The complex association between social media use intensity and adolescent wellbeing: A longitudinal investigation of five factors that may affect the association

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A B S T R A C T

The present study examined five possible explanations for the mixed findings on the association between adolescents' social media use (SMU) intensity and wellbeing. Particularly, it investigated whether the association between SMU intensity and life satisfaction depended on (1) the type of SMU activity the adolescent engaged in, (2) the (non)linearity of the association, (3) individual differences, (4) inclusion of SMU problems, and (5) the level of analysis. Data from four waves of longitudinal data among 1419 adolescents were used ($M_{age(T1)} = 12.51$ (0.60), 45.95% girl). Multilevel analyses showed that at the within-person level, on average, changes in different types of SMU activities were not associated with changes in life satisfaction. Within individuals, the associations ranged from negative to positive across adolescents. In general, this variation could not be explained by adolescents' engagement in upward social comparisons. At the between-person level, the higher adolescents' average intensity of certain SMU activities, the lower their average level of life satisfaction. However, these associations were confounded by adolescents' SMU problems. No curvilinear associations were found. Overall, the findings underline that to enhance our understanding of the association between SMU and wellbeing in adolescence, it is important to acknowledge the heterogeneity of effects, distinguish between SMU intensity and SMU problems, and disentangle within-from between-person effects.

1. Introduction

Most adolescents spend a lot of time on social media nowadays, which raises concerns among many (Griffiths & Kuss, 2011). Social media refer to social network sites (SNS) and instant messengers (IM), such as Instagram and WhatsApp, respectively. Some researchers suggest that high levels of social media use (SMU) intensity are detrimental to adolescents' wellbeing, for instance to their life satisfaction (Kelly, Zilanawala, Booker, & Sacker, 2018; Twenge, Martin, & Campbel, 2018). Other scholars suggest that the association between SMU intensity and wellbeing is more complex, however (Dienlin & Johannes, 2020). Review studies highlight that the overall association is weak, and that the direction and strength of the association is contingent on many theoretical and methodological factors, including the conceptualization of SMU and the used analytical approach (Meier & Reinecke, 2020; Odgers & Jensen, 2020; Orben, 2020). Nevertheless, factors that may affect the association between SMU intensity and wellbeing are typically studied in isolation, painting an incomplete picture of the association. To enhance knowledge on the association between adolescents' SMU intensity and wellbeing, the current study examined five factors that may affect this association. Using four waves of longitudinal data among Dutch secondary school adolescents, the current study tested how these five factors jointly affect the association between adolescents' SMU intensity and wellbeing.

1.1. The association between SMU intensity and wellbeing depends on the type of SMU activity the adolescent engages in

Adolescents' overall *SMU intensity* encompasses their intensity of engagement in different SMU activities, that is, their active and passive SMU. *Active SMU* refers to communication and content creation on social media, for example posting messages or photos on social media or chatting with others. *Passive SMU* refers to viewing other people's messages or photos on social media and scrolling through social media

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feeds. Research suggests that active SMU is beneficial to adolescents' wellbeing, whereas passive SMU is detrimental (Verduyn, Ybarra, Résibois, Jonides, & Kross, 2017). Presumably, active SMU enhances one's social network, which may increase social capital and feelings of connectedness. Conversely, because people tend to present themselves in an overly appealing way on social media, passive SMU implicates exposure to unrealistically flattering portrayals of others. This exposure may induce feelings of envy or upward social comparisons, such as the perception that others are more successful (Verduyn et al., 2017).

The proposition that particularly passive SMU is detrimental to wellbeing has received empirical support. A meta-analysis showed that passive SMU was negatively associated with indicators of wellbeing, whereas active SMU was positively associated with wellbeing, albeit both with small effect sizes (Liu, Baumeister, Yang, & Hu, 2019). Recent experience sampling studies with multiple daily assessments challenge these results (Beyens, Pouwels, Valkenburg, & Van Driel, 2020; Beyens, Pouwels, Van Driel, Keijsers, & Valkenburg, 2020; Jensen, George, Russell, & Odgers, 2019). Particularly, one study found that, on average, moments when adolescents had used Instagram or WhatsApp passively were associated with moments of increased affective wellbeing. In contrast, moments of active use of Instagram or WhatsApp were not associated with changes in wellbeing (Beyens, Pouwels, Valkenburg, & Van Driel, 2020). Another study found that, on days when adolescents showed increased levels of passive SMU or active SMU, adolescents did not report daily changes in depression or worries (Jensen et al., 2019). Similarly, a study that distinguished between the intensity of passive public (i.e., viewing posts or stories of others), passive private (i.e., reading direct messages), and active private (i.e., sending direct messages) SMU showed that, on average, neither of the three SMU activities predicted immediate changes in wellbeing (Beyens, Pouwels, Van Driel et al., 2020). Overall, while meta-analytic results suggest that passive SMU is detrimental, and that active SMU is beneficial to wellbeing, recent studies using intensive daily measurements question the robustness of this finding.

1.2. The association between SMU intensity and wellbeing may or may not be linear

According to the 'Goldilocks hypothesis', the association between adolescents' SMU intensity and wellbeing is curvilinear (Dienlin & Johannes, 2020; Przybylski & Weinstein, 2017). Specifically, in contemporary society where (social) media are integrated into the daily lives of many young people, both very little as well as excessive SMU may be harmful to wellbeing. Adolescents who barely use social media may miss out on social information and interaction with peers, while adolescents who use social media excessively may displace meaningful offline activities to online activities. In contrast, moderate SMU may not be harmful and could even be advantageous to adolescent wellbeing (Przybylski & Weinstein, 2017). Therefore, the association between SMU intensity and wellbeing may show an inverted u-shape.

Cross-sectional research supports this hypothesis by showing that adolescents who do not use social media and those who use it excessively report lower levels of happiness and overall mental wellbeing than those who use it moderately (Przybylski & Weinstein, 2017; Twenge et al., 2018). However, longitudinal research does not support this hypothesis. Specifically, a longitudinal study on the association between overall screen time and depressive symptoms did not find any differences in the association across groups of adolescents below or above certain thresholds of screen time (Houghton et al., 2018). In addition, an experience sampling study did not yield curvilinear associations over time between several social media activities and depression or worry, except for active SMU: In line with the Goldilocks hypothesis, on days when adolescents did not create or created a lot of content on social media, they reported increased depressive symptoms, whereas on days when they created some content, they reported decreased depressive symptoms (Jensen et al., 2019). Nevertheless, the

researchers emphasized that this finding should be interpreted with caution, because very few adolescents created a lot of content on one day (Jensen et al., 2019). Thus, while cross-sectional research supports the Goldilocks hypothesis, longitudinal and experience sampling studies hardly replicate these findings.

1.3. The association between SMU intensity and wellbeing depends on individual differences

Some adolescents may be negatively affected by high SMU intensity, some positively, and some may not be affected at all. Therefore, researchers increasingly advocate for studying *heterogeneity* in the association between adolescents' SMU intensity and wellbeing (Beyens, Pouwels, Valkenburg, & Van Driel, 2020; Odgers, Schueller, & Ito, 2020; Orben, 2020). According to the Differential Susceptibility to Media effects Model (DSMM), media effects depend on individuals' susceptibility to media effects (Valkenburg & Peter, 2013). One characteristic that may make individuals more susceptible to media effects may be adolescents' tendency to compare themselves to others, that is, their *social comparison tendency*. The 'social comparison perspective' posits that for adolescents who are sensitive to social comparison, exposure to others' messages on social media leads to decreased wellbeing through feelings of envy (De Vries, Möller, Wieringa, Eigenraam, & Hamelink, 2018). According to the 'emotional contagion perspective', adolescents who do not have this sensitivity may take over the positive emotions they encounter on social media, which may lead to increased wellbeing (De Vries et al., 2018). It has been argued that this moderating effect occurs when adolescents engage in *upward* social comparison, that is, when they evaluate others as superior (Verduyn, Gugushvili, Massar, Täht, & Kross, 2020). Thus, SMU activities may negatively or positively affect wellbeing, depending on adolescents' upward social comparison tendency.

Recent experience sampling studies confirm that adolescents strongly differ in their susceptibility to SMU effects (Beyens, Pouwels, Valkenburg, & Van Driel, 2020; Beyens, Pouwels, Van Driel et al., 2020; Valkenburg, Beyens, Pouwels, & Van Driel, 2021). For example, one study showed that momentary associations between adolescents' intensity of passive and active SMU activities and affective wellbeing ranged from a moderate negative to a moderate positive association across adolescents (Beyens, Pouwels, Van Driel et al., 2020). In an experimental study, adolescents with a strong social comparison tendency were negatively affected by exposure to positively framed Instagram posts. In contrast, adolescents who lacked this tendency were positively affected by exposure to such posts (De Vries et al., 2018). A cross-sectional study indicated that among adolescents with a low social comparison tendency, there was a negative association between their intensity of active Instagram use and their level of loneliness. However, among adolescents with a high social comparison tendency, no association between active Instagram use and loneliness was found (Yang, 2016). Overall, these studies suggest that the association between SMU activities and wellbeing depend on adolescents' sensitivity for (upward) social comparison.

1.4. The association between SMU intensity and wellbeing depends on whether SMU problems are considered

Adolescents' SMU intensity refers to the frequency or time spent on SMU activities, while SMU problems are characterized by symptoms of addiction to social media, for example, loss of control over SMU (Griffiths, Kuss, & Demetrovics, 2014). SMU intensity is correlated with SMU problems with a small to moderate effect size (Frost & Rickwood, 2017; Parry, Davidson, Sewall, Fisher, & Quintana, 2020). Longitudinal research using the same data as the present study shows that although many adolescents with SMU problems report high SMU intensity, most adolescents show high SMU intensity without any SMU problems and that some adolescents who report SMU problems do not show high SMU

intensity (Boer, Stevens, Finkenauer, & Van den Eijnden, 2021a). Rather than higher levels of SMU intensity, higher levels of SMU problems may be detrimental to adolescents' wellbeing (Primack et al., 2017; Van den Eijnden, Koning, Doornwaard, Van Gurp, & Ter Bogt, 2018). Adolescents engaging in high SMU intensity may be well able to regulate their SMU and to combine it with a healthy lifestyle. In contrast, when adolescents experience SMU problems, which means that SMU dominates their everyday life and impairs control over thoughts and behaviors, this may threaten their wellbeing. Given that SMU intensity and SMU problems are correlated, but could have differential associations with wellbeing, observed negative associations between SMU intensity and wellbeing may be driven by SMU problems.

Notwithstanding the previous reasoning, few studies included both indicators of SMU in their analyses. Previous longitudinal research using data from the present study showed that, when controlled for SMU problems, adolescents' overall SMU intensity did not predict changes in life satisfaction and depressive symptoms over time. Furthermore, SMU problems predicted decreases in life satisfaction and increases in depressive symptoms (Boer, Stevens, Finkenauer, De Looze, & Van den Eijnden, 2021b; Van den Eijnden et al., 2018). Also, in a cross-sectional study among adolescents from 29 countries, intensive communication on social media was not associated with life satisfaction, whereas problematic SMU was negatively associated with life satisfaction (Boer et al., 2020). A limitation of these studies is that they did not compare the association between SMU intensity and wellbeing with and without controlling for SMU problems. Hence, it remained unclear whether the association between SMU intensity and indicators of wellbeing was confounded by SMU problems. Research overcoming this limitation showed that adolescents' time spent on SMU was associated with depressive symptoms in a bivariate model, but this association disappeared when controlling for SMU problems (Shensa et al., 2017). Overall, the few studies including both SMU intensity and SMU problems suggest that SMU problems are negatively associated with wellbeing, while SMU intensity is not.

1.5. The association between SMU intensity and wellbeing depends on the level at which it is being analyzed

Alongside the abovementioned four more theoretical factors, the association between SMU intensity and wellbeing may also depend on methodological factors. Many studies on the association between SMU intensity and wellbeing, including review studies, rely on cross-sectional data (Odgers & Jensen, 2020; Orben, 2020). Cross-sectional data are more likely to reflect associations at the *between-person level* than at the *within-person level*. Between-person associations reveal whether adolescents who report higher SMU intensity report lower levels of wellbeing *relative to adolescents* who report lower SMU intensity. Longitudinal data allow for testing both within- and between person associations, although many longitudinal studies did not make this distinction (Coyne, Rogers, Zurcher, Stockdale, & Booth, 2020). Within-person associations reflect the processes occurring within the individual adolescent. These associations denote whether changes in SMU intensity *relative to one's individual average level* of SMU intensity are associated with changes in wellbeing relative to one's individual average level of wellbeing. It is not uncommon that within-person associations differ from between-person associations; not only in effect size, but also in direction (Dienlin & Johannes, 2020; Hamaker, 2012; Orben, 2020).

Several longitudinal studies showed small to moderate negative associations between the intensity of SMU activities and indicators of wellbeing (e.g., internalizing problems, life satisfaction) at the between-person level, while there were no or very small associations at the within-person level (Beeres, Andersson, Vossen, & Galanti, 2020; Coyne et al., 2020; Jensen et al., 2019; Orben, Dienlin, & Przybylski, 2019; Stavrova & Denissen, 2020). In two other longitudinal studies, adolescents' overall SMU intensity or text messaging was not associated with internalizing problems, depressive symptoms, and life satisfaction,

neither at the between-person nor at the within-person level (George et al., 2020; Schemer, Masur, Geiß, & Mu, 2020). In another longitudinal study, overall SMU intensity was positively related to depression and negatively to self-esteem, both at the between-person and within-person level, but effect sizes were not reported (Boers, Afzali, Newton, & Conrod, 2019). Thus, most studies that separate within-person from between-person variance show no or a negligible negative association at the within-person level, while the association at the between-person level is more inconsistent.

1.6. Current study

Findings on the association between SMU intensity and wellbeing are conflicting. Based on the existing literature, we identified five theoretical and methodological factors that may explain these inconsistencies. Translating these factors into research questions (RQs), the present study investigated:

- RQ1: Which type of SMU activity is negatively associated with adolescent wellbeing?
- RQ2: Is the association between SMU intensity and wellbeing non-linear?
- RQ3: (a) Does the association between SMU intensity and wellbeing differ across adolescents and if so, (b) can these differences be explained by adolescents' tendency to engage in upward social comparisons?
- RQ4: Is the negative association between SMU intensity and wellbeing confounded by SMU problems?
- RQ5: Does the negative association between SMU intensity and wellbeing occur at the within-person and/or between-person level?

These research questions have mostly been examined in isolation. Therefore, it remains unknown whether and how they affect the association between SMU intensity and wellbeing when being considered in concert. This is important to improve our understanding of possible SMU effects on adolescent wellbeing and to fuel specific directions for future research. To study our research questions, we used four waves of longitudinal data with yearly time intervals among Dutch secondary school adolescents ($n = 1419$). We examined adolescents' SMU intensity using self-reported SMU frequencies and wellbeing using self-reported life satisfaction. While the scientific discourse on SMU effects often focuses on a dichotomy between active and passive SMU activities, the present study distinguished six SMU activities that ranged from more active (e. g., posting messages on SNS) to more passive (e.g., viewing messages on SNS).

2. Methods

2.1. Data

We used data from the Digital Youth (DiYo) project, which is a longitudinal survey with yearly time intervals among Dutch secondary school adolescents, conducted in 2015 until 2019 (Van den Eijnden et al., 2018). The survey assessed self-report internet-related behaviors and wellbeing. For the present study, we selected four waves of data from adolescents who were in 7th grade at time of the 2015 ($n = 1352$) or 2016 ($n = 998$) survey assessments. Adolescents who had repeated a class ($n = 46$) or who participated in less than two waves ($n = 885$) were excluded, which yielded an analysis sample of 1419 adolescents. The proportion of boys, pre-vocational educated adolescents, and adolescents with an immigrant background was higher among excluded adolescents than among included adolescents. However, these differences were very small (Cramer's $V < 0.109$). In addition, excluded adolescents reported lower life satisfaction at T1 until T3, higher SNS posting intensity at T1 and T2, higher SNS and IM viewing intensity at T1, lower levels of upward social comparison at T2, and more SMU problems at T1

until T3, as compared to included adolescents. Again, these differences were small (Cohen's *D* range = 0.151 to 0.368).

Adolescents in the analysis sample (*n* = 1419) were on average 12.51 years at T1 (*SD* = 0.60), 45.95% was female, and 21.86% had an immigrant background. In the Dutch education system, adolescents are enrolled in different educational levels from 12 years onwards (i.e., when transitioning to secondary school), namely pre-vocational, inter-mediate, and pre-university level (57.79%, 28.54%, and 13.67%, respectively in the present study). The distributions of female adoles-cents and adolescents with an immigrant background in our study were approximately similar to the distributions in the 13- to 16-year-old population in the Netherlands in 2018/2019 (Central Bureau for Sta-tistics, 2021). Adolescents enrolled in the pre-vocational educational level were slightly overrepresented (57.79% vs. 49.42%) and adoles-cents enrolled in the pre-university educational level were slightly un-derrepresented (13.67% vs. 20.62%) in our study (Central Bureau for Statistics, 2021).

In T1, 44.89% of the analysis sample did not participate. In T2, this was 6.48%, in T3 24.10% and in T4 65.12%. Dropout in T1 was due to the fact that adolescents who entered the study after T1 were also included in the sample. The high dropout rate in T4 was mainly due to dropout of entire pre-vocational schools, school years, and school clas-ses, for example because the survey assessment could not be scheduled due to practical constraints. Hence, the dropout was not related to in-dividual selection.

Parents of participating adolescents were provided with the oppor-tunity to refuse participation of their child. Adolescents were informed that their participation was anonymous and voluntary, and that they could withdraw their participation at any time. The survey assessment took place in the classroom setting through digital self-completion under supervision of research assistants. The assessments were carried out in accordance with the Declaration of Helsinki and approved by the board of ethics of Utrecht University (FETC16-076 Eijnden).

2.2. Measures

Life satisfaction. Life satisfaction was measured using the 7-item Student's Life Satisfaction Scale (Huebner, 1991). Respondents were asked about their thoughts around their own life, for example: 'My life is going well' and 'I have what I want in life'. Response options ranged from (1) *strongly disagree* to (6) *strongly agree*. A mean score was computed that denoted adolescents' life satisfaction. Cronbach's alpha was 0.83.

SMU intensity. We distinguished four SNS and two IM activities, each measured with one item (Van den Eijnden et al., 2018). SNS in-tensity was indicated by *SNS viewing* ('How many times *per day* do you view social network sites?'), *SNS posting* ('How many times *per week* do you post a message, photo, or video on social network sites?'), *SNS liking* ('How many times *per week* do you 'like' messages, photos, or videos of others on social network sites?'), and *SNS responding* ('How many times *per week* do you respond to messages, photos, or videos on social network sites?'). Response options ranged from (1) *never or less than once* to (7) *more than 40 times*. The questionnaire presented examples of SNS including 'Facebook, Twitter, Instagram, Google+, or Pinterest, but not WhatsApp or SnapChat'. Regarding IM intensity, we assessed *IM viewing* ('How many times *per day* do you check your smartphone to see whether you have received a message?'), and *IM sending* ('How many times *per day* do you send a message, photo or video via your smartphone?'). Response options ranged from (1) *never or less than once* to (7) *more than 80 times*. The questionnaire presented examples of IM, including 'WhatsApp, Chat, SnapChat, or SMS'. SNS posting was considered the most *active SMU activity*, followed by IM sending, SNS responding, and SNS liking. This is because SNS posting involves self-broadcasting messages, photos, or videos to a large public audience. IM sending in-volves sending personalized messages, photos, or videos to specific persons or private groups. SNS responding typically involves brief

responses to other people's posts. SNS liking includes one-click feedback on other people's posts or responses. SNS viewing was considered the most *passive SMU activity*, followed by IM viewing. This is because SNS viewing involves browsing other people's posts or reading news feed, whereas IM viewing has a more social component because it involves reading received personalized messages.

Social comparison. Social comparison was measured using a newly developed 5-item scale on social comparison during SMU. Specifically, the scale examined *upward social comparison* during SMU, because up-ward comparisons are regarded to elicit greater sensitivity to SMU ef-fects than downward or general comparison behaviors (Verduyn et al., 2020). Respondents were asked 'How often do you have the following thoughts when viewing your peers' messages, photos, and videos on social network sites?', followed by: '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 than me', 'He or she received more 'likes' than me', and 'He or she looks better than I do', with responses ranging from (1) *never* to (5) *very often.* Cronbach's alpha was 0.88.

Controls. We controlled for SMU problems, gender, educational level, and immigrant background. We used the 9-item Social Media Disorder Scale to assess adolescents' *SMU problems* (Boer, Stevens, Fin-kenauer, Koning, & Van den Eijnden, 2021c; Van den Eijnden, Lem-mens, & Valkenburg, 2016). The items correspond to the nine criteria for internet gaming disorder as established in the appendix of the Diagnostic and Statistical Manual of Mental Disorders, including preoccupation, tolerance, withdrawal, persistence, displacement, problems, deception, escape, and conflict (American Psychiatric Association, 2013; Lemmens, Valkenburg, & Gentile, 2015). Respondents were asked: 'During the past year, have you (…)', followed by, for example, 'often felt bad when you could not use social media?' (withdrawal). Response options were (1) *yes* and (0) *no*. A sum-score was computed that denoted adolescents' number of present criteria. As appropriate for dichotomous items, in-ternal consistency was calculated using the tetrachoric correlation ma-trix (Gadermann, Guhn, Zumbo, & Columbia, 2012), which yielded an alpha of 0.85.

Respondents' *gender* was measured by asking whether they were (0) *boy* or (1) *girl*. Also, adolescents reported their *educational level:* (1) *pre-vocational*, (2) *intermediate*, or (3) *pre-university*. Adolescents' educa-tional level was defined as their most recent reported educational level. *Immigrant background* was determined based the reported country of origin of the parents.

Table 1 shows the descriptive statistics of all study variables.

Table 1
Descriptive statistics.

	Mean/ proportion	SD	Min.	Max.	*n*
Time variant variables					
Life satisfaction	4.664	0.842	1	6	5676
SNS viewing	4.190	1.675	1	7	5676
SNS posting	1.980	1.457	1	7	5676
SNS liking	4.950	2.089	1	7	5676
SNS responding	3.450	1.925	1	7	5676
IM viewing	4.454	1.575	1	7	5676
IM sending	4.259	1.732	1	7	5676
Upward social comparison	1.841	0.815	1	5	5676
SMU problems	1.186	1.519	0	9	5676
Time invariant variables					
Girl	0.459		0	1	1419
Pre-vocational education	0.578		0	1	1419
Immigrant background	0.219		0	1	1419

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; *SD* = standard deviation; Min. = minimum; Max. = maximum; *n* = sample size.

2.3. Analytical approach

Missing data. Missing data ranged between 6.55% (SMU intensity T2) and 67.94% (upward social comparison T4). Little's Chi-square test for missing data showed that the data were not completely missing at random ($\chi^2(2564) = 3073.68$, $p < 0.001$). To overcome potential bias that is often associated with listwise deletion of respondents when data are not missing completely at random, missing data were imputed using multiple imputation by chained equations using Stata 13.0 (Royston & White, 2011; StataCorp, 2013). Particularly, missing data were imputed based on available data on the study variables in other waves with the data in 'wide format' ($n = 1419$). Multiple imputation is considered to reduce potential bias related to missing data even when the percentage of missing data is very high (Madley-Dowd, Hughes, Tilling, & Heron, 2019). We conducted five imputations, which were based on predictive mean matching using the five nearest observations. As such, all 1419 respondents were retained for the analyses.

Data organization. After imputation, data were restructured into 'long format'. That is, observations reflected repeated measures (i.e., level 1, within-person level: $n = 5676$), which were nested in adolescents (i.e., level 2, between-person level: $n = 1419$). Subsequently, to examine SMU activities and SMU problems and their associations with life satisfaction on both levels, we computed adolescents' person-specific means of SMU activities and SMU problems based on their respective repeated measures. Also, we computed adolescents' person-specific means of upward social comparison to test whether these means explained potential individual differences in the within-person associations between SMU activities and life satisfaction. Subsequently, the repeated measures of adolescents' SMU activities and SMU problems were centered using their computed person-specific mean (Wang & Maxwell, 2015). Due to this centering, associations on the first level denote, for example, whether changes in SNS viewing intensity relative to one's average SNS viewing intensity were associated with changes in life satisfaction relative to one's average life satisfaction. The continuous time-invariant predictors (i.e., average SNS viewing) and the moderator (i.e., upward social comparison) were centered using the grand mean. Associations on the second level reflect, for example, whether adolescents with higher means in SNS viewing intensity reported higher means in life satisfaction than adolescents with lower means in SNS viewing intensity.

Modelling. Next, the data were exported to Mplus 8.6 (Muthén & Muthén, 2017) to conduct a series of multilevel models. First, fixed effects models were conducted to test the associations between the six different SMU activities and life satisfaction. Specifically, we estimated the within-person and between-person associations between adolescents' intensity of SMU activities and their life satisfaction, for each SMU activity separately (M1a-f). In these models, the within-person associations were constrained to be equal across adolescents. The models included 'wave' as a level-1 control variable to account for common time trends (Hox, 2010a; Wang & Maxwell, 2015). Also, we included gender, educational level, and immigrant background as level-2 control variables. This first series of models are referred to as the baseline models. To test whether the associations were confounded by SMU problems, we subsequently extended the baseline models with SMU problems as additional level-1 and level-2 control variable (M2a-f). In the next step, we extended the baseline models with quadratic terms for the SMU activities on both levels (M3a-f). Thereafter, we extended the quadratic models with SMU problems as additional control variable on both levels (M4a-f).

Further, we extended the baseline models with random slopes for the within-person associations between the six SMU activities and life satisfaction (M5a-f). As recommended for multilevel modeling, a covariance between the random slope and random intercept was specified (Hox, 2010c). When adding the random parameters significantly improved model fit, this indicated that the respective within-person association varied across adolescents. Model fit was evaluated based on the *deviance*, where lower values indicated better model fit. The difference in deviance was evaluated using a chi-square difference test, with a corrected *p*-value as appropriate for testing slope variance (Hox, 2010b; Stoel, Garre, Dolan, & Van den Wittenboer, 2006). Also, lower *Akaike Information Criterion* (AIC) and *Bayesian Information Criterion* (BIC) values indicated better model fit (Hox, 2010b). In addition, *95% prediction intervals* (PIs) were computed, which express the estimated range of the associations across adolescents (Hox, 2010c). Subsequently, these random effects models were extended with SMU problems as additional control variable on both levels (M6a-f). Continuing on the random effects models, we examined whether the variances of the within-person associations between the six SMU activities and life satisfaction were explained by adolescents' average level of upward social comparisons (M7a-f), after which we extended these models with SMU problems (M8a-f). All models were run and read with the *MplusAutomation*-package in RStudio 1.4.1106 (Hallquist & Wiley, 2018; RStudio Team, 2021).

To interpret effect sizes, coefficients in the fixed effects models (M1-4) were STDYX-standardized, whereby 0.1 denoted a small effect, 0.3 moderate, and 0.5 large (Cohen, 1988). All models were estimated using Maximum Likelihood estimation. Codes for all data handling, imputation of missing data, and analyses are publicly available at https://osf.io/3fn2s/.

3. Results

3.1. Bivariate associations

The intra class correlations of the study variables ranged from 0.195 (SNS posting) to 0.453 (IM viewing). This means that 54.7 to 81.5 percent of the variance of the study variables was related to changes over time, which is considered substantial. Table 2 shows the correlations between the study variables. At the within-person level (level 1), adolescents' life satisfaction decreased over time, with an almost moderate effect size. The more active SMU activities showed different changes over time: While the intensity of SNS responding and SNS liking increased over time with (very) small effect size, SNS posting decreased over time with small effect size, and IM sending did not change over time. The intensity of more passive SMU activities, namely SNS and IM viewing, increased over time with moderate and small effect sizes, respectively. In addition, increased intensity of all SMU activities, except for SNS posting, were associated with decreased life satisfaction, but with very small effect sizes. Increased SMU problems were associated with decreased life satisfaction and increased intensity of all SMU activities except for SNS posting, with small to moderate effect sizes.

At the between-person level (level 2), the higher adolescents' average intensity of more passive SMU activities (i.e., SNS and IM viewing) and IM sending, the lower was their average level of life satisfaction, although effect sizes were small. The higher the adolescents' average level of upward social comparison, the lower was their average level of life satisfaction, with a large effect size. There was a moderate to large negative correlation between adolescents' average level of SMU problems and life satisfaction. For all six SMU activities except for SNS posting, higher average SMU intensity was associated with higher averages in upward social comparison, with small to moderate effect sizes.

Girls reported lower averages in life satisfaction than boys. For all six SMU activities except for SNS posting, girls reported higher average SMU intensity than boys. Also, girls reported higher average levels of upward social comparison than boys. Except for SNS liking, adolescents attending pre-vocational education reported higher intensity of all SMU activities than adolescents attending intermediate or pre-university education. Adolescents attending pre-vocational education reported lower average levels of upward social comparison than adolescents attending other educational tracks. Adolescents with an immigrant background reported lower average intensity of SNS liking and IM sending than

Table 2

Bivariate associations.

Level 1, within-person level (n = 1419)	Life satisfaction		SNS viewing		SNS posting		SNS liking		SNS responding		IM viewing		IM sending		Wave	
	r	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*
SNS viewing	−0.08***	0.02														
SNS posting	0.03	0.02	0.16***	0.03												
SNS liking	−0.05*	0.02	0.43***	0.02	0.07***	0.02										
SNS responding	−0.06*	0.03	0.40***	0.03	0.22***	0.02	0.46***	0.03								
IM viewing	−0.06**	0.02	0.45***	0.02	0.08***	0.02	0.33***	0.02	0.30***	0.02						
IM sending	−0.06**	0.02	0.31***	0.02	0.11***	0.03	0.28***	0.02	0.30***	0.03	0.54***	0.02				
Wave	−0.26***	0.03	0.29***	0.03	−0.18***	0.03	0.14***	0.04	0.08*	0.04	0.17***	0.02	0.06	0.03		
SMU problems	−0.17***	0.01	0.14***	0.03	0.04	0.03	0.10***	0.02	0.13***	0.02	0.19***	0.02	0.15***	0.03	0.02	0.03

Level 2, between-person level (*n* = 5676)	Life satisfaction		SNS viewing		SNS posting		SNS liking		SNS responding		IM viewing		IM sending		Upward social comparison		SMU problems	
	r	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*	*r*	*SE*
SNS viewing	−0.10*	0.04																
SNS posting	−0.07	0.05	0.41***	0.05														
SNS liking	−0.06	0.04	0.69***	0.01	0.25***	0.04												
SNS responding	−0.06	0.04	0.69***	0.02	0.43***	0.04	0.69***	0.02										
IM viewing	−0.11**	0.03	0.73***	0.02	0.38***	0.04	0.62***	0.02	0.60***	0.02								
IM sending	−0.10**	0.03	0.63***	0.02	0.31***	0.03	0.56***	0.03	0.59***	0.02	0.76***	0.01						
Upward social comparison	−0.49***	0.03	0.19***	0.03	0.06	0.04	0.23***	0.03	0.22***	0.03	0.21***	0.03	0.20***	0.03				
SMU problems	−0.39***	0.03	0.35***	0.04	0.27***	0.03	0.24***	0.03	0.28***	0.04	0.37***	0.03	0.30***	0.03	0.42***	0.03		
	β	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*	*β*	*SE*
Girl	−0.11*	0.05	0.15***	0.04	−0.01	0.04	0.21***	0.04	0.33***	0.04	0.10*	0.04	0.14**	0.04	0.27***	0.04	0.06	0.04
Pre-vocational education	−0.01	0.05	0.19***	0.04	0.22***	0.04	0.05	0.04	0.16***	0.04	0.12**	0.04	0.08*	0.04	−0.10*	0.04	0.15***	0.04
Immigrant background	0.02	0.10	0.08	0.06	0.10	0.06	−0.12*	0.06	0.01	0.06	−0.11	0.06	−0.13*	0.06	−0.03	0.06	0.05	0.06

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; Level 1 = yearly measurements; Level 2 = adolescents; *r* = correlation (0.1 = small, 0.3 = moderate, 0.5 = large effect); *SE* = standard error; *β* = STDY-standardized coefficient (0.2 = small, 0.5 = moderate, 0.8 = large effect). *** p <0.001; **<0.01; *p <0.05.

adolescents without an immigrant background.

3.2. Associations between SMU intensity and life satisfaction

Table 3 shows the summary of the results from the baseline fixed effects models (see Table S1 from the Supplementary Material for all model estimates). At the within-person level, for none of the SMU activities, changes in adolescents' SMU intensity were associated with changes in their life satisfaction, regardless of whether we controlled for SMU problems. At the between-person level, high averages in more passive SMU activities, namely SNS viewing and IM viewing, were associated with lower averages in life satisfaction, but with small effect sizes (M1a,e: $\beta = -0.084$; $\beta = -0.106$, respectively). Also, the higher adolescents' average level of IM sending, the lower their level of life satisfaction (M1f: $\beta = -0.087$). Hence, the negative association between SMU intensity and wellbeing was not specific to either more passive or active SMU (**RQ1**). Furthermore, the negative associations were only observed at the between-person level (**RQ5**). However, when controlled for SMU problems, these between-person associations disappeared (M2a,e,f). These results suggest that the observed negative associations were confounded by SMU problems (**RQ4**). In addition, a sensitivity analysis was conducted where all SMU activities were simultaneously included in one model, while controlling for SMU problems. Also in this model, on both levels, no associations between any of the SMU activities and life satisfaction were found.

3.3. Curvilinear associations between SMU intensity and life satisfaction

Table 4 shows the summary of the fixed effects models extended with quadratic effects (see Table S2 from the Supplementary Material for all model estimates). Results showed that neither at the within-person nor at the between-person level quadratic effects were significant, regardless of whether we controlled for SMU problems (M3a-f, M4a-f). For the within-person level, this means that in years when adolescents showed very low or very high SMU intensity relative to their individual average, adolescents reported equal levels of life satisfaction as in years when their SMU intensity was around their individual average. At the between-person level, it means that adolescents who showed much less or much more SMU intensity than other adolescents, reported equally high levels of life satisfaction as adolescents who showed moderate SMU intensity. Hence, no curvilinear associations between any of the SMU activities and life satisfaction were found (**RQ2**).

3.4. Individual differences in the associations between SMU intensity and life satisfaction

Individual differences. Table 5 summarizes the results of the random effect models, which allowed the within-person associations between the SMU activities and life satisfaction to vary across adolescents (see Table S3 from the Supplementary Material for all model estimates). The models with random slopes improved model fit, because they showed a significant decrease in the deviance relative to the baseline fixed effects models (M5a-f: deviance $p_{range} = < 0.001$ to 0.009). Correspondingly, in all models, the AIC decreased (M5a-f AIC$_{range} = -16.9$ to -4.6). In contrast, the BIC increased for two models (M5a,b: BIC = 6.8 and 8.7), suggesting that for these models the random slopes deteriorated model fit. However, given that for all models the majority of the indices, if not all, showed significant slope variance, the findings suggest that the within-person associations between all six SMU activities and life satisfaction varied across adolescents. Furthermore, the 95% PIs suggest that in all models, the associations ranged from moderate negative to moderate positive associations (M5a-f: LL-$\beta_{range} = -0.361$ to -0.271; UL-$\beta_{range} = 0.231$ to 0.314), which is considered substantial. This means that for some adolescents, increased intensity of a SMU activity was associated with decreased life satisfaction, whereas for others, increased intensity of a SMU activity was associated with increased life satisfaction (**RQ3a**). When controlled for SMU problems, the variances in the associations decreased somewhat (M6a-f). However, most of the fit indices indicated that there were still significant variances in the within-person associations between the SMU activities and life satisfaction.

Differences by upward social comparison. Table 6 shows whether the observed variation in the within-person associations could be explained by adolescents' average level of upward social comparison (see Table S4 from the Supplementary Material for all model estimates). All models showed that the higher the average level of upward social comparison, the lower was the average level of life satisfaction. A moderating effect of the average level of upward social comparison on the association between one of the indicators of SMU intensity and life satisfaction was found: Among adolescents who reported lower averages in upward social comparison, increases in SNS liking were associated with increases in life satisfaction, whereas among adolescents with higher averages in upward social comparison, increases in SNS liking were associated with decreases in life satisfaction (M7c: $B_{SNS\ liking} = -0.030*$upward social comparison). This moderating effect was also found when controlling for SMU problems (M8c). However, the variance of the slope of SNS liking was not reduced by this moderation (M5/6c

Table 3
Summary results of fixed effects models, life satisfaction.

		Not controlled for SMU problems (M1)				Controlled for SMU problems (M2)			
Level 1 ($n = 1419$)	**Model**	***B***	***SE***	***p***	***β***	***B***	***SE***	***p***	***β***
SNS viewing	a	−0.003	0.011	0.807	−0.005	0.012	0.013	0.356	0.020
SNS posting	b	−0.012	0.008	0.136	−0.021	−0.008	0.009	0.356	−0.014
SNS liking	c	−0.005	0.007	0.499	−0.010	0.003	0.007	0.658	0.006
SNS responding	d	−0.022	0.012	0.062	−0.044	−0.011	0.013	0.364	−0.023
IM viewing	e	−0.013	0.011	0.247	−0.021	0.007	0.011	0.552	0.011
IM sending	f	−0.025	0.012	0.046	−0.043	−0.011	0.013	0.385	−0.019
Level 2 ($n = 5676$)	**Model**	***B***	***SE***	***p***	***β***	***B***	***SE***	***p***	***β***
SNS viewing	a	−0.036*	0.018	0.048	−0.084	0.022	0.017	0.192	0.051
SNS posting	b	−0.040	0.026	0.127	−0.069	0.017	0.029	0.554	0.029
SNS liking	c	−0.015	0.013	0.258	−0.044	0.016	0.014	0.238	0.048
SNS responding	d	−0.013	0.016	0.420	−0.035	0.027	0.016	0.080	0.072
IM viewing	e	−0.046**	0.015	0.002	−0.106	0.016	0.016	0.299	0.037
IM sending	f	−0.036**	0.013	0.008	−0.087	0.012	0.014	0.409	0.029

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; Level 1 = yearly measurements; Level 2 = adolescents; B = unstandardized coefficient; SE = standard error, p = p-value; $β$ = STDYX-standardized coefficient. Variables with the same letter (a-f) were included in the same model. Models 1a-f were controlled by wave (level 1) and gender, educational level, and immigrant background (level 2). Models 2a-f extended model 1a-f with SMU problems as additional control variable on the first and second level. ***$p < 0.001$; ** < 0.01; *$p < 0.05$.

Table 4
Summary results of fixed effects models with quadratic effects, life satisfaction.

		Not controlled for SMU problems (M3)				Controlled for SMU problems (M4)			
Level 1 (n = 1419)	**Model**	**B**	**SE**	**p**	**β**	**B**	**SE**	**p**	**β**
SNS viewing	a	−0.002	0.011	0.849	−0.004	0.012	0.013	0.334	0.021
SNS viewing$^{\sim2}$	a	0.010	0.008	0.209	0.028	0.010	0.007	0.188	0.027
SNS posting	b	−0.022	0.011	0.050	−0.038	−0.016	0.012	0.177	−0.028
SNS posting$^{\sim2}$	b	0.010	0.007	0.140	0.040	0.009	0.007	0.238	0.034
SNS liking	c	−0.004	0.007	0.574	−0.008	0.004	0.007	0.588	0.008
SNS liking$^{\sim2}$	c	0.002	0.005	0.755	0.007	0.002	0.005	0.693	0.008
SNS responding	d	−0.022	0.012	0.062	−0.045	−0.012	0.013	0.352	−0.025
SNS responding$^{\sim2}$	d	0.008	0.006	0.201	0.030	0.008	0.005	0.159	0.029
IM viewing	e	−0.014	0.012	0.231	−0.021	0.006	0.012	0.584	0.010
IM viewing$^{\sim2}$	e	−0.009	0.007	0.205	−0.021	−0.006	0.007	0.393	−0.014
IM sending	f	−0.024*	0.012	0.049	−0.043	−0.010	0.013	0.408	−0.018
IM sending$^{\sim2}$	f	0.005	0.009	0.608	0.014	0.006	0.009	0.481	0.020
Level 2 (n = 5676)	**Model**	**B**	**SE**	**p**	**β**	**B**	**SE**	**p**	**β**
SNS viewing	a	−0.038*	0.019	0.042	−0.089	0.021	0.017	0.222	0.049
SNS viewing$^{\sim2}$	a	−0.010	0.011	0.381	−0.035	−0.003	0.009	0.704	−0.012
SNS posting	b	−0.079*	0.032	0.014	−0.137	−0.001	0.033	0.972	−0.003
SNS posting$^{\sim2}$	b	0.021	0.019	0.268	0.063	0.006	0.018	0.750	0.017
SNS liking	c	−0.014	0.015	0.357	−0.042	0.018	0.015	0.226	0.053
SNS liking$^{\sim2}$	c	<0.001	0.007	0.976	0.001	0.001	0.006	0.859	0.007
SNS responding	d	−0.015	0.017	0.384	−0.038	0.027	0.016	0.088	0.072
SNS responding$^{\sim2}$	d	−0.003	0.008	0.693	−0.013	−0.008	0.009	0.384	−0.031
IM viewing	e	−0.047**	0.015	0.002	−0.107	0.018	0.016	0.261	0.042
IM viewing$^{\sim2}$	e	<0.001	0.012	0.996	<0.001	0.007	0.013	0.575	0.024
IM sending	f	−0.035**	0.013	0.009	−0.087	0.013	0.015	0.374	0.031
IM sending$^{\sim2}$	f	0.001	0.010	0.925	0.003	0.005	0.009	0.576	0.018

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; Level 1 = yearly measurements; Level 2 = adolescents; B = unstandardized coefficient; SE = standard error, p = p-value; β = STDYX-standardized coefficient. Variables with the same letter (a-f) were included in the same model. Models 3a-f were controlled by wave (level 1) and gender, educational level, and immigrant background (level 2). Models 4a-f extended model 3a-f with SMU problems as additional control variable on the first and second level. ***p < 0.001; ** < 0.01; *p < 0.05.

Table 5
Summary results of random effects models, within-person associations (level 1), life satisfaction.

		Model estimates				Model comparison[a]								
Not controlled for SMU problems	**Model**	**B**	**SE (B)**	**p**	**Var.**	**SE (Var.)**	**Δ Par.**	**Δ Deviance**	**Δ Deviance p[b]**	**Δ AIC**	**Δ BIC**	**LL-B**	**UL-B**	**LL-β**	**UL-β**
SNS viewing	5a	−0.002	0.012	0.865	0.008	0.004	2	−10.504**	0.003	−6.5	6.8	−0.172	0.168	−0.296	0.289
SNS posting	5b	−0.012	0.008	0.164	0.006	0.003	2	−8.568**	0.009	−4.6	8.7	−0.157	0.133	−0.271	0.231
SNS liking	5c	−0.004	0.007	0.602	0.005	0.003	2	−18.406***	<0.001	−14.4	−1.1	−0.145	0.137	−0.303	0.288
SNS responding	5d	−0.021	0.012	0.065	0.006	0.002	2	−17.342***	<0.001	−13.3	−0.1	−0.178	0.135	−0.361	0.275
IM viewing	5e	−0.011	0.011	0.324	0.012	0.004	2	−18.098***	<0.001	−14.1	−0.8	−0.226	0.203	−0.349	0.314
IM sending	5f	−0.024	0.012	0.052	0.007	0.004	2	−20.926***	<0.001	−16.9	−3.6	−0.182	0.135	−0.320	0.237
Controlled for SMU problems	**Model**	**B**	**SE (B)**	**p**	**Var.**	**SE (Var.)**	**Δ Par.**	**Δ Deviance**	**Δ Deviance p[b]**	**Δ AIC**	**Δ BIC**	**LL-B**	**UL-B**	**LL-β**	**UL-β**
SNS viewing	6a	0.012	0.013	0.344	0.006	0.004	2	−8.726**	0.008	−4.7	8.6	−0.140	0.165	−0.242	0.284
SNS posting	6b	−0.008	0.009	0.396	0.005	0.004	2	−8.914**	0.007	−4.9	8.4	−0.145	0.130	−0.253	0.226
SNS liking	6c	0.004	0.007	0.613	0.005	0.002	2	−15.502***	<0.001	−11.5	1.8	−0.133	0.140	−0.280	0.295
SNS responding	6d	−0.011	0.013	0.377	0.006	0.002	2	−13.024**	0.001	−9.0	4.3	−0.161	0.139	−0.328	0.283
IM viewing	6e	0.008	0.011	0.469	0.011	0.004	2	−15.822***	<0.001	−11.8	1.5	−0.198	0.215	−0.308	0.334
IM sending	6f	−0.011	0.012	0.393	0.005	0.003	2	−14.822***	<0.001	−10.8	2.5	−0.153	0.132	−0.271	0.233

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; B = unstandardized coefficient; SE = standard error, p = p-value; Δ = change relative to the baseline fixed effects models M1,2a-f; Var. = variance of the slope; Par. = Number of free parameters; Deviance = −2*loglikelihood; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; LL = 95% prediction interval lower limit; UL = 95% prediction interval upper limit; β = STDYX-standardized coefficient. Models 5a-f were controlled by wave (level 1) and gender, educational level, and immigrant background (level 2). Models 6a-f extended model 5a-f with SMU problems as additional control variable on the first and second level. All models included a covariance between the random slope and random intercept. ***p < 0.001; **<0.01; *p < 0.05.
[a] Models 5a-f were compared to Model 1a-f, respectively; Models 6a-f were compared to Models 2a-f, respectively.
[b] The p-value for the deviance was corrected to take into account the boundary of the slope variance parameter (Hox, 2010b; Stoel et al., 2006).

relative to M7/8c), which indicates that the explanatory power of upward social comparison in the variance of the association between SNS liking and life satisfaction is negligible. The associations between the other SMU activities and life satisfaction were not moderated by upward social comparison (M7/8a,b,d-f). Overall, we did not find (strong)

evidence that individual differences in the association between SMU intensity and wellbeing were explained by adolescents' tendency to engage in upward social comparisons (**RQ3b**).

Table 6
Summary results of random effects models with upward social comparison as moderator, life satisfaction.

	Model	Not controlled for SMU problems (M7)			Controlled for SMU problems (M8)		
Level 1 (n = 1419)		**B**	**SE**	**p**	**B**	**SE**	**p**
SNS viewing	a	−0.002	0.011	0.862	0.013	0.013	0.339
SNS posting	b	−0.012	0.008	0.159	−0.008	0.009	0.389
SNS liking	c	−0.005	0.007	0.509	0.003	0.007	0.709
SNS responding	d	−0.021	0.012	0.076	−0.011	0.013	0.403
IM viewing	e	−0.011	0.011	0.320	0.008	0.012	0.472
IM sending	f	−0.024	0.012	0.051	−0.011	0.013	0.388
Level 2 (n = 5676)	**Model**	**B**	**SE**	**p**	**B**	**SE**	**p**
SNS viewing	a	0.005	0.017	0.785	0.031*	0.016	0.046
SNS posting	b	−0.014	0.024	0.558	0.014	0.026	0.599
SNS liking	c	0.019	0.013	0.136	0.031*	0.013	0.021
SNS responding	d	0.023	0.016	0.139	0.040**	0.015	0.009
IM viewing	e	<0.001	0.015	0.992	0.028	0.015	0.059
IM sending	f	0.003	0.013	0.842	0.023	0.014	0.103
Cross-level interactions	**Model**	**B**	**SE**	**p**	**B**	**SE**	**p**
SNS viewing * upward social comparison	a	−0.006	0.019	0.745	0.002	0.018	0.926
SNS posting * upward social comparison	b	−0.013	0.015	0.377	−0.011	0.016	0.481
SNS liking * upward social comparison	c	−0.030*	0.013	0.025	−0.027*	0.013	0.035
SNS responding * upward social comparison	d	−0.025	0.019	0.185	−0.023	0.018	0.217
IM viewing * upward social comparison	e	−0.007	0.018	0.684	0.002	0.018	0.929
IM sending * upward social comparison	f	−0.024	0.017	0.153	−0.019	0.017	0.263

Notes: SNS = social network sites; IM = instant messengers; SMU = social media use; Level 1 = yearly measurements; Level 2 = adolescents; B = unstandardized coefficient; SE = standard error, p = p-value; Variables with the same letter (a-f) were included in the same model. Models 7a-f were controlled by wave (level 1) and gender, educational level, and immigrant background (level 2). Also the main effect of upward social comparison was included (level 2). Models 8a-f extended model 7a-f with SMU problems as additional control variable on the first and second level. All models included a covariance between the random slope and random intercept. ***$p < 0.001$; ** < 0.01; *$p < 0.05$.

3.5. Additional findings

Models 7 and 8 yielded additional findings. Table 6 shows that the previously found negative between-person association between more passive (i.e., SNS viewing, IM viewing) and more active (i.e., IM sending) SMU activities and life satisfaction were not observed anymore when controlling for upward social comparison (M7a,e,f). Furthermore, when we controlled for both upward social comparison and SMU problems at the between-person level, we observed positive between-person associations between one more passive (i.e., SNS viewing) and some more active (i.e., SNS liking, SNS responding) SMU activities (M8a,c,d) and life satisfaction. Thus, SMU problems and upward social comparison may together suppress positive between-person associations between some SMU activities and life satisfaction.

4. Discussion

The present study investigated the extent to which the association between SMU intensity and wellbeing is dependent on (1) the SMU activity adolescents engage in, (2) the (non)linearity of the association, (3) individual differences, (4) whether SMU problems are considered, and (5) the level of analyses. In doing so, we distinguished SMU activities ranging from more active (i.e., SNS posting, IM sending, SNS responding, SNS liking) to more passive (i.e., SNS viewing, IM viewing). Wellbeing was indicated by life satisfaction. At the within-person level, there was no average association between any of the SMU activities and life satisfaction, regardless of whether we controlled for SMU problems. However, the associations at the within-person level varied: For some adolescents, increases in SMU activities were associated with decreases in life satisfaction, whereas for others, increases in SMU activities were associated with increases in life satisfaction. In general, this variation could not be explained by adolescents' tendency to engage in upward social comparisons. At the between-person level, higher average intensity of some more passive activities (i.e., SNS and IM viewing) and one more active activity (i.e., IM sending) were associated with lower average life satisfaction with a small effect size. However, these

associations disappeared when controlling for adolescents' average level of SMU problems. In addition, for none of the SMU activities, evidence was found that the association between SMU intensity and life satisfaction was curvilinear.

Our findings highlight the importance of three factors for understanding the association between SMU activities and wellbeing in adolescence. First, answering the question whether the association between SMU intensity and wellbeing differs across adolescents (**RQ3a**), our findings showed that within-person effects of SMU intensity ranged from positive to negative across adolescents. This result is in line with experience sampling studies showing that for some adolescents, momentary increases in the intensity of SMU activities were associated with momentary decreases in wellbeing, but for others with increases or no changes in wellbeing (Beyens, Pouwels, Valkenburg, & Van Driel, 2020; Beyens, Pouwels, Van Driel et al., 2020). This study extends these findings as it revealed that also with annual assessments, associations between adolescents' intensity of SMU activities and life satisfaction varied across adolescents.

Second, answering the question whether a negative association between SMU intensity and wellbeing is driven by SMU problems (**RQ4**), our findings indicated that negative between-person associations between certain SMU activities and life satisfaction disappeared when controlling for SMU problems. These findings suggest that a negative association between SMU intensity and life satisfaction may be explained by the presence of SMU problems rather than by engagement in specific SMU activities. Therefore, negative associations between SMU intensity and wellbeing revealed in previous studies may have been driven by unobserved SMU problems (e.g., Kelly et al., 2018; Twenge et al., 2018). However, even after controlling for SMU problems, we found that the within-person associations between the SMU activities and life satisfaction ranged from negative to positive. Hence, for some adolescents, increases in SMU activities were associated with decreases in life satisfaction, which could not be attributed to increases in SMU problems.

Third, related to our question at which level a negative association between SMU intensity and wellbeing occurs (**RQ5**), we found no

average associations at the within-person level, while there were negative associations at the between-person level (although only when not controlling for SMU problems). This finding demonstrates that between-level associations do not necessarily reflect within-person dynamics, which was also found in earlier longitudinal studies (Beeres et al., 2020; Coyne et al., 2020; Orben et al., 2019). Conceptually, this finding suggests that the observed between-person association between higher SMU intensity and lower wellbeing was not a causal relation, as changes in SMU intensity were not related to changes in wellbeing within an adolescent.

Above all, some of the factors affecting the association between SMU intensity and life satisfaction need to be considered in concert when understanding this association. As noted above, SMU problems confound the association between certain SMU activities and life satisfaction, but only with regards to between-person associations.

We also examined which type of SMU activity could be detrimental to wellbeing (**RQ1**). At the within-person level, we found no average associations between any of the SMU activities and life satisfaction, which aligns with findings from experience sampling studies (Beyens, Pouwels, Van Driel et al., 2020; Jensen et al., 2019). At the between-person level, the observed negative associations between adolescents' intensity of engaging in SMU activities and life satisfaction were not specific to passive SMU activities, as proposed by researchers (Liu et al., 2019; Verduyn et al., 2017). In line with our findings, other studies also showed that adolescents' active as well as passive SMU activities were negatively correlated with their wellbeing at the between-person level (Beyens, Pouwels, Van Driel et al., 2020). Passive and active SMU activities are possibly difficult to disentangle, because adolescents often engage in such SMU activities simultaneously (Valkenburg, Van Driel, & Beyens, 2021). For example, responding to a message on an IM requires viewing that message first. Accordingly, our study showed very high correlations between IM sending and IM viewing at the between-person level. As such, their differential associations with wellbeing may be difficult to grasp, which may explain why in our study IM sending and IM viewing were both negatively related to life satisfaction. However, we stress that these negative associations disappeared when we controlled for SMU problems.

Based on the Goldilocks hypothesis (Przybylski & Weinstein, 2017), we also investigated whether the association between SMU intensity and wellbeing was nonlinear (**RQ2**), which was not confirmed in our study. Findings of the present study are thereby consistent with other longitudinal studies that did not find curvilinear associations (Houghton et al., 2018; Jensen et al., 2019). Curvilinear associations were mainly found in cross-sectional studies (Przybylski & Weinstein, 2017; Twenge et al., 2018), which could imply that the Goldilocks hypothesis applies to associations at the between-person level at one particular timepoint. Alternatively, earlier found curvilinear associations may have been country-specific. International research shows that the association between adolescents' SMU and wellbeing are susceptible to country-level factors, for example the extent to which social media are adopted among youth within society (Boer et al., 2020).

Further, we examined whether the association between adolescents' SMU intensity and wellbeing would depend on the tendency to engage in upward social comparisons (**RQ3b**). We found no evidence for this moderating effect, with one exception: Among adolescents reporting high levels of upward social comparison, increases in SNS liking were associated with decreases in life satisfaction, which supports the social comparison perspective (De Vries et al., 2018). Among adolescents reporting low levels of upward social comparison, increases in SNS liking were associated with increases in life satisfaction, which corresponds to the emotional contagion perspective (De Vries et al., 2018). However, the individual differences in the associations between SNS liking and life satisfaction were not reduced when upward social comparisons were considered. Also, this was the only moderating effect found out of the six SMU activities that were examined. Therefore, future studies are necessary to replicate our findings.

Our findings provide several implications for future research on the association between SMU intensity and adolescent wellbeing. Specifically, future longitudinal studies that acknowledge heterogeneity in effects, consider SMU problems, and distinguish between within-person and between-person effects would be promising. Research considering these three factors seems more informative than research aiming to disentangle the effects of different SMU activities or examining curvilinear associations. Furthermore, our findings illuminate why earlier studies on the link between SMU intensity and adolescent wellbeing are so inconsistent: Depending on whether researchers investigate specific groups of adolescents, control for SMU problems when examining SMU intensity, or study within-person or between-person associations, the link can range from positive to negative.

In addition, our findings can also inform those concerned with the wellbeing of adolescents, including parents and teachers. They suggest that most adolescents engaging in higher SMU intensity are not at risk for impairments in wellbeing, regardless of whether this concerns engaging in more active or more passive SMU activities. Higher SMU intensity may be considered as normative adolescent behavior that contributes to adolescents' individual development and daily interaction with peers (Granic, Morita, & Scholten, 2020; Valkenburg & Peter, 2011). Nevertheless, our findings imply that risks to wellbeing could arise when adolescents report SMU problems, indicated by symptoms of addiction (e.g., loss of control over SMU). Therefore, investing in the prevention, early detection, and treatment of problematic SMU may be warranted. Yet, our findings also showed that for a particular group of adolescents, increases in SMU intensity are indicative of decreased wellbeing. Research focusing on identifying the individual characteristics that make adolescents vulnerable to negative SMU effects could provide directions for targeted prevention or intervention programs.

Although we tested many ways in which adolescents' SMU and their wellbeing could be related, the association may be dependent on more factors that were not addressed in this study. First, it may depend on whom adolescents have contact with on social media. For example, longitudinal research on adults showed that receiving Facebook messages from close friends increased wellbeing, whereas receiving such messages from acquaintances did not change wellbeing (Burke & Kraut, 2016). Other research showed that adolescents who reported more Instagram use with close friends reported more friendship closeness than adolescents who showed less Instagram use with close friends (Pouwels, Valkenburg, Beyens, Van Driel, & Keijsers, 2021). This association was not observed with regards to Instagram use without close friends (Pouwels et al., 2021). Second, the association may depend on the wellbeing outcome being studied. Meta-analytic findings indicate that SMU intensity has different associations with self-esteem and social capital than with life satisfaction (Meier & Reinecke, 2020). Furthermore, research suggests that the association is different for positive indicators of wellbeing than for negative indicators, for example depression and negative affect (Huang, 2017; Wirtz, Tucker, Briggs, & Schoemann, 2020). Third, the association may be contingent on the social media platform used. More specifically, the use of highly visual social media, such as Instagram and Snapchat, may induce more impact than less visual social media, such as Facebook and Twitter. Highly visual social media are mainly focused on uploading visual content, including photos and videos, and allow users to edit this content in more appealing ways using filters (McCrory, Best, & Maddock, 2020). Exposure to modified idealized online portrayals may reinforce a negative body image, which, in turn, could undermine wellbeing (Marengo, Longobardi, Fabris, & Settanni, 2018).

4.1. Strengths and limitations

Using four waves of longitudinal data among secondary school adolescents and a systematic multilevel analytical approach, the present study examined five factors that possibly affect the association between SMU intensity and wellbeing. However, results of this study should be

interpreted while considering several limitations. The yearly time intervals of the data used in the present study only allowed for estimating long-term associations. Consequently, potential short-term effects of the intensity of SMU activities could not be captured. Yet, findings from studies on the association between different SMU activities and wellbeing using (multiple) daily assessments showed some comparable results. Often, these studies also observed no average within-person relation between passive and active SMU activities and wellbeing. Also, they showed that these within-person associations ranged from negative to positive across adolescents (Beyens, Pouwels, Valkenburg, & Van Driel, 2020; Beyens, Pouwels, Van Driel et al., 2020; Jensen et al., 2019). Additionally, self-report measures of adolescents' SMU intensity may not accurately represent actual use, because adolescents may over- or underestimate their use. Indeed, research showed a moderate correlation between self-report and tracked SMU (Parry et al., 2020). Research replicating our study using tracked data of SMU activities is warranted. In addition, the present analyses did not explore the direction of the associations between the intensity of SMU activities and life satisfaction. Studying directionality would require a different analytical approach (e. g., random intercept cross-lagged panel modelling), which cannot be adopted within the present multilevel framework. Although we examined life satisfaction as an outcome of higher SMU intensity, a reverse order may be plausible as well. A meta-analysis on the direction of the association supports our assumption, although it investigated the direction of the relation between screen time in general and depression symptoms (Tang, Werner-Seidler, Torok, Mackinnon, & Christensen, 2021). Finally, the data included considerable dropout of adolescents, which may have affected the quality of the data, especially in the final wave. However, this dropout was mostly not due to individual refusal (i. e., not due to selective dropout), but to classes and schools dropping out. Also, we aimed to limit any potential bias by imputing missing data based on available data at all waves (Madley-Dowd et al., 2019).

5. Conclusion

Findings from this study showed that at the within-person level, on average, changes in adolescents' intensity of engagement in SMU activities were not associated with changes in their wellbeing (i.e., life satisfaction). However, across adolescents, these within-person associations ranged from negative to positive, suggesting that SMU can be beneficial as well as harmful to wellbeing. At the between-person level, a higher intensity of some SMU activities was associated with lower wellbeing. However, these associations were small and disappeared when controlling for SMU problems. Thus, these negative associations were explained by SMU problems rather than by adolescents' SMU intensity. The results imply that considering individual differences, distinguishing SMU intensity from SMU problems, and disentangling within-from between-person effects are crucial for understanding the association between adolescents' SMU intensity and their wellbeing.

Credit author statement

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2021.107084.

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