.1% were first year

students. In addition, 43.1% were girls, 25.7% had an immigrant background, and students were attending education at different levels (65.3% pre-vocational, 24.2% intermediate, and 10.5% pre-university). Girls and students with pre-university education were somewhat underrepresented compared to the Dutch adolescent population of the same age category in 2017 (49.1% girl, 51.1% pre-vocational, 22.1% intermediate, and 21.6% pre-university) (Statistics Netherlands, 2019). Sample characteristics in T2 were approximately the same as in T1 (45.0% girls, 23.7% immigrant background, 62.5% pre-vocational, 26.2% intermediate, and 11.3% pre-university). In T3, two pre-vocational level schools dropped out due to practical circumstances, as well as several pre-vocational level classes from the other schools, which yielded a different sample composition compared to T1 and T2 (43.9% girls, 17.6% immigrant background, 33.8% pre-vocational, 44.6% intermediate, and 21.6% pre-university).

Two weeks prior to the survey assessment, information letters were sent to parents to provide information about the survey and to allow parents to refuse participation of their child. One week prior to the survey assessment, students were informed about the subject and purpose of the study, that participation was voluntary and anonymous, and that they could resign participation at any moment. Students completed the online survey during school hours. Research-assistants monitored students' survey completion and provided help where necessary. The study procedures adhered to the Declaration of Helsinki and were approved by the ethical board of the Faculty of Social Sciences at Utrecht University (FETC16-076 Eijnden).

2.2. Measures

2.2.1. SMU problems

SMU problems were measured using 9 items from the Social Media Disorder Scale, that assesses nine symptoms of addiction to social media (Van den Eijnden et al., 2016). Respondents were asked 'During the past year, have you … ', followed by 'regularly found that you can't think of anything else but the moment that you will be able to use social media again' (preoccupation), 'regularly felt dissatisfied because you wanted to spend more time on social media' (tolerance), 'often felt bad when you could not use social media' (withdrawal), 'been unable to stop using social media, even though others told you that you really should' (persistence), 'regularly had no interest in hobbies or other activities because you would rather use social media' (displacement), 'regularly had arguments with others because of your social media use' (problems), 'often used social media secretly' (deception), 'often used social media so you didn't have to think about unpleasant things' (escape), and 'had serious conflict with your parent(s) and siblings(s) because of your social media use (conflict), with a dichotomous response scale (*yes* or *no*). The scale has been found to have solid structural and criterion validity and good reliability (Boer, Stevens, Finkenauer, Koning, & Van den Eijnden, 2020). Due to the dichotomous nature of the items, internal consistency was calculated using the tetrachoric correlation matrix (Gadermann, Guhn, Zumbo, & Columbia, 2012). This yielded an ordinal alpha that varied between 0.83 and 0.85 at the different waves.

2.2.2. SMU intensity

Four items assessed respondents' SMU intensity (Boer, Stevens, Finkenauer, & Van den Eijnden, 2020), which measured the frequency of different social media activities. The first three items examined 'How many times *per day* do you view social network sites', 'How many times *per week* do you 'like' messages, photos, or videos of others on social network sites', and 'How many times *per week* do you respond to messages, photos, or videos of others on social network sites' (1 *never or less than once* to 7 *more than 40 times*). The questionnaire provided examples of social network sites ('for example Facebook, Twitter, Instagram, Google+, or Pinterest, but not WhatsApp or SnapChat'). The fourth item examined 'How many times *per day* do you send a message, photo or video via your smartphone, for example a WhatsApp, Chat, SnapChat, or

SMS' (1 *less than once* to 7 *more than 80 times*). Cronbach's alpha varied between 0.78 and 0.84 across the waves. The original scale consisted of two additional items: 'How many times *per week* do you post a message, photo, or video on social network sites' 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?'. The first item of these two was excluded because its factor loading was low (< 0.5). The second item was excluded because it showed relatively high overlap with the other item on smartphone use ($r = 0.7$), and therefore removing the item yielded substantial model fit improvement (Boer, Stevens, et al., 2020).

2.2.3. Depressive symptoms

Respondents reported on their depressive symptoms using the 6-item Depressive Mood List (Kandel & Davies, 1982). They indicated, for example, how often in the past year they were 'Feeling too tired to do things', 'Feeling unhappy, sad, or depressed', 'Having trouble going to sleep or staying asleep', 'Feeling hopeless about the future', 'Feeling nervous or tense', and 'Worrying too much about things' (1 *never* to 5 *always*). The scale has been validated among U.S. secondary school students but has been adopted extensively in adolescent surveys (Compas, Ey, & Grant, 1993), also in translated form among Dutch adolescents (e.g., Engels, Finkenauer, Meeus, & Deković, 2001; Van Rooij et al., 2014). The scale has been found to have appropriate internal consistency and test-retest reliability (Compas et al., 1993). In the present sample, Cronbach's alpha varied between 0.81 and 0.87 in all waves.

2.2.4. Life satisfaction

Respondents indicated their life satisfaction using the 7-item Student's Life Satisfaction Scale (Huebner, 1991). Respondents were asked about their thoughts around their own life: 'My life is going well', 'My life is just right', 'I would like to change many things in my life', 'I wish I had a different kind of life', 'I have a good life', 'I have what I want in life', and 'My life is better than most kids' (1 *strongly disagree* to 6 *strongly agree*). The third and fourth item were recoded such that higher values indicated higher life satisfaction. The scale has been validated extensively among elementary and secondary school U.S. students and showed adequate convergent and discriminant validity and test-retest reliability (see for an overview Huebner, 2004). The scale has been translated and adopted across many countries (Proctor, Linley, & Maltby, 2009). In the present study, Cronbach's alpha varied between 0.83 and 0.84 in all waves.

2.2.5. Upward social comparisons

A newly developed 5-item scale measured the extent to which respondents engage in upward social comparison during their SMU. This scale was developed because existing validated measures on social comparison typically assess respondents' overall tendency to compare themselves to others (i.e., not specifically as a result of viewing social media). Respondents indicated, when viewing their peers' messages, photos, or movies on social network sites, how often they thought 'He or she does more fun things than I do', 'He or she has more friends than I do', 'He or she is more popular dan me', 'He or she received more 'likes' than me', and 'He or she looks better than I do' (1 *never* to 5 *very often*). Cronbach's alpha was 0.88 in all three waves.

2.2.6. Cybervictimization

The 10-item Multidimensional Online Peer Victimization Scale was used to assess respondents' level of online peer victimization (Sumter, Valkenburg, Baumgartner, Peter, & Van der Hof, 2015). Respondents indicated how often in the past six months a peer had 'Called me names', 'Insulted me', 'Sent me aggressive messages', 'Send me nasty messages', 'Embarrassed me', 'Told my secrets to others so that others do not like me anymore', 'Excluded me from something I wanted to participate in', 'Not let me join a conversation or chat while I wanted to', 'Purposely

acted like I did not exist', and 'Not let me participate in something I wanted to do' (1 *never* to 6 *about every day*). Cronbach's alpha varied between 0.89 and 0.91 across all waves.

2.2.7. Subjective school achievements

Three items assessed respondents' subjective school achievements. Respondents were asked 'How satisfied were you with the grades in your most recent school report?' (1 *not satisfied at all* to 5 *very satisfied*), 'How many failing grades did you have in your most recent school report?' (1 *none* to 5 *four or more*), and 'As compared to most of my classmates, I achieve … school grades' (1 *much worse* to 5 *much better*). The second item was recoded such that high values indicated high school achievement. Cronbach's alpha varied between 0.79 and 0.81 in all the waves. Across all waves, adolescents' mean scores on the three items correlated strongly with their GPA-scores that were obtained from teachers of the participating schools ($r = 0.63$ to 0.69, $p < 0.001$), which suggests that adolescents' subjective school achievements show high overlap with their objective school achievements. We selected subjective school achievements for this study, as there were relatively many missing values on the GPA-data.

2.2.8. Face-to-face contacts with friends

Respondents reported on their intensity of face-to-face contact with friends using three items on the frequency of peer contact (Baams, Van de Bongardt, & Doornwaard, 2017, pp. 46–47). Respondents were asked 'How often do you spend time with friends after school or in the weekends?', 'How often are you at your friends' house?', and 'How often do you go out at night or go to a party with friends?'. In order to extend the measurement, a fourth item was added to the scale, including 'How often are your friends at your home?' (1 *never* to 6 *very often*). Cronbach's alpha varied between 0.85 and 0.87 across the waves.

2.3. Preliminary analyses

Prior to our main analyses, we conducted three preliminary analyses using Mplus 8.4 (Muthén & Muthén, 2017).

2.3.1. Attrition analyses

First, we carried out attrition analyses by predicting dropout in T2 and T3 with the study measures at the previous wave using multivariate logistic regressions with the measures modelled as latent variables. Results showed that adolescents with higher levels of SMU problems, lower life satisfaction, lower upward social comparisons, less face-to-face contact, or lower school achievements in T1 were more likely to drop out in T2 ($OR_{range} = 1.166$ to 1.408). Adolescents with higher levels of SMU problems, higher SMU intensity, higher levels of cyber-victimization, or lower levels of upward social comparisons in T2 were more likely to drop out in T3 ($OR_{range} = 1.115$ to 1.626). The magnitudes of these associations varied from very small ($OR < 1.5$) to small ($OR < 2$) (Sullivan & Feinn, 2012). Thus, although there were relatively many pre-vocational level educated adolescents that dropped out (particularly in T3), associations between our study variables and dropout were limited.

2.3.2. Measurement invariance

Second, we conducted measurement invariance analysis, because in order to draw valid conclusions about changes over time, our measures should have the same measurement properties across the investigated years (Chen, 2007; Cheung & Rensvold, 2002). Hence, we examined whether the magnitudes of the item factor loadings and intercepts (or thresholds in case of categorical items) were consistent over time. 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 (ΔCFI = decrease of ≤ 0.010) and Root Mean Square Error of Approximation (ΔRMSEA = increase of ≤ 0.015; Chen, 2007). In case

equality constraints deteriorated model fit, modification indices were consulted to find the source of misfit. For all measures, applying equality constraints to the factor loadings did not deteriorate model fit, which suggests that all measures had invariant factor loadings over time. Four out of eight measures had one intercept that was not invariant over time. However, each measure had at least two items where the item intercepts were equal over time, which is sufficient for the purpose of our study, namely comparing effect sizes and latent means over time (Van de Schoot, Lugtig, & Hox, 2012).

2.3.3. Plausible values

Third, we calculated *plausible values* for our measures, which are imputed values that represent the values of latent variables based on a specified factor model using Bayes estimation (Asparouhov & Muthén, 2010b). We followed this method because due to the complexity of our main analyses, it was not feasible to use latent variables in our models. In addition, due to the highly skewed distribution of the sum-score of SMU problems it was not possible to use item sum-scores. Plausible values have been found to accurately resemble covariances between latent variables (Asparouhov & Muthén, 2010b), and as such have been used by researchers to obtain reliable scores for their measures that can be used for subsequent analyses (e.g., Ciarrochi et al., 2016; Deutsch, Hoffman, & Wilcox, 2014; Rhee et al., 2013). For each latent variable, we imputed 20 plausible values based on the factor models as established in our measurement invariance analyses. That is, item factor loadings and intercepts (or thresholds) for which measurement invariance was established were constrained to be equal over time.

Our data were not completely missing at random, as the attrition analysis showed that there were small relationships between the observed data and dropout. In that case, retention of dropout cases provides more reliable model estimates than listwise deletion of dropout cases, especially when dropout rates are high (Enders & Bandalos, 2001). Hence, plausible values for complete as well as dropout cases were estimated with a full information approach (Asparouhov & Muthén, 2010a). That is, plausible values of dropout cases could be estimated based on available data from previous and/or subsequent waves. As a result, all respondents ($n = 2109$) were retained in our analyses. All imputations were merged into one dataset for subsequent analyses. Table 1 shows the descriptive statistics of the plausible values over the imputed datasets in long format. The plausible values were used for our main analyses.

2.4. Main analyses

2.4.1. Analytical approach

Directionality can be established by studying whether adolescents' increases in, for example, SMU problems precede or follow from increases in, for example, depressive symptoms. Grasping such dynamic processes that occur within adolescents requires separating within-person variance from between-person variance. Hence, we

Table 1
Descriptive Statistics (Long Format, $n = 6327$).

Variable	Mean	SD	Min.	Max.
SMU problems	−0.013	0.663	−2.411	2.530
SMU intensity	0.120	1.278	−4.470	4.176
Depressive symptoms	0.089	0.618	−1.890	2.554
Life satisfaction	−0.212	1.044	−4.723	3.069
Upward social comparison	0.006	0.645	−2.121	2.604
Face-to-face contact with friends	−0.042	1.042	−3.712	3.533
School satisfaction	−0.006	0.946	−3.508	3.240
Cybervictimization	0.030	1.003	−3.340	6.405

Note: Results denote the descriptive statistics of the computed plausible values averaged over 20 imputed datasets. Descriptive statistics were computed with data structured in long format (i.e. each row in the dataset represents an observation).

investigated our research questions using the 'random intercept cross-lagged panel model' (RI-CLPM), which is an innovative modelling technique that examines bidirectional processes within persons (Hamaker, Kuiper, & Grasman, 2015). By disentangling within- and between-person variance, the RI-CLPM controls for all possible stable characteristics, providing more accurate estimates of directionality (Hamaker et al., 2015).

2.4.2. Modelling the RI-CLPM

Fig. 2 illustrates a RI-CLPM with SMU intensity, SMU problems, and depressive symptoms. The *between-person part* of the model consisted of the random intercepts (light gray circles), which are latent variables that denote the time-invariant levels of the respective behaviors. The random intercepts were extracted from three repeated plausible values (white squares), with factor loadings constrained to one. The RI-CLPM also included correlations between the random intercepts (gray double arrows). The *within-person part* of the model is denoted by the within-person values (dark gray circles), which are latent variables that are extracted from their respective plausible value, each with factor loading constrained to one. The residual variances of the plausible values were constrained to zero. Due to this model specification, the within-person values indicate adolescents' deviations from their time-invariant scores. Hence, positive cross-lagged paths (diagonal black arrows) indicate, for example, whether adolescents who reported increased SMU problems relative to their usual level of SMU problems at T1 reported increased depressive symptoms relative to their usual level of depressive symptoms at T2. By including auto-regressive paths (horizontal black arrows), the cross-lagged paths were controlled for preceding increases (or decreases) of the behaviors. By including correlations between within-person values in the same year (gray double arrows), the cross-lagged paths were also controlled for associated increases (or
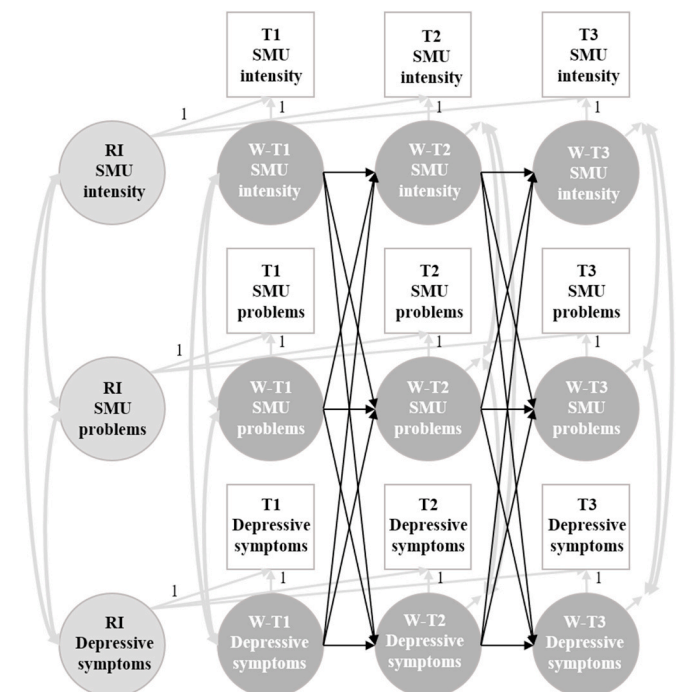
Fig. 2. Random intercept cross-lagged panel model (RI-CLPM). White squares denote plausible values at three measurement occasions (T_x). Light gray circles denote the between-level part of the model: the random intercepts (RIs). Correlations between the RIs were specified (gray double arrows). Dark gray circles denote the within-level part of the model: the within-person values (W). Correlations between the within-person values from the same measurement occasion were specified (gray double arrows). Diagonal black arrows depict the cross-lagged paths. Horizontal black arrows depict the auto-regression paths.

decreases) in behaviors within the same year. All RI-CLPMs were estimated using Maximum Likelihood with Robust standard errors (MLR).

2.4.3. Modelling procedure

In our first model, we fitted a RI-CLPM with three repeated measures of SMU intensity, SMU problems, and depressive symptoms (M1a). In our second model, we estimated the first model but with life satisfaction instead of depressive symptoms (M2a). We examined depressive symptoms and life satisfaction in separate models due to their collinearity. In subsequent models, we extended the first and second model with the four mediators, with one mediator per model (M1b-e and M2b-e). Model fit was evaluated using the Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean square Residual (SRMR). The standardized results (STDYX) of the models were used for the interpretation of the effect sizes. Analyses were conducted using Mplus 8.4 (Muthén & Muthén, 2017).

3. Results

3.1. Descriptive analyses

Prior to the main analyses, we studied whether adolescents' scores on the study measures changed over time and associations between the demographic characteristics and the study measures using multilevel analysis on the data in long format (Table 2). On average, adolescents' SMU problems did not change over time. Relative to T1, adolescents' SMU intensity increased in T2 and T3. In addition, adolescents reported increased depressive symptoms and decreased life satisfaction in T2 and T3 when compared to T1. Also, adolescents reported decreased face-to-face contact in T2 and T3 relative to T1. On average, upward social comparisons, cybervictimization, and subjective school achievements did not change over time. Although on average some measures did not change over time, the within-person residual variances of all measures were significant. This suggests that adolescents reported differential

developmental trajectories regarding all eight measures, which is a prerequisite for studying their associations over time.

Girls reported higher averages in SMU problems, SMU intensity, depressive symptoms, upward social comparisons, and face-to-face contact, and lower averages in life satisfaction and cybervictimization than boys. Adolescents who attended pre-vocational education reported higher levels of SMU problems, SMU intensity, cybervictimization, and face-to-face contact, and lower levels of upward social comparison and subjective school achievements than adolescents who attended pre-university education. Adolescents who attended intermediate education showed higher reports of SMU problems, cybervictimization, and face-to-face contact, and lower reports of subjective school achievements than adolescents who attended pre-university education. Finally, immigrant adolescents reported lower levels of subjective school achievements and less face-to-face contact than non-immigrant adolescents. The revealed associations between adolescents' demographics and the study measures do not influence the bidirectional associations from our main analyses, as the RI-CLPM controls for all possible stable confounders.

3.2. Direct cross-lagged associations between SMU and mental health

Table 3 reports the within-person auto-regressive and cross-lagged associations between SMU intensity, SMU problems, depressive symptoms (M1a), and life satisfaction (M2a). Both models had excellent model fit (M1a: CFI = 0.997, TLI = 0.980, RMSEA = 0.043, SRMR = 0.010; M2a: CFI = 0.996, TLI = 0.975, RMSEA = 0.047, SRMR = 0.011).

3.2.1. SMU intensity and mental health

The cross-lagged associations between SMU intensity and both mental health indicators were all non-significant. This means that adolescents whose SMU intensity increased did not report increased depressive symptoms or decreased life satisfaction one year later. Reversely, adolescents whose depressive symptoms increased, or whose life satisfaction decreased did not report increased SMU intensity one

Table 2
Descriptive Analyses ($n_{observations}$ = 6327, $n_{individuals}$ = 2109).

	SMU problems	SMU intensity	Depressive symptoms	Life satisfaction	Upward social comparisons	Cyber-victimizaton	Subjective school achievements	Face-to-face-contact
Level 1 (observations)	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*
T2 (ref.: T1)	−0.053	0.309***	0.200***	−0.332***	−0.020	0.062	−0.014	−0.092*
	(0.063)	(0.053)	(0.037)	(0.039)	(0.043)	(0.038)	(0.050)	(0.044)
T3 (ref.: T1)	−0.106	0.324***	0.503***	−0.519***	0.090	0.056	0.011	−0.156**
	(0.099)	(0.075)	(0.061)	(0.051)	(0.071)	(0.051)	(0.046)	(0.049)
Level 2 (adolescents)	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*	*β (SE)*
Girl[1] (ref.: boy)	0.163**	0.418***	0.439***	−0.119*	0.382***	−0.159**	0.122	0.217***
	(0.060)	(0.048)	(0.052)	(0.055)	(0.055)	(0.058)	(0.063)	(0.052)
Pre-vocational educational level[2] (ref.: pre-university educational level)	0.431***	0.396***	−0.076	−0.170	−0.254*	0.328***	−0.496***	0.426***
	(0.091)	(0.081)	(0.085)	(0.087)	(0.098)	(0.080)	(0.107)	(0.073)
Intermediate educational level[2] (ref.: pre-university educational level)	0.199*	0.131	0.130	−0.169	−0.141	0.197*	−0.480***	0.223**
	(0.098)	(0.091)	(0.088)	(0.095)	(0.105)	(0.090)	(0.113)	(0.080)
Immigrant background[3] (ref.: native)	0.073	−0.070	−0.114	0.015	−0.036	−0.048	−0.162*	−0.275***
	(0.059)	(0.057)	(0.059)	(0.067)	(0.065)	(0.065)	(0.074)	(0.062)
Random parameters	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**
Residual variance within adolescents	0.134***	0.422***	0.147***	0.545***	0.212***	0.551***	0.579***	0.435***
	(0.021)	(0.029)	(0.013)	(0.019)	(0.009)	(0.038)	(0.028)	(0.024)
Residual variance between adolescents	0.296***	1.131***	0.214***	0.515***	0.194***	0.438***	0.305***	0.624***
	(0.042)	(0.068)	(0.020)	(0.036)	(0.013)	(0.037)	(0.029)	(0.036)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; $β$ = STDY-standardized; SE = standard error.
Notes: The models were examined with multivariate multilevel regression analyses (level 1 = observations, level 2 = individuals) using the 20 imputed datasets of plausible values. The models were estimated with Maximum Likelihood with robust standard errors. [1] Based on question whether respondent was a boy or a girl. [2] Based on question which level of education the respondent was following. Educational level was determined using the most recent reported educational level. [3] Based on question in which country parent(s) were born.

Table 3

RI-CLPMs on Depressive symptoms and Life Satisfaction, Within-Person Cross-Lagged Associations ($n = 2109$).

M1a	SMU problems T2		SMU intensity T2		Depressive symptoms T2	
	β	(SE)	β	(SE)	β	(SE)
SMU problems T1	0.695***	(0.039)	0.185**	(0.058)	0.176**	(0.064)
SMU intensity T1	0.094**	(0.033)	0.335*	(0.130)	0.027	(0.058)
Depressive symptoms T1	0.062	(0.032)	0.013	(0.053)	0.257	(0.131)
	SMU problems T3		SMU intensity T3		Depressive symptoms T3	
	β	(SE)	β	(SE)	β	(SE)
SMU problems T2	0.746***	(0.032)	0.247**	(0.089)	0.086*	(0.043)
SMU intensity T2	0.027	(0.038)	0.374*	(0.178)	−0.001	(0.046)
Depressive symptoms T2	0.020	(0.026)	0.001	(0.063)	0.421***	(0.078)
M2a	SMU problems T2		SMU intensity T2		Life satisfaction T2	
	β	(SE)	β	(SE)	β	(SE)
SMU problems T1	0.703***	(0.038)	0.185**	(0.057)	−0.163***	(0.043)
SMU intensity T1	0.096**	(0.035)	0.334**	(0.128)	−0.010	(0.061)
Life satisfaction T1	−0.050	(0.029)	−0.024	(0.050)	0.084	(0.097)
	SMU problems T3		SMU intensity T3		Life satisfaction T3	
	β	(SE)	β	(SE)	β	(SE)
SMU problems T2	0.750***	(0.030)	0.249*	(0.098)	−0.116*	(0.048)
SMU intensity T2	0.028	(0.038)	0.374*	(0.177)	−0.022	(0.064)
Life satisfactionT2	−0.008	(0.024)	0.009	(0.063)	0.113	(0.066)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized; SE = standard error.
Notes: Results in table show the average estimates over 20 imputed datasets of plausible values. All models included correlations between (the residuals of the) measurements in the same year (results not shown).
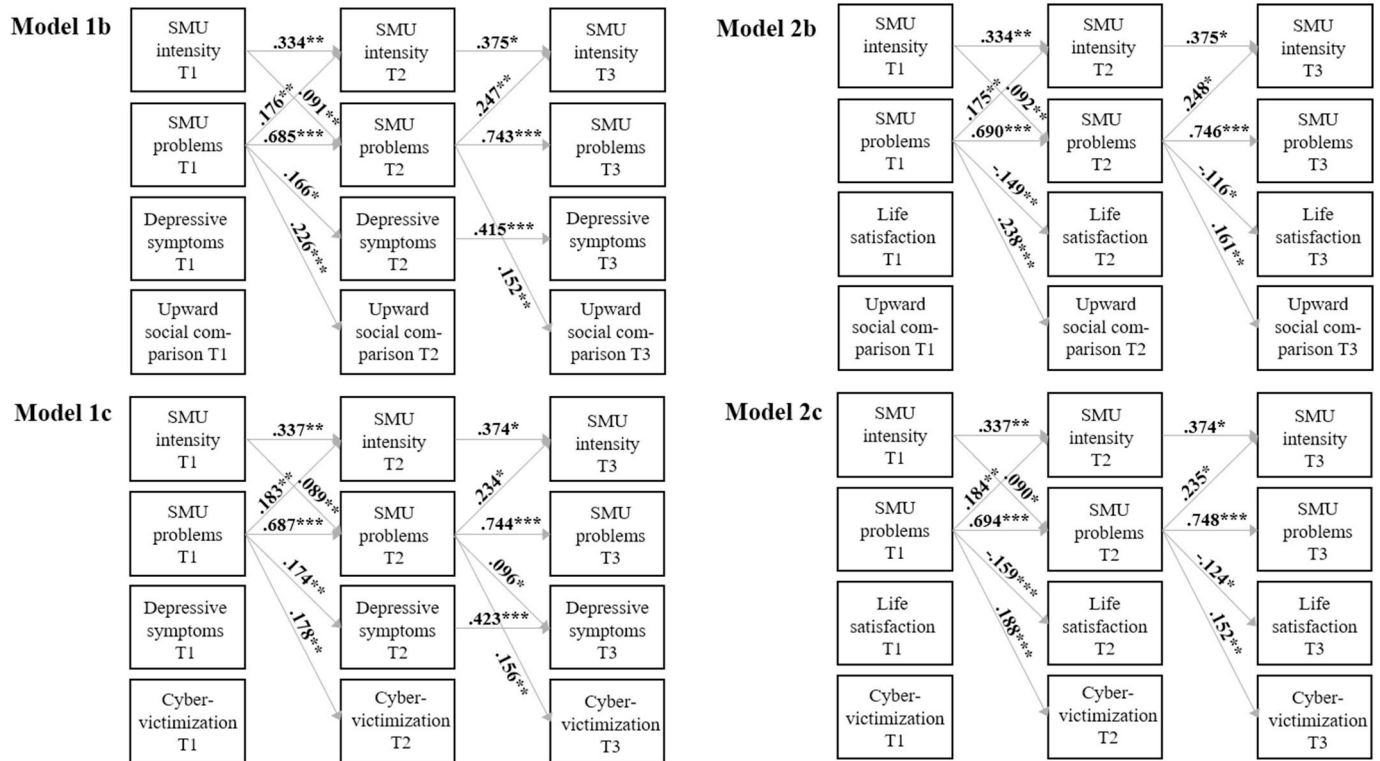
Fig. 3. Significant associations from the RI-CLPMs (STDYX-standardized). The figure displays the significant auto-regressive and (cross-)lagged associations between the within-person values of the measures (see Appendix 1 for all estimates). *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

year later. Thus, conform our expectations, SMU intensity and mental health were not associated in any direction.

3.2.2. SMU problems and mental health

In contrast, adolescents whose SMU problems increased reported increased depressive symptoms one year later (M1a: $\beta_{T1,T2} = 0.176$, $p = 0.006$ and $\beta_{T2,T3} = 0.086$, $p = 0.046$). Adolescents whose SMU problems

increased showed decreased life satisfaction one year later (M2a: $\beta_{T1,T2} = -0.163$, $p < 0.001$ and $\beta_{T2,T3} = -0.116$, $p = 0.017$). The reverse paths were non-significant, which means that adolescents whose depressive symptoms increased or whose life satisfaction decreased did not show increased SMU problems one year later. Thus, consistent across waves, we observed a unidirectional association between SMU problems and low mental health, which partially confirms our expectations.

3.3. Indirect cross-lagged associations between SMU and mental health

The RI-CLPM with depressive symptoms (M1a) was extended with four mediators, namely upward social comparisons, cybervictimization, subjective school achievements, and face-to-face contact, with one mediator per model (M1b-e). Similarly, we extended the RI-CLPM with life satisfaction (M2a) with the four mediators (M2b-e). Fig. 3 displays the models where we found significant cross-lagged paths with the mediators. All estimates of these models can be found in Appendix 1 (Tables A1 and A2).

3.3.1. SMU intensity and mental health

Adolescents' changes in SMU intensity, depressive symptoms, and life satisfaction did not precede or follow from changes in upward social comparisons, cybervictimization, subjective school achievements, or face-to-face contact with friends (Appendix 1). Hence, in line with our expectations, SMU intensity and mental health were neither directly, nor indirectly associated over time in any direction.

3.3.2. SMU problems and mental health

Fig. 3 shows that adolescents whose SMU problems increased reported increased upward social comparisons (M1b: $\beta_{T1,T2} = 0.226$, $p < 0.001$ and $\beta_{T2,T3} = 0.152$, $p = 0.001$) and cybervictimization (M1c: $\beta_{T1,T2} = 0.178$, $p = 0.001$ and $\beta_{T2,T3} = 0.156$, $p = 0.003$) in the next year. However, in turn, adolescents' increased upward social comparisons and cybervictimization did not predict increased depressive symptoms or decreased life satisfaction one year later. Increases in SMU problems were not associated with decreases in school achievements and face-to-face contact one year later, and decreases in school achievements and face-to-face contact in turn were not associated with increases in depressive symptoms or decreases in life satisfaction one year later (Appendix 1). Therefore, we did not find evidence that SMU problems decreased mental health indirectly through any of the four suggested mediators.

Reversely, changes in depressive symptoms and life satisfaction did not predict changes in upward social comparisons, cybervictimization, subjective school achievements, or face-to-face contact with friends one year later, and in turn, changes in these four suggested mediators did not predict changes in SMU problems one year later (Fig. 3, Appendix 1). Thus, in contrast to our expectations, we did not observe any direct or indirect effects of low mental health on SMU problems.

3.4. Additional findings

3.4.1. Additional mediations

The analyses provided several additional insights. Table 3 shows that adolescents whose SMU intensity increased in T1 reported increased SMU problems in T2 (M1a: $\beta = 0.094$, $p = 0.002$), and that in turn, adolescents whose SMU problems increased in T2 showed increased depressive symptoms in T3 (M1a: $\beta = 0.086$, $p = 0.046$) and decreased life satisfaction in T3 (M2a: $\beta = -0.116$, $p = 0.017$). However, mediation analysis showed that the indirect path between SMU intensity in T1 via SMU problems in T2 to depressive symptoms in T3 was not significant ($\beta = 0.008$, $p = 0.093$). Also, the indirect path between SMU intensity in T1 via SMU problems in T2 to life satisfaction in T3 was not significant ($\beta = -0.011$, $p = 0.060$). In addition, increases in SMU intensity in T1 were indirectly associated with increases in upward social comparisons and cybervictimization in T3 via SMU problems in T2 (Fig. 3). Mediation analyses, however, showed that the strength of these indirect associations was close to zero ($\beta = 0.015$, $p = 0.027$ and $\beta = 0.014$, $p = 0.049$, respectively).

3.4.2. Correlations within the same year

The RI-CLPMs also included correlations between (the residuals of the) within-person values of our measures within the same year. Appendix 2 (Tables A3 and A4) reports these correlations from M1b to M1e

and M2b to M2e. Results showed that, although we did not observe any cross-lagged associations between SMU intensity and mental health, adolescents whose SMU intensity increased in T1 reported increased depressive symptoms within the same year (M1b: $r = 0.155$, $p = 0.015$). Increases in SMU intensity did not co-occur with decreases in life satisfaction within the same year in any of the waves. Also, adolescents who reported increased SMU intensity in T1 reported increased upward social comparisons (M1b: $r = 0.170$, $p < 0.001$) and cybervictimization (M1c: $r = 0.187$, $p < 0.001$) and decreased subjective school achievements (M1d: $r = -0.116$, $p = 0.009$) in the same year. In addition, adolescents with increased SMU intensity in T1 or T2 reported increased face-to-face contact within the same year (M1e: $r_{T1} = 0.195$, $p < 0.001$ and $r_{T2} = 0.117$, $p = 0.022$). However, we cannot infer directionality from these correlations. Moreover, correlations with SMU intensity in T1 may be driven by SMU problems in T1, as correlations in T1 did not take into account variance due to T1-covariates (Fig. 2).

Also, we did not find evidence that SMU problems decreased mental health via upward social comparisons and cybervictimization, because increased upward social comparisons and cybervictimization in T2 did not predict decreased mental health one year later. However, adolescents' increases in upward social comparisons in T2 were associated with increases in depressive symptoms (M1b: $r = 0.204$, $p = 0.001$) and decreases in life satisfaction (M2b: $r = -0.172$, $p = 0.006$) within the same year. Also, increases in cybervictimization in T2 co-occurred with increases in depressive symptoms within the same year (M1c: $r = 0.114$, $p = 0.030$). Yet, we cannot infer directionality from these correlations.

3.4.3. Gender differences

Finally, we examined whether our results were robust to gender. Researchers proposed that girls have a higher tendency to ruminate about content on social media and to compare themselves with others online than boys (Nesi & Prinstein, 2015; Underwood & Ehrenreich, 2017). Consequently, girls may be more prone to adverse effects of SMU (problems) than boys. Gender differences were investigated using multiple group RI-CLPMs. More specifically, we estimated RI-CLPMs where all parameters were free to vary across boys and girls. In these models, we obtained z-scores for the differences in the strength of the cross-lagged parameters between the two groups. Findings of these results may be consulted in Appendix 3 (Tables A5 and A6). The analyses showed that although the strength and significance of the cross-lagged parameters differed slightly between boys and girls, these differences were not significant in any of the waves. These findings suggest that the associations are equally strong for boys and girls.

4. Discussion

The present study investigated bidirectional associations between SMU and mental health using longitudinal data collected among adolescents. In doing so, we distinguished between SMU intensity and addiction-like SMU problems. We also examined whether the proposed bidirectional associations were mediated by upward social comparisons, cybervictimization, decreased subjective school achievements, and less face-to-face contact. Findings showed that adolescents whose SMU problems increased reported increased depressive symptoms and decreased life satisfaction one year later. Also, SMU problems predicted increases in upward social comparisons and cybervictimization over time. Yet this, in turn, did not predict increases in depressive symptoms or decreases in life satisfaction over time, suggesting that upward social comparisons and cybervictimization did not mediate the observed effect of SMU problems on mental health. Reversely, increased depressive symptoms or decreased life satisfaction did not predict increased SMU problems one year later, neither directly nor indirectly through any of the mediators. We did not observe any direct or indirect associations between SMU intensity and mental health over time: Adolescents whose SMU intensity increased did not report increased depressive symptoms or decreased life satisfaction one year later, and neither vice versa.

Scholars have raised concerns about the adverse effects of SMU among adolescents (Primack & Escobar-Viera, 2017; Underwood & Ehrenreich, 2017). The present study suggests that particularly adolescents who show addiction-like SMU problems, but not adolescents who solely show high SMU intensity, are at risk for decreases in mental health. More specifically, being unable to control SMU impulses, constantly thinking about SMU, feeling bad when SMU is restricted, or attaching vital importance to SMU seem to evoke detrimental consequences to adolescents' mental health, rather than using social media a lot. Thus, adverse effects of SMU may depend on the extent to which adolescents have agency over their SMU, and not on their frequency of SMU. To that end, adolescents who engage in high SMU intensity without any SMU problems may be well able to regulate their SMU; their SMU may not necessarily interfere with life domains relevant to their mental health. After all, nowadays, high SMU intensity has become an integral part of adolescents' daily lives, and most adolescents use social media intensively to maintain social contact with peers (Boyd, 2014). Moreover, the finding that SMU problems and SMU intensity have differential associations with mental health supports the suggestion that these two types of SMU should be regarded as two separate dimensions of SMU.

Our suggestion that adolescents' high SMU intensity does not impair mental health challenges previous research that showed a negative association between SMU intensity and mental health (Kelly et al., 2018; Riehm et al., 2019; Twenge et al., 2018a, 2018b). This discrepancy could be related to the fact that most previous studies on the association between SMU intensity and mental health did not control for SMU problems. The few studies that did so showed that when SMU intensity and SMU problems are studied in one model, only or particularly SMU problems are associated with poor mental health (Boer, Van den Eijnden, et al., 2020; Shensa et al., 2017; Van den Eijnden et al., 2018). Hence, previously found negative associations between SMU intensity and mental health were potentially confounded by unobserved SMU problems. Moreover, the discrepancy may be related to the fact that previous longitudinal studies that showed that high SMU intensity decreased mental health over time were based on analytical approaches that lack separation of within- and between-person variance (e.g., Frison & Eggermont, 2017; Riehm et al., 2019; Vannucci & McCauley Ohannessian, 2019). As a result, previously found effects over time were possibly confounded by unobserved time-invariant traits (Hamaker et al., 2015; Orben, 2020), such as personality. The analysis of the present study controlled for this possibility, which makes results that are inconsistent with previous longitudinal studies plausible (Hamaker et al., 2015). Longitudinal studies that adopted a comparable analytical approach as in the present study showed, in line with our findings, that adolescents' SMU intensity was not or only weakly associated with poorer mental health over time (Coyne et al., 2019; George et al., 2020; Houghton et al., 2018; Jensen, George, Russell, & Odgers, 2019; Orben et al., 2019). Thus, there is increasing evidence that engaging in high SMU intensity by itself does not impose a risk to adolescents' mental health.

Yet, adolescents who show increased SMU intensity may be vulnerable to other risks, as our findings showed that increased SMU intensity predicted increased SMU problems one year later, although this was only observed from T1 to T2. More research on this potential association, focusing on for which group of adolescents high SMU intensity turns into developing SMU problems, is considered as an important direction for future research. At the same time, high SMU intensity may also be beneficial, as our findings showed that adolescents whose SMU

intensity increased reported increased face-to-face peer contact within the same year (in T1 and T2). Although we cannot derive directionality from this correlation, the finding refutes the idea that time spent on social media replaces time spent with friends offline, as frequently proposed (Twenge et al., 2018a, 2018b; Underwood & Ehrenreich, 2017; Wallsten, 2013). In line with our finding, other researchers also reported a positive association between SMU intensity and offline social interaction with friends or perceived friends support (Boer, Van den Eijnden, et al., 2020; De Looze et al., 2018; Valkenburg & Peter, 2007). High SMU intensity may be used to maintain contact with existing friends and may thereby be indicative of social involvement with peers, rather than neglecting friendships. Furthermore, research has shown that the more adolescents socialize with peers on social network sites, the less lonely they feel, which supports the idea that SMU may be used to strengthen and maintain friendships (Apaolaza, Hartmann, Medina, Barrutia, & Echebarria, 2013).

In contrast, findings of the present study underline the potential harmful effect of SMU problems to adolescents' mental health. Moreover, SMU problems predicted increased levels of upward social comparisons and cybervictimization over time. These increases, in turn, did not decrease mental health one year later, which implies that upward social comparison and cybervictimization did not mediate the negative effect of SMU problems on mental health. However, adolescents' increases in upward social comparisons and cybervictimization co-occurred with decreases in mental health within the same year. Therefore, and because of previously found effects of social comparisons and cybervictimization on mental health (Feinstein et al., 2013; Roeder et al., 2016), there may have been a mediating effect, but the measurements were possibly too far apart to observe it. For example, research shows that while adolescents experience increased emotional arousal shortly after posting on Facebook, this effect does not persist in the long run (Bayer, Ellison, Schoenebeck, Brady, & Falk, 2018). Correspondingly, when adolescents experience cybervictimization on social media or increased levels of upward social comparisons due to viewing social media content, they may experience more depressive symptoms or less life satisfaction within the same time frame, but this decrement in mental health may not persist for a year. In other words, mediating processes whereby adolescents' SMU problems decrease mental health through upward social comparisons and cybervictimization may emerge within a shorter time frame. More longitudinal research, using shorter time intervals, is required to verify this suggestion.

In addition, our results suggest that the negative association between SMU problems and mental health was unidirectional, thus that decreases in mental health did not lead to increases in SMU problems. In our additional analysis on gender differences, the unidirectional finding remained stable, suggesting that this accounted both for boys and girls. Hence, we did not find support for the cognitive behavioral model of addiction, which posits that pre-existing psychopathology drive the development of addiction-like internet-related behaviors (Davis, 2001; Griffiths, 2013). However, other longitudinal research among adults showed that, in line with the cognitive behavioral model, decreased life satisfaction predicted increased social media self-control failure (Du, 2020), which is also an element of SMU problems. An explanation for the seemingly contrasting findings might be that adults with poor mental health may be more sensitive to developing SMU problems than adolescents with mental health impairments. It has been proposed that while adults with mental health problems may engage in addiction-like SMU to alleviate their problems, adolescents with poor mental health

may refrain from social media because SMU further deteriorates their mental health, as they may be more sensitive to comparing themselves with others on social media than adults (Ho, Lwin, & Lee, 2017). Alternatively, the conclusion that mental health problems do not underlie adolescents' SMU problems may be premature. Although the cognitive behavioral model postulates that pre-existing psychopathology is a necessary condition for the development of addiction symptoms, pre-existing psychopathology does not by definition lead to developing addiction-like behavior (Davis, 2001). To that end, mental health problems may pose a risk for developing SMU problems for a specific group of adolescents, which is possibly not detected in our analysis on a heterogeneous sample. Therefore, more longitudinal research on the effect of poor mental health on SMU problems is warranted, focusing on potential moderators of the effect (e.g., social anxiety, personality traits).

4.1. Strengths and limitations

The present study has important strengths, such as the conceptual difference between SMU intensity and SMU problems in relation with mental health, the definition of mental health that encompasses the presence of wellbeing as well as absence of mental illnesses, the longitudinal data and innovative modelling techniques that provide insight into the directionality of associations, and the number of mediators investigated that allow for a more in-depth understanding of associations. However, findings of this study should be interpreted in light of several limitations.

First, our conceptualization of SMU intensity combines passive (e.g., viewing social media) and active social media activities (e.g., responding to messages). Disentangling the independent effects of passive and active SMU intensity was beyond the scope of the present study. Our findings should be interpreted in light of this operationalization: When examining overall SMU intensity, SMU intensity and mental health do not seem to be associated over time. However, it has been proposed that particularly passive SMU threatens mental health (Odgers & Jensen, 2020; Orben, 2020), although experimental and longitudinal research suggests that this depends on the characteristics of the adolescent (Beyens, Pouwels, van Driel, Keijsers, & Valkenburg, 2020; De Vries, Möller, Wieringa, Eigenraam, & Hamelink, 2018; Wenninger, Krasnova, & Buxmann, 2014). To consolidate our conclusion that SMU intensity does not impair mental health, more research testing the effects of passive and active SMU intensity separately is essential. To that end, the use of objective measures, such as tracked time spent or frequency of active and passive SMU, would be promising, as such measures provide more reliable estimates of SMU than self-report measures (Junco, 2013).

Second, we proposed that mental health problems could both cause and result from SMU problems. However, it could be argued that this proposition reflects a circular relationship between mental health and SMU problems rather than a bidirectional association. Mental health problems that cause SMU problems may differ from mental health problems that arise from SMU problems. More specifically, while it is argued that pre-existing pathological mental health problems underly the development of SMU problems (Davis, 2001; Griffiths, 2013), SMU problems may not lead to pathological levels of mental health problems,

but rather to decreases in mental health in general. Third, although the yearly time intervals of the repeated measures provide insight into potential long-term effects over time, such time intervals also have drawbacks. More specifically, behaviors may influence each other within a shorter time frame (Orben, 2020), which could not be captured with the research design of the present study. Therefore, more longitudinal research replicating our study using more intensive longitudinal data, such as daily measures of SMU and mental health, is considered as an important direction for future research. Fourth, as is typical for longitudinal studies, the present study dealt with considerable dropout of participants. Although the dropout in the present study was not selective and the associations between our study variables and dropout were small, dropout remained a limitation. We aimed to limit the bias that is typically associated with dropout by retaining all adolescents in the analyses.

4.2. Conclusion

Most adolescents spend considerable time on social media, which raises concerns among many. Findings of the present study emphasize the importance of considering SMU intensity and SMU problems as two distinct behaviors, because our results suggest that particularly SMU problems pose a risk to adolescents' mental health. The reverse pattern was not observed, which suggests that poor mental health does not lead to developing SMU problems. Moreover, SMU problems were found to increase upward social comparisons and cybervictimization, which implies that adolescents with SMU problems face multiple adversities. High SMU intensity and mental health were not associated in any direction. The findings imply that policies and guidelines aimed at identifying, preventing, or informing about unhealthy SMU should focus on SMU problems rather than on high SMU intensity. More longitudinal research replicating our findings is warranted and may advance our insight into the origins of SMU problems as well as the underlying mechanisms explaining the link between SMU problems and low mental health.

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Author contributions

All authors contributed to the development of the study concept. R. van den Eijnden initiated and coordinated the data collection of the data from the present study. M. Boer analyzed the data and wrote the first draft as well as the resubmission of the manuscript. G. Stevens, C. Finkenauer, M. de Looze, and R. van den Eijnden provided feedback on all sections of the initial and revised manuscript. All authors approved the final version of the manuscript.

Declaration of competing interest

None.

Appendix 1

Table A1
RI-CLPMs on Depressive symptoms Extended With Mediators, Within-Person Cross-Lagged Associations ($n = 2109$)

M1b	SMU problems T2		SMU intensity T2		Depressive symptoms T2		Upward social comparisons T2	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.685***	(0.041)	0.176**	(0.057)	0.166*	(0.064)	0.226***	(0.060)
SMU intensity T1	0.091**	(0.034)	0.334**	(0.129)	0.027	(0.058)	0.042	(0.075)
Depressive symptoms T1	0.056	(0.032)	0.009	(0.053)	0.253	(0.129)	0.073	(0.079)
Upward social comparisons T1	0.044	(0.026)	0.034	(0.045)	0.027	(0.066)	0.006	(0.103)
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Upward social comparisons T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.743***	(0.032)	0.247**	(0.092)	0.079	(0.043)	0.152**	(0.044)
SMU intensity T2	0.026	(0.038)	0.375*	(0.178)	−0.002	(0.046)	0.009	(0.058)
Depressive symptoms T2	0.017	(0.027)	0.001	(0.065)	0.415***	(0.078)	0.052	(0.066)
Upward social comparisons T2	0.015	(0.025)	0.000	(0.069)	0.029	(0.046)	0.104	(0.096)
M1c	**SMU Problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Cybervictimization T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.687***	(0.039)	0.183**	(0.059)	0.174**	(0.064)	0.178**	(0.053)
SMU intensity T1	0.089**	(0.034)	0.337**	(0.129)	0.026	(0.059)	0.107	(0.063)
Depressive symptoms T1	0.059	(0.033)	0.013	(0.054)	0.257	(0.131)	0.016	(0.070)
Cybervictimization T1	0.036	(0.027)	0.006	(0.045)	−0.004	(0.055)	0.156	(0.099)
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Cybervictimization T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.744***	(0.032)	0.234*	(0.090)	0.096*	(0.046)	0.156**	(0.053)
SMU intensity T2	0.026	(0.038)	0.374*	(0.177)	0.001	(0.046)	0.030	(0.058)
Depressive symptoms T2	0.019	(0.026)	−0.004	(0.063)	0.423***	(0.077)	−0.030	(0.060)
Cybervictimization T2	0.009	(0.024)	0.045	(0.064)	−0.036	(0.042)	0.100	(0.091)
M1d	**SMU problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Subjective school achievements T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.695***	(0.039)	0.182**	(0.057)	0.176**	(0.065)	−0.039	(0.036)
SMU intensity T1	0.093**	(0.033)	0.336*	(0.132)	0.026	(0.060)	−0.078	(0.052)
Depressive symptoms T1	0.062	(0.032)	0.011	(0.053)	0.257	(0.132)	−0.006	(0.056)
Subj. school achievements T1	−0.001	(0.023)	−0.037	(0.043)	0.000	(0.058)	0.289***	(0.063)
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Subjective school achievements T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.746***	(0.032)	0.240**	(0.088)	0.088*	(0.043)	−0.062	(0.041)
SMU intensity T2	0.027	(0.037)	0.376*	(0.177)	0.000	(0.047)	−0.032	(0.055)
Depressive symptoms T2	0.021	(0.026)	−0.004	(0.063)	0.422***	(0.079)	−0.017	(0.055)
Subj. school achievements T2	0.004	(0.023)	−0.053	(0.053)	0.020	(0.035)	0.078	(0.090)
M1e	**SMU Problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Face-to-face contact T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.695***	(0.039)	0.184**	(0.057)	0.177**	(0.064)	0.032	(0.041)
SMU intensity T1	0.095**	(0.034)	0.326*	(0.127)	0.030	(0.058)	0.084	(0.059)
Depressive symptoms T1	0.061	(0.032)	0.012	(0.054)	0.256*	(0.130)	−0.012	(0.067)
Face-to-face contact T1	−0.003	(0.024)	0.055	(0.047)	−0.018	(0.053)	0.286**	(0.103)
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Face-to-face contact T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.746***	(0.031)	0.245**	(0.089)	0.086*	(0.044)	0.051	(0.041)
SMU intensity T2	0.028	(0.037)	0.371*	(0.178)	−0.001	(0.045)	0.009	(0.065)
Depressive symptoms T2	0.020	(0.026)	0.002	(0.063)	0.420***	(0.078)	−0.024	(0.051)
Face-to-face contact T2	−0.003	(0.027)	0.032	(0.064)	0.000	(0.038)	0.400***	(0.085)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized; SE = standard error.
Notes: Results in table show the average estimates over 20 imputed datasets of plausible values. All models included (residual) correlations between measurements in the same year (estimates presented in Appendix 2).

Table A2
RI-CLPMs on Life Satisfaction Extended With Mediators, Within-Person Cross-Lagged Associations (*n* = 2109)

M2b	SMU problems T2		SMU intensity T2		Life satisfaction T2		Upward social comparisons T2	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.690***	(0.041)	0.175**	(0.057)	−0.149**	(0.047)	0.238***	(0.059)
SMU intensity T1	0.092**	(0.035)	0.334**	(0.127)	0.008	(0.061)	0.043	(0.076)
Life satisfaction T1	−0.046	(0.028)	−0.021	(0.050)	0.079	(0.096)	−0.042	(0.070)
Upward social comparisons T1	0.051	(0.026)	0.032	(0.046)	−0.044	(0.053)	0.014	(0.101)
	SMU problems T3		**SMU intensity T3**		**Life satisfaction T3**		**Upward social comparisons T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.746***	(0.031)	0.248*	(0.100)	−0.116*	(0.053)	0.161**	(0.044)
SMU intensity T2	0.027	(0.038)	0.375*	(0.177)	−0.022	(0.065)	0.011	(0.059)
Life satisfaction T2	−0.005	(0.024)	0.009	(0.063)	0.112	(0.066)	−0.020	(0.044)
Upward social comparisons T2	0.017	(0.025)	0.001	(0.067)	0.002	(0.055)	0.109	(0.094)
M2c	**SMU Problems T2**		**SMU intensity T2**		**Life satisfaction T2**		**Cybervictimization T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.694***	(0.039)	0.184**	(0.058)	−0.159***	(0.045)	0.188***	(0.048)
SMU intensity T1	0.090*	(0.035)	0.337**	(0.127)	−0.008	(0.061)	0.106	(0.063)
Life satisfaction T1	−0.047	(0.028)	−0.022	(0.050)	0.086	(0.098)	0.037	(0.061)
Cybervictimization T1	0.040	(0.027)	0.005	(0.046)	−0.007	(0.054)	0.164	(0.100)
	SMU problems T3		**SMU intensity T3**		**Life satisfaction T3**		**Cybervictimization T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.748***	(0.031)	0.235*	(0.097)	−0.124*	(0.048)	0.152**	(0.050)
SMU intensity T2	0.027	(0.038)	0.374*	(0.176)	−0.023	(0.065)	0.029	(0.058)
Life satisfaction T2	−0.007	(0.023)	0.014	(0.063)	0.117	(0.067)	0.018	(0.048)
Cybervictimization T2	0.010	(0.024)	0.045	(0.064)	0.031	(0.050)	0.099	(0.091)
M2d	**SMU problems T2**		**SMU intensity T2**		**Life satisfaction T2**		**Subjective school achievements T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.704***	(0.038)	0.182**	(0.056)	−0.160***	(0.044)	−0.042	(0.033)
SMU intensity T1	0.094**	(0.035)	0.336**	(0.130)	−0.007	(0.062)	−0.078	(0.052)
Life satisfaction T1	−0.050	(0.029)	−0.021	(0.050)	0.080	(0.096)	−0.006	(0.046)
Subj. school achievements T1	0.001	(0.023)	−0.035	(0.043)	0.048	(0.052)	0.290***	(0.064)
	SMU problems T3		**SMU intensity T3**		**Life satisfaction T3**		**Subjective school achievements T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.750***	(0.030)	0.242*	(0.096)	−0.115*	(0.048)	−0.067	(0.039)
SMU intensity T2	0.028	(0.037)	0.376*	(0.175)	−0.023	(0.064)	−0.034	(0.055)
Life satisfaction T2	−0.009	(0.024)	0.014	(0.063)	0.112	(0.066)	−0.004	(0.052)
Subj. school achievements T2	0.004	(0.024)	−0.054	(0.053)	0.011	(0.047)	0.081	(0.091)
M2e	**SMU Problems T2**		**SMU intensity T2**		**Life satisfaction T2**		**Face-to-face contact T2**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T1	0.703***	(0.038)	0.182**	(0.057)	−0.166***	(0.043)	0.038	(0.037)
SMU intensity T1	0.096**	(0.036)	0.325**	(0.125)	−0.022	(0.061)	0.086	(0.058)
Life satisfaction T1	−0.051	(0.029)	−0.028	(0.050)	0.079	(0.096)	0.038	(0.049)
Face-to-face contact T1	0.001	(0.024)	0.058	(0.046)	0.068	(0.054)	0.281**	(0.102)
	SMU problems T3		**SMU intensity T3**		**Life satisfaction T3**		**Face-to-face contact T3**	
	β	(*SE*)	β	(*SE*)	β	(*SE*)	β	(*SE*)
SMU problems T2	0.750***	(0.030)	0.246*	(0.097)	−0.117*	(0.048)	0.044	(0.042)
SMU intensity T2	0.028	(0.037)	0.371*	(0.176)	−0.024	(0.064)	0.009	(0.065)
Life satisfaction T2	−0.008	(0.024)	0.004	(0.064)	0.111	(0.067)	0.004	(0.046)
Face-to-face contact T2	−0.003	(0.027)	0.031	(0.065)	0.021	(0.048)	0.399***	(0.089)

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized; SE = standard error.
Notes: Results in table show the average estimates over 20 imputed datasets of plausible values. All models included (residual) correlations between measurements in the same year (estimates presented in Appendix 2).

Appendix 2

Table A3
RI-CLPMs on Depressive symptoms, Within-Person (Residual) Correlations Within Same Year ($n = 2109$)

M1b	SMU problems			SMU intensity			Depressive symptoms		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.304***	0.159**	0.057						
Depressive symptoms	0.325***	0.138***	0.053	0.155*	0.056	0.000			
Upward social comparisons	0.306***	0.157***	0.056	0.170***	0.074	−0.012	0.260***	0.204**	0.068
M1c	**SMU problems**			**SMU intensity**			**Depressive symptoms**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.306***	0.158**	0.056						
Depressive symptoms	0.324***	0.142***	0.055	0.152*	0.056	0.001			
Cybervictimization	0.297***	0.145***	0.052	0.187***	0.081	0.027	0.272***	0.114*	0.049
M1d	**SMU problems**			**SMU intensity**			**Depressive symptoms**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.306***	0.158**	0.056						
Depressive symptoms	0.338***	0.138***	0.055	0.152*	0.055	0.000			
Subjective school achievements	−0.103**	−0.027	−0.024	−0.116**	−0.060	−0.011	−0.067	−0.068	−0.047
M1e	**SMU problems**			**SMU intensity**			**Depressive symptoms**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.305***	0.161**	0.057						
Depressive symptoms	0.329***	0.137***	0.055	0.152*	0.057	0.000			
Face-to-face contact	0.071*	0.003	0.005	0.195***	0.117*	−0.10	0.021	−0.031	−0.022

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized; SE = standard error. *Notes*: Results in table show the average estimates over 20 imputed datasets of plausible values. T1 estimates are correlations. T2 and T3 estimates are residual correlations.

Table A4
RI-CLPMs on Life Satisfaction Within-Person (Residual) Correlations Within Same Year ($n = 2109$)

M2b	SMU problems			SMU intensity			Life satisfaction		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.305***	0.157**	0.057						
Life satisfaction	−0.224***	−0.135**	−0.045	−0.089	−0.023	0.000			
Upward social comparisons	0.305***	0.162***	0.057	0.169***	0.073	−0.010	−0.169**	−0.172**	−0.034
M2c	**SMU problems**			**SMU intensity**			**Life satisfaction**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.307***	0.157**	0.056						
Life satisfaction	−0.223***	−0.138**	−0.046	−0.086	−0.022	0.000			
Cybervictimization	0.297***	0.149***	0.050	0.186**	0.081	0.027	−0.203***	−0.105	−0.031
M2d	**SMU problems**			**SMU intensity**			**Life satisfaction**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.307***	0.157**	0.056						
Life satisfaction	−0.226***	−0.135**	−0.047	−0.090	−0.022	−0.002			
Subjective school achievements	−0.101**	−0.029	−0.024	−0.114*	−0.060	−0.012	0.111*	0.121**	0.041
M2e	**SMU problems**			**SMU intensity**			**Life satisfaction**		
	r (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)	*r* (T1)	*r* (T2)	*r* (T3)
SMU intensity	0.306***	0.159**	0.057						
Life satisfaction	−0.226***	−0.136**	−0.046	−0.085	−0.026	−0.001			
Face-to-face contact	0.073*	0.004	0.004	0.197***	0.119*	−0.009	0.095	0.179***	0.065

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized; SE = standard error. *Notes*: Results in table show the average estimates over 20 imputed datasets of plausible values. T1 estimates are correlations. T2 and T3 estimates are residual correlations.

Appendix 3

Table A5

RI-CLPMs on Depressive symptoms Extended With Mediators, Within-Person Cross-Lagged Associations by Gender (n_{boys} = 1203 n_{girls} = 906)

M1b	SMU problems T2		SMU intensity T2		Depressive symptoms T2		Upward social comparisons T2	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.692***	0.684***	0.151**	0.222*	0.163*	0.194*	0.206**	0.249**
SMU intensity T1	0.069	0.107*	0.354**	0.278	−0.023	0.012	0.046	0.007
Depressive symptoms T1	0.050	0.056	−0.018	0.022	0.194	0.303	0.041	0.104
Upward social comparisons T1	0.039	0.042	0.049	0.002	0.009	0.016	0.001	0.012
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Upward social comparisons T3**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.739***	0.746***	0.203*	0.302*	0.081	0.084	0.135*	0.179*
SMU intensity T2	0.022	0.033	0.403*	0.326	0.002	−0.029	0.036	−0.042
Depressive symptoms T2	0.014	0.020	−0.010	−0.034	0.370***	0.432***	0.045	0.024
Upward social comparisons T2	0.013	0.018	0.024	−0.028	0.018	0.038	0.109	0.097
M1c	**SMU problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Cybervictimization T2**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.685***	0.694***	0.153**	0.227*	0.161*	0.196	0.173**	0.189*
SMU intensity T1	0.065	0.108*	0.358**	0.281	−0.033	0.015	0.126	0.094
Depressive symptoms T1	0.048	0.060	−0.019	0.029	0.198	0.310	−0.032	0.103
Cybervictimization T1	0.061	0.008	0.032	−0.022	0.013	0.004	0.177	0.128
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Cybervictimization T3**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.739***	0.748***	0.189*	0.293*	0.101	0.087	0.171**	0.142
SMU intensity T2	0.022	0.032	0.403*	0.322	0.007	−0.027	0.061	−0.010
Depressive symptoms T2	0.015	0.022	−0.017	−0.039	0.379***	0.441***	−0.030	0.015
Cybervictimization T2	0.010	0.010	0.070	0.010	−0.060	0.014	0.103	0.080
M1d	**SMU problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Subjective school achievements T2**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.700***	0.696***	0.157**	0.218*	0.169*	0.197	−0.018	−0.066
SMU intensity T1	0.071	0.107*	0.362**	0.275	−0.029	0.009	−0.112	−0.036
Depressive symptoms T1	0.054	0.060	−0.014	0.019	0.197	0.300	0.013	−0.035
Subj. school achievements T1	−0.004	0.000	−0.039	−0.050	0.019	−0.051	0.262***	0.321***
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Subjective school achievements T3**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.742***	0.750***	0.202*	0.286*	0.086	0.092	−0.054	−0.080
SMU intensity T2	0.023	0.033	0.406*	0.331	0.004	−0.026	−0.057	0.013
Depressive symptoms T2	0.018	0.024	−0.014	−0.039	0.375***	0.442***	0.007	−0.060
Subj. school achievements T2	0.012	−0.007	−0.069	−0.030	0.027	0.003	0.066	0.095
M1e	**SMU Problems T2**		**SMU intensity T2**		**Depressive symptoms T2**		**Face-to-face contact T2**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.700***	0.696***	0.161**	0.223*	0.169*	0.198*	0.044	0.025
SMU intensity T1	0.075	0.106*	0.348**	0.263	−0.027	0.025	0.058	0.100
Depressive symptoms T1	0.054	0.060	−0.014	0.024	0.197	0.310	0.006	−0.062
Face-to-face contact T1	−0.014	0.011	0.036	0.079	−0.013	−0.047	0.265*	0.303*
	SMU problems T3		**SMU intensity T3**		**Depressive symptoms T3**		**Face-to-face contact T3**	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.742***	0.751***	0.209*	0.289*	0.084	0.093	0.060	0.035
SMU intensity T2	0.022	0.035	0.401*	0.323	0.003	−0.025	0.014	0.007
Depressive symptoms T2	0.017	0.023	−0.008	−0.032	0.373***	0.439***	−0.023	−0.026
Face-to-face contact T2	0.002	−0.012	0.013	0.046	0.008	−0.023	0.409***	0.374**

***p < 0.001; **p < 0.01; *p < 0.05; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized.

Notes: Results in table show the average estimates over 20 imputed datasets of plausible values. All models included (residual) correlations between measurements in the same year. Observed differences between boys and girls were all not significant (p > 0.05).

Table A6
RI-CLPMs on Life Satisfaction Extended With Mediators, Within-Person Cross-Lagged Associations by Gender ($n_{\text{boys}} = 1203$ $n_{\text{girls}} = 906$)

M2b	SMU problems T2		SMU intensity T2		Life satisfaction T2		Upward social comparisons T2	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.695***	0.692***	0.145**	0.222*	−0.121*	−0.198*	0.212**	0.261**
SMU intensity T1	0.069	0.108*	0.353**	0.283	−0.028	0.033	0.047	0.005
Life satisfaction T1	−0.053	−0.034	−0.018	−0.021	0.089	0.054	−0.033	−0.051
Upward social comparisons T1	0.045	0.049	0.044	−0.001	−0.022	−0.083	0.003	0.033
	SMU problems T3		SMU intensity T3		Life satisfaction T3		Upward social comparisons T3	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.740***	0.753***	0.197*	0.303	−0.087	−0.160	0.142**	0.181*
SMU intensity T2	0.022	0.032	0.402*	0.332	−0.038	0.011	0.035	−0.041
Life satisfaction T2	−0.007	−0.001	−0.028	0.075	0.113	0.107	−0.025	−0.011
Upward social comparisons T2	0.014	0.021	0.018	−0.020	−0.024	0.038	0.112	0.101
M2c	SMU problems T2		SMU intensity T2		Life satisfaction T2		Cybervictimization T2	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.689***	0.703***	0.148**	0.228*	−0.134*	−0.203**	0.177**	0.206**
SMU intensity T1	0.066	0.108*	0.356**	0.286	−0.025	0.034	0.118	0.093
Life satisfaction T1	−0.052	−0.038	−0.014	−0.030	0.097	0.060	0.081	−0.057
Cybervictimization T1	0.064	0.014	0.027	−0.028	0.029	−0.077	0.183	0.130
	SMU problems T3		SMU intensity T3		Life satisfaction T3		Cybervictimization T3	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.741***	0.755***	0.182*	0.296	−0.108	−0.147	0.168**	0.150
SMU intensity T2	0.021	0.033	0.400*	0.329	−0.040	0.009	0.060	−0.011
Life satisfaction T2	−0.009	−0.003	−0.023	0.077	0.124	0.109	0.025	0.008
Cybervictimization T2	0.011	0.013	0.066	0.010	0.052	−0.002	0.105	0.077
M2d	SMU problems T2		SMU intensity T2		Life satisfaction T2		Subjective school achievements T2	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.706***	0.706***	0.152**	0.218*	−0.127**	−0.213**	−0.015	−0.076
SMU intensity T1	0.072	0.108*	0.359**	0.280	−0.025	0.033	−0.111	−0.035
Life satisfaction T1	−0.056	−0.037	−0.017	−0.020	0.085	0.070	−0.013	0.007
Subj. school achievements T1	0.001	−0.004	−0.037	−0.046	0.031	0.077	0.263***	0.320***
	SMU problems T3		SMU intensity T3		Life satisfaction T3		Subjective school achievements T3	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.744***	0.757***	0.196*	0.290	−0.094	−0.143	−0.054	−0.097
SMU intensity T2	0.023	0.033	0.403*	0.337	−0.041	0.011	−0.057	0.013
Life satisfaction T2	−0.012	−0.004	−0.024	0.078	0.120	0.101	−0.011	0.004
Subj. school achievements T2	0.012	−0.007	−0.066	−0.032	−0.021	0.054	0.068	0.099
M2e	SMU Problems T2		SMU intensity T2		Life satisfaction T2		Face-to-face contact T2	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T1	0.706***	0.706***	0.154**	0.223*	−0.133**	−0.220**	0.048	0.032
SMU intensity T1	0.075	0.108*	0.347**	0.267	−0.040	0.018	0.059	0.101
Life satisfaction T1	−0.054	−0.039	−0.024	−0.025	0.082	0.075	0.008	0.096
Face-to-face contact T1	−0.006	0.009	0.038	0.079	0.080	0.050	0.259*	0.304*
	SMU problems T3		SMU intensity T3		Life satisfaction T3		Face-to-face contact T3	
	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}	β_{boys}	β_{girls}
SMU problems T2	0.743***	0.759***	0.200*	0.294*	−0.092	−0.149	0.051	0.037
SMU intensity T2	0.022	0.036	0.398*	0.329	−0.043	0.004	0.014	0.011
Life satisfaction T2	−0.012	−0.002	−0.036	0.073	0.118	0.103	−0.020	0.045
Face-to-face contact T2	0.005	−0.015	0.018	0.037	0.004	0.049	0.410***	0.369**

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; RI-CLPM = random intercept cross-lagged panel model. SMU = social media use; β = STDYX-standardized.

Notes: Results in table show the average estimates over 20 imputed datasets of plausible values. All models included (residual) correlations between measurements in the same year. Observed differences between boys and girls were all not significant ($p > 0.05$).

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