Adolescents' Real-Time Social and Affective Experiences of Online and Face-to-Face Interactions

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Disclosures: All authors report no financial relationships with commercial interests.

Acknowledgements: The research leading to these results has received funding from a Research Foundation Flanders Odysseus grant to IMG (FWO G08416N) supporting RA, OJK and IMG. NH is also supported by a doctoral grant by the German scholarship foundation Cusanuswerk e.V. AL is supported by a PhD studentship from Research Foundation Flanders (FWO; 1104219N). OJK is currently supported by a Senior Postdoctoral Fellowship from Research Foundation Flanders (FWO 1257821N). MS is supported by a personal grant from the Swiss National Science Foundation (Grant number: PZ00P1_174206).

Abstract

Much disagreement exists surrounding the relationship between digital communication and adolescent well-being. Micro-level insight into the direct effect of online interaction on affective experiences in daily life is crucial to advancing this discussion. In this registered study, we used experience sampling in general-population adolescents (n = 1705) to examine different emotional and social experiences, at the moment they engage in online and face-to-face social interactions. Adolescents reported significantly less positive affect when alone compared to when interacting online (B(SE)=-.15(.04), p=.001), but significantly more positive affect (B(SE)=.12(.04), p<.001) and less negative affect (B(SE)=-.12(.03), p<.001) and loneliness (B(SE)=-.65(.05), p<.001) when interacting face-to-face compared to online. Exploratory moderator analyses do not support the hypothesis that those with more social support experience greater benefits from online interaction. This study uniquely highlights both the momentary affective benefits and potential disadvantages of online interaction, thereby bringing clarification and nuance to this highly contentious topic.

Introduction

In the modern day and age, we are constantly connected (Fowler & Christakis, 2011). Most people across the globe – and young people in particular – own smartphones (Anderson & Jiang, 2018; Taylor & Silver, 2019; Vanhaelewyn et al., 2020). As digital communication technologies have become increasingly integrated into our lives, voices have sprung up claiming their negative effects on teenagers' well-being. In conjunction, the body of research on this issue has grown, although with limited consensus so far. Recent reviews and meta-analyses suggest mixed findings, with either small positive and negative associations, or no associations between digital communication and well-being in adolescents (Best et al., 2014; Jensen et al., 2019; Odgers & Jensen, 2020; Orben, 2020).

This lack of consensus is driven by a substantial methodological heterogeneity, and an overrepresentation of low-quality, cross-sectional work (Orben & Przybylski, 2019a, 2019b). Many previous studies on the effects of technology use have assessed digital communication using retrospective self-report estimates of digital technology use (e.g., 'How many hours per week do you use digital communication technologies to interact with others?'). Such measures are, however, flawed, as they produce biased estimates of time spent on social media or the internet (Scharkow, 2016; Verbeij et al., 2021). Moreover, research employing retrospective measures provides limited information about the day-to-day mechanisms that are involved in digital communication.

To address this issue, an increasing number of studies have used Experience Sampling Methodology (ESM; Csikszentmihalyi & Larson, 1987; Myin-Germeys et al., 2018), also referred to as Ecological Momentary Assessment (EMA; Shiffman et al., 2008). ESM is an intensive longitudinal diary method, that can be used to examine the relationship between digital communication and well-being at a momentary level and assess how digital technology use in its naturalistic context relates to well-being around the time that it occurs (e.g., Berry et

al., 2018; Johannes et al., 2019; Kross et al., 2013). Many of these studies, however, have asked participants to report on their online activity either once at the end of a day (e.g., Gross, 2004; Jensen et al., 2019; Orben & Przybylski, 2019), multiple times daily since the previous momentary questionnaire (e.g., Reissmann et al., 2018), or within a preceding time period (Hall, 2017). To our knowledge, almost no studies have explicitly questioned participants about their online behavior at the time that it occurs (an exception is a study by Bayer et al., 2018 on *n* = 154 undergraduate students' Facebook use). Such a momentary focus would, however, be required to enable the assessment of the direct affective benefits or disadvantages of digital communication.

Researchers using ESM to study the associations between digital communication tools and well-being in both adolescent and adult samples have specifically focused on differential effects of non-interactive vs. interactive digital technology use (Clark et al., 2018). Non-interactive use of digital technology, such as scrolling on Facebook, seems to be negatively associated with momentary (affective) well-being (Aalbers et al., 2019; Verduyn et al., 2017). Conversely, evidence suggests that interactive use of digital technology is positively related to momentary well-being (Bayer et al., 2018; Lieberman & Schroeder, 2020; Liu et al., 2019; Orben, 2020). This potential beneficial relationship between online (interactive) behaviors and momentary well-being is most likely explained by increased feelings of connectedness (Best et al., 2014; Spies Shapiro & Margolin, 2014; Valkenburg & Peter, 2009). In addition to potential affective benefits of online communication, there is increasing evidence that when adolescents interact online, this may strengthen their social resources, which in turn can lead to increased well-being in the longer term (Domahidi, 2018). As the momentary benefit of social interaction may be different for emotional vs. social/connectedness outcomes (Bayer et al., 2018; Orben, 2020), it is useful to separate social from affective benefits here. It is not entirely clear however, to what extent the presumed underlying mechanism - that online interactions boost

connectedness, which increases well-being - is already apparent *at the moment of online interaction*.

At the same time, going online to communicate may be beneficial compared to being alone, but not necessarily when compared to interacting 'in real life' (Lieberman & Schroeder, 2020; Pea et al., 2012). Popular belief dictates that face-to-face interactions relate to more positive social outcomes compared to digital social interactions – although, again, this has not been systematically assessed at the moment of interaction. In addition, some empirical support exists for the idea that when people go online to communicate with others *while they are also with face-to-face company* (i.e., when there is a sort of 'double' social interaction happening), this may undermine connectedness to the face-to-face company (Brown et al., 2016; Dwyer et al., 2018; Kushlev & Heintzelman, 2014). What is unclear however, is whether such potential negative effects of double social interactions apply only to the social experience of the face-to-face company, or also to the experience of one's online company.

A further consideration is that although much of the extant research on the relationship between digital communication and momentary well-being suggests uniformity of digital communication effects across adolescents, the benefits or harms derived from digital communication may differ for different people (Spies Shapiro & Margolin, 2014). The 'rich-get-richer' hypothesis suggests that internet use predicts better (social) well-being outcomes for those with more social resources (Kraut et al., 2002). This hypothesis implies that people with relatively more social resources benefit most from internet use, as it provides them with more opportunities to connect with an existing strong social network. In contrast, the 'social compensation' (or 'poor-get-richer') hypothesis posits that people with fewer social resources may generally be more comfortable interacting online than face-to-face, and will therefore benefit most from digital communication (McKenna et al., 2002). However, within the context of these competing hypotheses, it is unclear what it means to be socially 'rich', as 'social

resources' have been defined differently across studies. Previous definitions have focused on both internal states (such as extraversion, social anxiety, or loneliness) (Kraut et al., 2002; McKenna et al., 2002), but also on external factors (such as the quality of friendships or social support) (Kraut et al., 2002; Selfhout et al., 2009). Moreover, to our knowledge, no published research has tested these competing hypotheses at the moment that people directly engage in different types of social interaction, despite these hypotheses referring to moment-level effects.

As previous work has largely neglected assessment of digital communication use and affective and social well-being at the momentary level, the direct affective and social correlates of digital communication are currently unclear. In this high-powered, registered study, we aim to test the experience of online interaction – as it is happening in the moment. To do this, we will use ESM to assess the affective/social differences between situations of online interaction vs. situations of non-interaction; and between online interaction vs. face-to-face interaction. Additionally, we will explore the momentary effects of simultaneously interacting online and face-to-face, as compared to singularly interacting online or face-to-face. Finally, we will test whether these within-person differences are moderated by social resources, and if so, in which direction – thereby testing the competing 'rich-get-richer' vs. 'social compensation' hypotheses. Since it is not clear what it means to be socially 'rich', we will investigate a number of moderating social resources: interpersonal skills, social support, the mean quality of daily face-to-face interactions, and the frequency of daily face-to-face interactions.

To this end, we will test the following confirmatory hypotheses:

H1: Online social interaction is related to higher levels of momentary affective well-being, compared to being alone and not interacting online;

H2: Compared to face-to-face interactions, online interactions are associated with higher levels of (a) affective well-being, and (b) social experience/connectedness.

And the following exploratory hypotheses:

H3: There is a general within-person difference in (a) affect, and (b) face-to-face /online social experience/connectedness when both interacting online AND face-to-face, compared to when only interacting face-to-face, or only interacting online;

H4: The within-person relationship in H1 is moderated by (a) the quantity of face-to-face interactions, (b) the mean quality of face-to-face interactions, (c) social support, and/or (d) interpersonal skills;

H5: The within-person relationships in H2 is moderated by (a) the quantity of face-to-face interactions, (b) the mean quality of face-to-face interactions, (c) social support, and/or (d) interpersonal skills.

Method

Participants

Between January 2018 and June 2019, a sample of N = 1913 adolescents was recruited as part of Wave 1 of the SIGMA study – a study aimed at elucidating the daily-life social and psychological processes associated with the development of psychopathology in adolescence (Kirtley et al., 2021). The full SIGMA study was approved by the local ethical committee (Ethics Committee Research UZ / KU Leuven S61395). A random sample of n = 100 participants was selected for the power analysis for the current study (see Power Analysis section below), and another 108 participants did not complete any ESM questionnaire. These participants were subsequently not included, thereby leaving a total sample of n = 1705 participants for the current analyses. For an overview of demographic information for this sample, see Table 1.

Participants within 22 cooperating secondary schools in the Flanders region of Belgium were informed about the study and invited to participate. When recruiting schools, we aimed to achieve diversity and representativeness in terms of geography, urbanicity, gender distribution,

non-Belgian cultural backgrounds, and school levels – and we largely succeeded in this aim (Kirtley et al., 2021). Participants were recruited from each of the five provinces in Flanders, and from both rural and urban areas. The SIGMA study has an accelerated longitudinal design (Galbraith et al., 2017), in which data from three cohorts of participants are collected within the same wave. In the sample, there is a deliberate overrepresentation of first-year students, as the main interest of the study was to investigate the developmental changes from early adolescence onwards. Apart from the ability to read and understand Dutch and understand the study's instructions, there were no specific inclusion criteria.

Procedure

Following an in-class information session, all participants and at least one parent or caregiver (for participants under 18) gave informed consent. Subsequently, participants completed a number of questionnaires that included the moderator variables for the present study (see Kirtley et al., 2021, for the full questionnaire battery) during an in-class testing session. At the end of the session, participants were instructed about the second part of the study involving the Experience Sampling Method (ESM; Csikszentmihalyi & Larson, 1987; Myin-Germeys et al., 2018). Each participant received a Motorola Moto E4 smartphone with the mobileQ application for ESM data collection (Meers et al., 2020). Participants were unable to access any settings/option on the smartphone (hereafter 'study device') other than the mobileQ application. Participants were instructed that for the next 6 days, they would receive ten prompts daily, at semi-random times between 7.30 AM and 10.30 PM. Prompts were distributed in blocks of 90 minutes with a minimum time window of 15 minutes between each consecutive prompt. As such, prompts were not too close together and roughly distributed throughout the day.

After prompts were sent out via the mobileQ app, participants had 90 seconds to respond to each prompt – after this period, the questionnaire would disappear. Once the questionnaire

was opened, participants again had 90 seconds to respond to each item – if they took longer for any item, the questionnaire would disappear. In the app, participants were able to modify whether they wanted the notifications to appear with a beeping sound, a vibration, or both a sound and vibration (they were unable to put the phone on 'silent' without turning off the phone completely). In order to minimize disruption from notifications during school hours, an equal random notification schedule for all participants within the same class room was set. Participants were asked to keep the study device with them and to answer as many prompts as possible, without endangering or overly disrupting their daily lives. Finally, researchers and participants went through the entire ESM questionnaire together, in order to clarify the meaning of each ESM item. For all ESM items used in this study, participants were instructed to answer items as referring to the *moment right before the study device notified them*. For example, participants were instructed that if they were annoyed by the ESM prompt, this should not affect their response to the item 'I feel irritated' (instead their irritation level should reflect the situation right before the prompt).

The incentive for participation was a 10-euro gift voucher. ESM compliance-based incentives were not used. Due to the large size of the study, and due to the fact that all data were stored locally and only uploaded after the measurement period, we were unable to personally contact or monitor participants during the ESM period. Participants could contact the researchers via e-mail or phone if they encountered any issues throughout the ESM period.

Measures

Experience Sampling Method

The full ESM questionnaire that participants received at every random prompt had a minimum of 41 and a maximum of 46 items. Survey length varied according to answers to conditionally branched items. See full ESM list on the OSF-page for this project (https://bit.ly/33dYEc2; also publicly available within the ESM Item Repository; Kirtley et al.,

2020). Mean questionnaire completion time was 162.8 seconds. Average compliance (defined as the mean proportion of prompts that were completed) for those participants who completed at least 1 ESM questionnaire was 42.3%. Although many previous ESM studies have set a minimum compliance rate for inclusion within their study, recent evidence suggests that this is not best practice, as potentially valuable data is omitted (Jacobson, 2020). Therefore, all complete ESM data was retained for the current study.

Independent Variable – Interaction Type. A momentary variable 'Interaction Type' was constructed based on three different ESM items: 'Face-to-face company' (i.e., 'Who am I with?', with ten non-mutually-exclusive possible answer options, of which nine are different types of company [e.g., 'Friend(s)'], and one is 'No one', to signify being alone); 'Face-to-face interaction' (follow-up question when people indicated to be in company of others 'We are doing something together', rated from 1 'Not at all' to 7 'Very much', where a score of 1 was considered no face-to-face interaction and a 2 or higher as a face-to-face interaction); and 'Online interaction' (i.e., 'I am virtually in contact with others', rated as 'Yes' or 'No').

The variable Interaction Type represented four situations relevant for the current analyses:

- 'No interaction' (reporting neither online nor face-to-face interaction);
- 'Online interaction only' (reporting no face-to-face company or interaction, but reporting online interaction);
- 'Face-to-face interaction only' (reporting face-to-face interaction, but no online interaction);
- 'Double interaction' (reporting both face-to-face interaction and online interaction);

Dependent Variables – Positive and Negative Affect. With each ESM prompt, participants were first presented with a number of affective items, phrased as 'I feel …' and rated from 1 'Not at all' to 7 'Very much'. From these variables, two outcome variables were constructed: Positive Affect (or PA; mean on items 'I feel cheerful', 'I feel satisfied', 'I feel relaxed'), and

Negative Affect (or NA; mean on items 'I feel irritated', 'I feel anxious', 'I feel insecure', and 'I feel sad'. Within-person reliability was ω_{within}= .65 for PA, and ω_{within}= .66 for NA; between-person reliability was $\omega_{between}$= .92 for PA, and $\omega_{between}$= .90 for NA. In addition to these PA and NA variables, responses to the item 'I feel lonely' were considered as a separate outcome variable of momentary loneliness.

Dependent Variable – Social Quality. When participants indicated being with any company, they were presented with three items inquiring about the quality of that current company: 'I feel at ease in this company', 'I feel appreciated by this company', and 'I feel like I belong', all rated on a scale from 1 'Not at all' to 7 'Very much'. Within-person reliability of these three items was ω_{within}= .86, and $\omega_{between}$= .92. Analogous items were presented when participants indicated being in online company: 'I feel at ease with the people that I am in virtual contact with', 'I feel appreciated by the people that I am in virtual contact with', and 'I feel like I belong with the people that I am in virtual contact with'. Reliability for these three items was ω_{within}= .84, and $\omega_{between}$= .92.

For each person, a 'Mean Social Quality (Face-to-Face)' variable, and a 'Mean Social Quality (Online)' variable was constructed, by taking the mean score on the three items inquiring about the quality of face-to-face and online company, respectively. For the analyses where online vs. face-to-face social quality scores are compared against each other within each person, these two variables were first combined into one variable 'Mean Social Quality (Online or Face-to-Face)'.

Moderator Variable – Mean Social Quantity. Based on the 'Face-to-Face Company' variable described above, a person-level 'Mean Social Quantity' variable was constructed. This variable refers to the quantity or proportion of face-to-face interactions in the ESM week, and was calculated by taking the proportion of time across all completed ESM prompts that any individual indicated being in the company of others.

Moderator Variable – Mean Social Quality. In order to get a person-level variable of the mean quality of face-to-face interaction, the mean score on the Mean Social Quality (Face-to-Face) variable was computed across all completed ESM prompts for that person.

Retrospective Questionnaires

Moderator Variable – Interpersonal Skills. An Interpersonal Skills score was calculated by taking the mean score on all 18 items of the 'Interpersonal Skills' subscale of the 'Vragenlijst Psychosociale Vaardigheden' (VPV; Scholte & Van der Ploeg, 2013). This subscale consists of the two subscales Relational Skills (e.g., 'I can get along well with different types of people'), and Affective Skills (e.g., 'I recognize in others how they feel or what they think'). All items were rated 1 'Completely disagree' to 5 'Completely agree'. The VPV also has two subscales on Self Guidance (e.g., 'I always do my best in school or at work') and Self Awareness (e.g., 'I think before I act'), together compiling an 18-item subscale of 'Intrapersonal Skills'. However, as these subscales largely target skills that are outside of what we consider 'social resources', these subscales were not used for the current study.

Moderator Variable – Social Support. A social support score is calculated by taking the mean score on all 12 items of the Social Support List-Interactions (SSL-I-12; van Donderen, 2012). The SSL-I-12 consists of three subscales: Daily support (e.g., 'How often does it happen that people show interest in you?'); Support with problems (e.g., 'How often does it happen that people give you good advice?'); and Appreciation (e.g., How often does it happen that people compliment you?'), and all items were scored from 1 'Rarely or never' to 4 'Very often'. Per the instruction manual, a maximum of four items were allowed to be missing for calculating the total score.

Power Analysis

For the current research questions, power was calculated for the confirmatory hypotheses pertaining to the difference in affect between being in online interaction vs. being

alone, and for online interaction vs. face-to-face interaction (i.e., H1 and H2). Given the unique nature of the current study, we had no indication of either the distribution of this variable, nor of its estimated effect size on affect. Therefore, we took a two-step approach for calculating the power (therein largely following Lafit et al., 2020), and registered this as such before looking at the data.

First, a n = 100 random subsample of participants from the full data set (= roughly the sample size of most previous ESM studies into the relationship between online behavior and well-being) was requested from the local data manager of the SIGMA study. Six participants of this n =100 had no ESM data and were subsequently excluded. In order to obtain estimates of the necessary effect sizes and model parameters, the confirmatory mixed effects analysis as outlined below was then conducted on this n = 94 sample.

Second, the model parameters and effect sizes of this analysis were used as input for 1000 Monte Carlo simulations of the data, with a sample size equal to the remainder of the data set (n = 1813). Of these simulations, the proportion of simulations where the null hypothesis – the effect size of interest being significantly different from zero – was rejected at p <.05 was taken as the power. As specified in the registration, we considered power exceeding .80 to be sufficient. However, since our estimates of the effect size were based on a subsample of 94 participants, we also accounted for the uncertainty around the parameters' estimates by performing sensitivity analysis and estimating power for the values in the upper and lower bound of the 95% confidence intervals of the estimated effects. The results of these simulation-based power analyses yielded power values of > .95 for all effects of interest, indicating sufficient power for our confirmatory hypotheses. R Markdown scripts detailing this power analysis can be found on the OSF-page for this study (https://bit.ly/33dYEc2).

Statistical Analysis

Confirmatory Analyses

For the confirmatory analyses pertaining to within-person differences between different types of online/face-to-face interaction vs. being alone (H1 and H2), mixed effects models with random intercepts were specified. Within these models, the time-varying categorical variable of 'Interaction Type' was a predictor at the momentary level, and the time-varying continuous affect variables were the momentary level outcomes (one model with PA as outcome; one with NA as outcome; one with loneliness as outcome). To assess the differential social qualities of online vs. face-to-face social interactions, a similar, separate analysis was specified with 'Mean Social Quality (Online or Face-to-Face)' as the outcome variable. For all analyses, the R package 'nlme' was used (version 3.1-150; Pinheiro et al., 2021).

The multilevel structure of the data means ESM prompts are nested within participants, nested within schools. However, since models did not converge when the school level was included, we followed our registered contingency plan for non-convergence and omitted the school level from further analyses. The errors were assumed to be Gaussian distributed and serially correlated. The serial correlation was modeled using an AR(1) process. Also, following non-convergence, different optimizers from the 'lmeControl'-function of the 'lmerTest'-package (version 3.1-3; Kuznetsova et al., 2017) were chosen for these analyses (as had been specified in the registration). As also specified in the registration, the fixed effects pertaining to the H1 and H2 were tested with two-tailed Wald tests, applying Holm's multiple comparisons correction (Holm, 1979), with an initial $\alpha = .05$, for deciding on the significance of results.

Exploratory Analyses

For the exploratory analyses focusing on situations where people indicate to be simultaneously interacting face-to-face and online (i.e., H3), additional analyses were performed. In these analyses, either 'Mean Social Quality (Face-to-Face)' was the dependent variable (in the comparison with situations where people are interacting face-to-face only) or

'Mean Social Quality (Online)' was the dependent variable (in the comparison with situations where people are interacting online only).

Open-Science Practices

All analyses of the current study were registered on the Open Science Framework (OSF) post-data collection using the template for registration of ESM studies (Kirtley, Lafit, et al., 2020). Registration happened post-data collection, but prior to data access (https://bit.ly/3vbLTuM), in line with what has been referred to as postregistration (Benning et al., 2019). All relevant code and materials have been made available online on the OSF-project for this study https://bit.ly/33dYEc2 (ESM items are also publicly available in the ESM Item Repository; (Kirtley, Hiekkaranta, et al., 2020). Moreover, we aimed to adhere as much as possible to reporting guidelines for ESM studies with adolescents (van Roekel et al., 2019).

Deviation from Registration: Moderator Analysis

In the registration for this study, we originally intended to perform a multiverse analysis (also referred to as specification curve analysis or SCA; Simonsohn et al., 2020; Steegen et al., 2016) for our moderator analyses (i.e., H4 and H5), to explore all possible equally justifiable combinations of analytic decisions and moderators. However, we later reconsidered this decision, based on arguments from a manuscript that was released following our registration (Del Giudice & Gangestad, 2021). The authors of this overview paper argued how multiverse analysis is inappropriate when, in fact, the different specifications that are selected are not all arbitrary and equally justifiable. For our moderator analysis, this was the case, and we therefore decided to instead only perform the twelve most comprehensive analyses.

These comprehensive models are mixed-effects models predicting each of three affect variables from the four moderator variables directly, and from the cross-level interaction effects of each moderator variable with the social interaction variable. The four moderating variables are deliberately not simultaneously entered in the models, as doing so would unnecessarily

reduce the explained variance of each moderator (Del Giudice & Gangestad, 2021). These analyses were conducted by adding the cross-level moderators of social support, interpersonal skills, quantity of face-to-face social interactions, and mean quality of face-to-face interactions to each of the mixed-effects models described in the previous section. Age and gender were also added as predictors of both the mean level of affect/loneliness, and as moderators of the relationship between interaction type and affect. We originally intended to include an AR(1) correlation structure as well, but since the models did not converge with this included, it was omitted from these moderator analyses. The interpretation of results of this moderator analysis will be done similarly to what was initially planned for the multiverse analysis, where the general pattern of effect sizes and p-values for the selected set of plausibly justifiable analytic decisions is explored.

Results

Descriptive statistics

Descriptive statistics of all included variables are presented in Table 1. Because missingness varied for different variables, the available sample size for every variable is also presented in Table 1. Of particular note is that, for each category of this variable, there are participants who did not endorse this category at any time during the ESM period. Notably, only 776 participants indicated being 'Online only' – the main category of interest, representing the situation where participants indicated being physically alone and interacting online - at least once during the ESM period. In a further investigation of potential differences between responders and non-responders to this category, we observed that the n = 776 participants who had responded 'Online only' at least once in the ESM week were, on average, older ($t(df)$=-10.13(1560.9), p<.001), more likely to be girls ($\chi(df)$=24.8(1), p<.001), and had completed more ESM questionnaires ($t(df)$==7.19(1689.4), p<.001) than the n = 929 participants who had never responded 'Online only'.

Confirmatory analyses

Being alone vs. interacting online (H1)

Participants reported significantly less PA when they were alone compared to when they were in online interaction only. We found no evidence for a significant difference in either NA or loneliness between being alone and interacting online. The results pertaining to the first research question are displayed in Table 2, and visualized in Figure 1.

Interacting face-to-face vs. interacting online (H2)

We also tested the affective differences between situations when participants were interacting face-to-face vs. when they were interacting online. The results displayed in Table 2 demonstrate how the average participant reported significantly more PA, less NA, and less loneliness in the moment that they were interacting face-to-face compared to the moment when they were interacting online (see Figure 1). However, in the comparison of the social quality scores (consisting of feeling appreciated, at ease, and belonging in online vs. face-to-face company), participants generally reported significantly *lower* quality of face-to-face interactions than of online interactions (*B(SE)* = -.19 (.05), p = <.001).

Exploratory Analyses

Double social interaction effects (H3)

Then, we explored differing affect levels when participants reported interacting with face-to-face and online company simultaneously. In contrast to our expectations, participants actually reported more PA (*B*(*SE*)= .27 (.04), p <. 001) and less loneliness (*B(SE*)= -.49 (.05), p < .001) when they engaged in such a 'double interaction', as compared to when they were only interacting online (see Figure 1, Table 2). Participants also generally reported more PA in such a 'double interaction' than when they were only interacting face-to-face, but they also reported more NA and more loneliness when they indicated interacting with both online and face-to-face company, as opposed to interacting with 'just' face-to-face company.

Finally, participants reported significantly higher face-to-face social interaction quality when they were in double interaction than when in face-to-face interaction only (*B(SE)* = .11(.02), *p* <.001). Conversely, participants reported a significantly lower online social interaction quality when they were in a double interaction than when they were in online interaction only (*B*(*SE*) = -.17(.05), *p* <.001).

Moderating effects of social resources (H4 & H5)

The potential roles of four social resource moderators on the affective differences between being alone and being in online interaction were assessed in an exploratory analysis, the results of which are presented in Table 3. For α = .05, one significant negative moderation effect arose: Social support moderated the difference in PA between being alone and interacting online. This means that those with higher levels of social support might experience a greater PA increase when interacting online (compared to being alone), than those with relatively lower levels of social support. However, the rest of the moderator analyses yielded no significant moderator effect of any social resource on any affective outcome.

Discussion

The current ESM study is unique both in its measurement of how adolescents feel while engaging in an online interaction, and in its direct comparison with how they feel in face-to-face interactions. Results indicate, on average, significant intra-individual affective differences when adolescents interact online vs. when they do not. What stands out primarily, is that PA levels are higher when interacting online vs. when alone, but lower when interacting online vs. face-to-face. Furthermore, moderator analyses yielded no strong support for either the 'rich-get-richer' or 'social compensation' hypothesis, where the affective benefit of online interaction differs depending on one's social resources. Exploratory analysis of how adolescents feel when simultaneously interacting both online and face-to-face yielded perhaps the most puzzling

result: participants actually indicated experiencing *more* positive affect, and a *higher* social quality of their face-to-face company than when they were interacting online or face-to-face only.

More Positive Affect When Interacting Online Than When Alone

Participants generally reported significantly more positive affect when they were interacting online than when they were not (interacting) with anyone. This association is in line with previous studies that reported positive associations between digital communication or (inter)active social media use and affective well-being (Liu et al., 2019; Verduyn et al., 2017). What the current results add to this literature, is first and foremost information on the *timing* of potential affective benefits. The slightly increased average levels of PA (of about 0.15 on a 1-7 scale) happen within the moment that adolescents interact online. As such, they may represent an immediate affective benefit derived from online social interaction.

This affective benefit may indicate the immediate appeal of interacting online, reflecting adolescents' (and humans') need for connectedness (Valkenburg & Peter, 2009, 2011). We are all social beings with a need to belong (Baumeister & Leary, 1995), and digital communication likely allows for fulfillment of that need, at least to some extent, and has the potential to enable social connectedness (Clark et al., 2018). This is also reflected in the finding that, on average, participants in the current study indicated feeling substantial levels of belongingness, being at ease, and appreciation from their online interaction partners within the moment of interaction. These micro-level associations may, in certain cases and for certain individuals, contribute to the more substantive long-term positive effects of online interaction that have been previously reported, such as increased self-esteem, perceived social support, or increased social capital (Best et al., 2014). However, results did not indicate that NA and loneliness levels differed when participants were alone vs. when they were interacting online. This suggests that while

online interactions may trigger some positive emotions, they may not necessarily alleviate negative emotions or loneliness.

Worse Affect but Higher Social Interaction Quality When Interacting Online Versus Face-To-Face

The current results also provide insight into the relative social and affective experiences when adolescents were interacting solely face-to-face vs. solely online. Could it be that digital communication brings comparable benefits to face-to-face interactions? It seems not. Participants reported higher PA, lower NA, and considerably lower loneliness levels, when interacting with face-to-face company compared to online company. A plausible interpretation is that physical presence of interaction partners makes a major difference to whether social interactions are experienced as beneficial. The advantages of face-to-face interactions over online communication have also been reported in previous between-person studies (e.g., Pea et al., 2012). At the same time, however, participants rated social interaction quality (i.e., how participants felt about their company, rather than how they felt in general) higher when interacting with online as opposed to face-to-face interaction partners. This may reflect that, compared to face-to-face interactions, online interaction allows for a higher degree of selectiveness (Lieberman & Schroeder, 2020), providing adolescents with more opportunity to decide to interact with people that make them feel at ease and appreciated. This can be in contrast to face-to-face interactions at home and school, where adolescents spend much time with company that they were unable to choose.

Some additional key differences between digital communication and face-to-face interaction have been described previously that may help explain the added affective benefit of face-to-face interactions over online interactions (Lieberman & Schroeder, 2020; Valkenburg & Peter, 2009). Although it varies across the specific platform and features that are used, online interactions generally involve fewer nonverbal cues – which may relate to the diminished

benefits derived from online interaction relative to face-to-face interaction. Perhaps most crucially, however, online interactions generally involve more asynchronicity, where there is a lag between the sending and receiving of information from your interaction partner. Recent behavioral conceptualizations of social interactions emphasize how it is the direct real-time reciprocity that makes an interpersonal encounter feel truly *interactive* (e.g., De Jaegher et al., 2010; Redcay & Schilbach, 2019) – and consequently, perhaps more enjoyable. This idea is also supported by the results of an ESM study, which indicated that college students experienced interactions on the mobile platform Snapchat as more enjoyable than other online interactions (Bayer et al., 2016). The explanation that the authors offered for this finding related to the ephemeral nature of Snapchat, where content is presented for a limited time only and cannot be viewed later. This more 'life-like' characteristic may therefore be crucial, and it would be interesting for future work to further disentangle which characteristics of online interactions relate to more enjoyable and/or more social experiences.

Mixed Results for Simultaneous Face-to-Face and Online Interactions

Based on previous studies (Brown et al., 2016; Dwyer et al., 2018; Kushlev & Heintzelman, 2014), we expected that communicating online while also interacting face-to-face would undermine the affective and social benefits of both types of interaction. This expectation was partially confirmed, as participants reported higher levels of loneliness and negative affect when in a 'double interaction' compared to a 'single' face-to-face interaction. Additionally, we found that participants appreciated their online company less when they were also interacting with people face-to-face, suggesting that online interaction quality may also be undermined by simultaneous face-to-face interaction.

We did not, however, anticipate the reverse associations, where adolescents reported *more* positive affect when engaging in a double interaction – as compared to the experience of both online and face-to-face interactions. More surprisingly, adolescents also reported feeling

more appreciated, at ease, and belonging in their current face-to-face company when they were interacting online at the same time. Further qualitative research – where, for example, adolescents are interviewed about their experiences of digital communication use – may be helpful in disentangling adolescents' experiences of these moments.

Little support for moderating effects of social resources

In the exploratory moderator analyses, we set out to test the competing 'rich-get-richer'/'social compensation' hypotheses, where those with more/fewer social resources experience a larger affective boost from interacting online. Most previous between-person studies investigating these effects have reported more positive associations between social media use and well-being for those with more social resources (Spies Shapiro & Margolin, 2014). However, when testing these hypotheses at the within-person level, the current results do not support either hypothesis. As recent work has emphasized substantial variation in how young people experience social media (Beyens et al., 2020), it is worthwhile to further explore what individual and environmental factors explain these individual differences. Future work might primarily benefit from an idiographic approach, where the effects of digital communication on well-being are explored in greater detail within individuals (Pouwels et al., 2021; Valkenburg et al., 2021).

Strengths and Limitations

The current study has a number of key strengths, adding to some novel contributions to the existing literature. First, the use of experience sampling to study associations between online communication and affective well-being allows for the much-need disentangling of within- from between-person effects – and has therefore been widely encouraged as an assessment tool to investigate this relationship (Dienlin & Johannes, 2020; Odgers & Jensen, 2020; Orben, 2020; Przybylski et al., 2019). Moreover, we are unique in using experience sampling to investigate online interactions and affective well-being in a naturalistic context, *in the moment*

that those interactions occur. In addition to the substantive contributions already described, our study demonstrates that it is possible to study online interactions within the moment. Second, the analysis is transparent and reproducible, as we registered the full analysis plan, and published all R code online (https://bit.ly/33dYEc2). This is particularly relevant for studies on the relationship between digital communication and well-being – a field fraught with methodological and statistical issues. Third, the sample size is substantially larger than that of most existing experience sampling studies investigating the relationship between online communication and well-being. This allowed for a high-powered study, in which we were well able to investigate cross-level interactions.

However, some important limitations and challenges are worth considering. The current study has a relatively large amount of missing data, due to a low compliance to the ESM protocol. Compliance might have been increased with, for example, a longer time to respond to the questionnaire (although this does make assessments less 'in-the-moment'), or more incentivization of completing ESM questionnaires (although this might have also led to more careless responding). Future studies may consider using shorter questionnaires to increase compliance (Eisele et al., 2020) or employing planned missingness designs (Silvia et al., 2014).

Finally, recent research also suggests the relevance of further investigating individual variability in the effects of digital communication on well-being, as some individuals experience an affective benefit from social media, while for others there is a weaker, no, or even an adverse effect (Beyens et al., 2020). Establishing the heterogeneity of these effects is important, as it allows for conclusions that extend beyond the one-size-fits-all recommendations derived from much between-person research. Still, in order to obtain helpful conclusions and recommendations for groups of people, we also need to learn more about the moderating factors driving the heterogeneity in (digital communication) effects.

Conclusion

The current study directly assessed the potential benefits and disadvantages of naturalistic online interactions within a large sample of adolescents. Our results highlight the potential for assessing the experience of online social interactions at the moment that young people engage in them. We observed a direct affective benefit of interacting with others online relative to being alone. At the same time, however, the results also suggest unique benefits of socializing in real life, as adolescents generally felt best when they were interacting face-to-face. While the current study precludes any causality claims, it uniquely highlights the direct experience of different types of social interactions for adolescents. More work is needed to further illuminate both the idiosyncrasies and general tendencies in how communication technologies fulfill adolescents' universal need to connect with others – and, moreover, how this relates to well-being in the long term.

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Table 1: Descriptive information for the n = 1705 adolescents included in the current study.

	Variable	Available N	Mean (SD)	Median	Range
Demographic and background information	Age	1700	13.7 (1.8)	13.0	11.0 – 20.0
	Gender (%girls)[1]	1702	63.3		
	% in school year 1	1705	56.7		
	% in school year 3	1705	21.9		
	% in school year 5	1705	21.4		
	Non-Belgian geographic identification (%)	1276	35.7		
Moderator variables	Mean social quantity (ESM)	1705	86.7 (15.0)	91.7	0.0 – 100.0
	Mean social quality (ESM)	1693[2]	5.8 (1.0)	6.0	1.0 – 7.0
	Interpersonal skills (VPV)	1327	69.8 (7.7)	70.0	18.0 – 90.0
	Social support (SS-L-I)	1598	23.0 (6.1)	23.0	0.0 – 36.0
Independent variable: Interaction type (as % of all compliant beeps)	Online interaction only	1698	4.9		
	No company and no interaction	1698	9.0		
	Face-to-face interaction only	1698	54.6		
	Double interaction	1698	17.3		
Dependent variables (ESM)	Positive affect	1705	5.0 (1.0)	5.1	1.0 – 7.0
	Negative affect	1704	2.0 (0.9)	1.7	1.0 – 7.0
	Loneliness	1702	1.7 (0.9)	1.4	1.0 – 7.0
	Offline interaction quality	1693	5.8 (1.0)	6.0	1.0 – 7.0
	Online interaction quality	1472	5.8 (1.2)	6.1	1.0 – 7.0

1. *5 participants expressed their gender identity as neither male nor female*
2. *Note that the available n for 'mean social quantity' can be different from that for 'mean social quality', as participants were only presented with the social quality items after indicating to be in other people's company – these 12 participants thus indicated no company for any completed ESM questionnaire.*

Table 2: Multilevel linear regressions, predicting momentary affect from the momentary interaction type variable. P-values are adjusted following Holm's multiple comparison correction, for an initial alpha of .05.

	Mean PA					**Mean NA**					**Loneliness**				
Reference category: 'Online only'	*B (SE)*	*CI LL*	*CI UL*	*p*	*Adj. p*	*B (SE)*	*CI LL*	*CI UL*	*p*	*Adj. p*	*B (SE)*	*CI LL*	*CI UL*	*p*	*Adj. p*
No company	-.15 (.04)	-.23	-.06	**.001**	**.004**	.01 (.04)	-.06	.08	.78	>.99	-.01 (.05)	-.12	.11	.90	>.99
Face-to-face only	.12 (.04)	.05	.20	**.001**	**.004**	-.12 (.03)	-.18	-.06	**<.001**	**<.001**	-.65 (.05)	-.75	-.55	**<.001**	**<.001**
Double interaction	.27 (.04)	.19	.34	**<.001**	**<.001**	0.03 (.03)	-.10	.03	.35	>.99	-.49 (.05)	-.60	-.38	**<.001**	**<.001**
Reference category: 'Face-to-face only'															
Double interaction	.14 (.02)	.10	.19	**<.001**	**<.001**	.09 (.02)	.05	.13	**<.001**	**<.001**	.16 (.02)	.12	.21	**<.001**	**<.001**
Random Effects															
AR(1)			.22					.22					.14		
ICC			.72					.77					.88		

CI LL = Lower limit of the 95% confidence interval around the B coefficient; CI UL = Upper limit of the 95% confidence interval around the B coefficient; AR(1) is the autocorrelation; ICC = Intraclass Correlation Coefficient

Table 3: Results of twelve nultilevel linear regressions, predicting momentary affect (PA, NA, loneliness) from momentary interaction type, with age and gender as covariates predicting both random intercepts and random errors, and four social resource variables also predicting random intercepts and errors. For each analysis, the reference category for the InteractionType variable is 'Online interaction only'.

		Mean PA				**Mean NA**				**Loneliness**			
	Predictors	*Estimates (SE)*	*LL*	*UL*	*p*	*Estimates (SE)*	*LL*	*UL*	*p*	*Estimates (SE)*	*LL*	*UL*	*p*
Main effect	Social support	.05 (.01)	.03	.06	**<.001**	-.02 (.01	-.03	-.01	**<.001**	-.02 (.01)	-.03	.00	.08
Interaction effects: InteractionType*Social Support	No company and no interaction	-.02 (.01)	-.03	-.00	*.029*	.01 (.01)	-.00	.02	.23	.01 (.01)	-.01	.02	.60
	Face-to-face only	-.01 (.01)	-.02	.01	.29	.00 (.01)	-.01	.01	.52	-.01 (.01)	-.02	.01	.38
Main effect	Interpersonal skills	.03 (.01)	.02	.05	**<.001**	-.03 (.00)	-.04	-.02	**<.001**	-.02 (.01)	-.03	-.00	*.046*
Interaction effects: InteractionType*Interpersonal skills	No company and no interaction	-.01 (.01)	-.02	.01	.44	.00 (.00)	-.01	.01	.41	-.00 (.01)	-.02	.01	.81
	Face-to-face only	.01 (.01)	-.00	.02	.23	.00 (.00)	-.01	.01	.66	-.01 (.01)	-.02	.01	.49
Main effect	Quantity of social interactions	.69 (.28)	.14	1.24	*.015*	-.60 (.23)	-1.05	-.16	*.008*	-.28 (.35)	-.97	.41	.43
Interaction effects: InteractionType*Quantity of social interactions	No company and no interaction	-.05 (.29)	-.63	.59	.87	.27 (.22)	-.17	.71	.22	.29 (.38)	-.47	1.04	.46
	Face-to-face only	.25 (.26)	-.27	.77	.34	.12 (.20)	-.27	.51	.54	-.14 (.34)	-.80	.52	.68
Main effect	Quality of social interactions	.58 (.02)	.49	.66	**<.001**	-.36 (.03)	-.42	-.29	**<.001**	-.36 (.05)	-.47	-.25	**<.001**
Interaction effects: InteractionType*Quality of social interactions	No company and no interaction	-.03 (.05)	-.12	.06	.51	.02 (.04)	-.05	.09	.62	.04 (.06)	-.08	.15	.55
	Face-to-face only	.05 (.04)	-.03	.12	.25	-.02 (.03)	-.08	.04	.50	-.02 (.05)	-.12	.08	.71

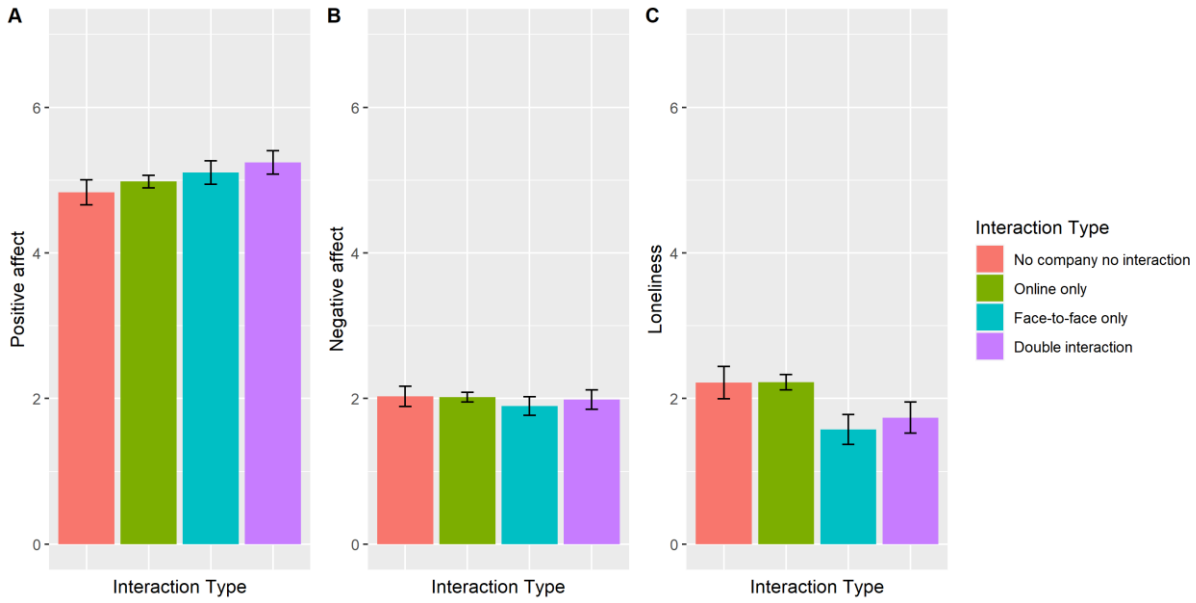

Figure 1: Estimated affect levels for A) positive affect, B) negative affect, and C) loneliness, and 95% confidence intervals when in different types of interaction/company.