EMPIRICAL ARTICLE

Linking video chatting, phone calling, text messaging, and social media with peers to adolescent connectedness

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Abstract

For 14 days three times per day (6072 observations), adolescents ($N = 207$, $M_{age} = 15.45$ years) reported their digital (i.e., video chatting, texting, social media, and phone calling) communication with peers and their social connectedness. Controlling for in-person interactions, adolescents felt more connected in hours when they had communicated with peers by video chatting, texting, or social media, but not phone calling. Girls communicated with peers via text and social media more than boys, and boys talked on the phone more than girls. Boys who talked, texted, or video chatted more on average reported higher connectedness on average, whereas girls did not. As the links with connectedness were only found at the hourly- and not the daily level, results highlight that a sense of connectedness from digital media may be fleeting in nature.

KEYWORDS
adolescence, digital media, ecological momentary assessments, gender, social connection

INTRODUCTION

In the United States, 95% of adolescents have access to a smartphone and use digital media nearly constantly (Schaeffer, 2019). In particular, adolescents use video chatting, texting, social media, and phone calling to maintain friendships and connect socially with others (Rideout & Robb, 2018; Schaeffer, 2019). While interacting with peers on digital media may promote feelings of connectedness, it is not clear if different forms of digital media (e.g., texting, video chatting, phone calls, and social media) are differentially linked to social connection with peers. Further, more work is needed to understand whether the link between digital media and social connectedness differs depending on individual characteristics, like gender. In the current study, we utilized ecological momentary assessments (EMAs) to examine whether the association between adolescents' feelings of social connectedness fluctuate when they have used different types of digital media to interact with their peers in the past hour. Further, we examined whether these hourly associations differ for boys and girls. Our goal is to further illuminate the complexities of how digital media use relates to adolescents' social well-being.

Digital media use and social connectedness

Adolescence is a critical period in which youth seek social belonging, community, and peer relationships (Tomova et al., 2021). The need for social connection is important throughout the lifespan but is of particular importance during adolescence, when adolescents demonstrate a strong need to affiliate with peers (Crockett et al., 1984; Newman & Newman, 2001; Tajfel & Turner, 1979). According to the Belonging Regulation model, individuals use their Social Monitoring System (SMS) to maintain and assess their current belonging needs (Gardner et al., 2005). Under conditions of low belonging, the SMS elicits a drive, similar to social hunger, which leads to heightened social monitoring, increased social acuity, and the engagement in behaviors to remediate social relationships (Knowles & Gardner, 2008; Tomova et al., 2020). This amplified SMS highlights new opportunities for social interactions and reintegration with social contexts (Gardner et al., 2005). Use of digital media may afford adolescents with one way to fulfill their belonging needs by connecting with peers and maintaining relationships (see Anderson & Jiang, 2018; Rideout & Robb, 2018).

Using digital media is a pervasive and constant feature of adolescents' daily lives (Boulianne & Theocharis, 2020).

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Nearly all (95%) adolescents have access to a smartphone, and nearly half (45%) report being online constantly (Anderson & Jiang, 2018). Relative to children, adolescents spend more time interacting with peers, and these peer relations are more socially salient and complex (Foulkes & Blakemore, 2016). Digital spaces provide adolescents with a venue to exchange content and ideas with peers and maintain social and emotional connections with friends (Armstrong–Carter & Telzer, 2021; Giedd, 2020). As such, it is important to understand how adolescents' experiences while navigating digital landscapes may generate feelings of social connection. Feelings of social connectedness are crucial for adolescents' social well-being and identity formation, as social connectedness provides adolescents with companionship, belonging, and a sense of affiliation within the context of their social environment (Lee & Robbins, 1995).

Much work examining digital media use and social connected has examined person-level associations and only one mode of communication. For example, middle schoolers in Canada who used social media use for longer than 2 hours daily reported less school connectedness (Sampasa-Kanyinga et al., 2019). Moreover, following a social media abstinence intervention, adults ($N = 61$) spending less time on social media experienced better mental well-being, increased social connectedness, and decreased fear of missing out (FoMO; Brown & Kuss, 2020). In contrast, in a sample of 79 university students in China, students who spent more time on social networking sites reported higher social connectedness (Lukindo, 2016). Still, this work is limited because it focuses solely on one mode of digital communication and examines person-level differences in social connectedness. Because social connectedness likely fluctuates within the same individual across different contexts throughout the day, person-level effects should not be generalized for understanding what potential impact digital media use may have within a single individual (Fisher et al., 2018). As such, researchers must draw from within-person designs while considering the specific effects of digital communication mode.

Within-person digital media effects

While most prior research has relied on retrospective self-reports of time spent on digital media (Ellis, 2019; Kaye et al., 2020; Odgers et al., 2020), retrospective questionnaires are limited because adolescents may have recall biases. To mitigate these limitations, a few studies have used momentary assessment designs to examine how digital media use relates to adolescents' experiences at the daily or hourly level. For example, using 2155 EMAs, adolescents varied in well-being after passively using social media, with some adolescents feeling no difference (44%), some feeling better (46%), and some feeling worse (10%; Beyens et al., 2020). In another study using EMAs, when adolescents had used Instagram or WhatsApp more frequently, they experienced higher levels of social connectedness with friends (Pouwels et al., 2021). In a recent study, increased smartphone screen time predicted

lower social connectedness among participants (ages 14–80) in the following hour (Anderl et al., 2023). Together, findings across studies show positive, negative, and null associations between digital media use and social connectedness.

Different types of digital media

According to the transformation framework, it is important to disaggregate different types of digital media such as texting, video chatting, and social media, because the specific mode effects how adolescent peer interactions transpire (Nesi et al., 2018). Indeed, digital communication modes offer novel features (e.g., interpersonal cues, synchrony, publicness, and quantifiability), which augment the nature of peer interactions (Nesi et al., 2018). As opposed to face-to-face interactions, digital modes of communication provide fewer social cues. In turn, by selecting a certain mode of digital communication adolescents are able to control which interpersonal cues (i.e., visual, textual, auditory, and video) are presented (Valkenburg & Peter, 2013). Depending on the selected modes of communication, adolescents may be able to engender rich and complex to crude social exchanges with peers. The synchrony (i.e., time lapsed within a conversation) and publicness (i.e., whether other parties may access conversation) across different digital communication modes also transform characteristics of adolescents' social interactions (Nesi et al., 2018). The transformation framework illustrates that features of digital communication (e.g., synchrony, publicness, interpersonal cues, and visualness) may alter the degree to which adolescents connect with peers during interactions. As such, digital modes like video chatting, social media, text messaging, and phone calling may offer opportunities for emotional conversation, social support, and self-disclosure.

To date, research on the effects of digital media has largely focused on social networking sites such as Instagram, Facebook, and Twitter (Kaye et al., 2020; Odgers et al., 2020), with relatively less emphasis on other types of digital media such as texting, phone calling or video chatting. Still, over the past 5 years, adolescents have increased their total digital media use from an average of 6 hours and 40 minutes to nearly 8 hours and 40 minutes (Rideout et al., 2022). This includes 1.5 hours a day of using social media and 20 minutes a day video chatting (Rideout et al., 2022) and sending or receiving an average of 72.3 text messages and 3.7 phone calls (Rodman et al., 2021).

Only a few studies disaggregating the different modes of digital media communication have examined within-person associations. In one example, using experience sampling among adolescents revealed that in-person compared to online interaction was associated with more positive affect, less negative affect, and lower loneliness (Achterhof et al., 2022). In a five-day daily diary study with college students, researchers compared the frequency of divergent digital media use (e.g., Snapchat, email, messaging, phone calls) on the relational closeness of a selected peer and found only social media use (i.e., Snapchat) to be associated with increased closeness (Kahlow

et al., 2020). In another five-day daily diary study with college students, text messaging and the quality and quantity of social media use were positively associated with improved self-esteem (Subrahmanyam et al., 2020). Similarly, among 334 emerging adults from the UK, Italy, and Argentina, messaging app use was associated with less loneliness; however, social media app use was associated with increased loneliness for people with high reported FoMO across a 4-week period (Fumagalli et al., 2021). In a daily diary study conducted during the onset of the COVID pandemic, adolescents reported greater closeness to peers on days when they texted or video chatted with peers more; however, more social media use was not linked to closeness (James et al., 2023). Together, these findings suggest that researchers should look beyond examining unidimensional measures of one mode and instead examine how the different types of digital media may differentially impact feelings of social connectedness.

Gender differences in digital media use and social connectedness

Digital media may impact boys' and girls' feelings of social connectedness differently. In general, girls use digital media more for socializing than boys (Rideout et al., 2022). In a sample of 717 high school and university students, girls used their smartphones for talking and texting more than boys, whereas boys used their smartphones for web browsing, media sharing, and video-gaming more than girls (Cocorădă et al., 2018). Among children ages 9–13, boys who used social networking sites reported higher feelings of belonging, whereas boys who did not use social networking sites reported decreased feelings of belonging. For girls, however, there was no association between social network site use and feelings of social belonging (Quinn & Oldmeadow, 2013).

Literature on offline peer interactions may help illuminate how gender differences manifest within digital interactions. According to the peer-socialization model, gender differences among children strengthen as they age into adolescents (Rose & Rudolph, 2006). In addition to self-disclosing more than boys, girls spend more time in social conversation than boys (Rose & Rudolph, 2006). Further, girls place higher value on social goals (e.g., having friends) than non-social goals (e.g., getting good grades, making money), when compared to boys (Rose & Rudolph, 2006). Importantly, girls' higher appraisal of social relationships may contribute to greater empathy but may also increase their concern about losing relationships, hurting others, and abandonment, making them more vulnerable to loneliness than boys (Rose & Rudolph, 2006). Though features characterizing offline gendered peer socialization processes may extend into digital interactions, digital contexts likely transform how such peer relations manifest. For instance, the self-disclosure hypothesis posits that, as boys typically demonstrate more difficulty with in-person self-disclosure than girls (McNelles & Connolly, 1999), digital communication may be a greater benefit to boys for disclosing to friends,

thereby garnering more social connectedness and well-being (Schouten et al., 2007, 2009).

More studies with robust within-subject designs may help to illuminate how digital media relates to boys' and girls' feelings of connectedness depending on the specific mode of communication. In one study, a cross-level interaction between adolescent WhatsApp use and friendship closeness was moderated by gender such that WhatsApp use and friendship closeness was negatively related among boys and non-significantly among girls; however, this pattern was not consistent across Instagram and Snapchat (Pouwels et al., 2021). These differences in digital media use and social experiences suggest that the link between adolescents' digital media use and momentary social connectedness may differ for boys compared to girls.

Current study

In the current study, we conducted a two-week intensive daily study, during which adolescents reported on their interactions with their peers and their feelings of connectedness. These assessments were collected three times a day across a 14-day Ecological Momentary Assessment (EMA) period. Data collection began in May 2020, a few months after the initial onset of the COVID-19 pandemic where many in-person social interactions were limited by lockdowns. As digital communication was the predominant way by which adolescents maintained relationships with their peers, scholars have called for more work seeking to document the uses of digital media in relation to COVID-19 (Hamilton et al., 2022). A meta-analysis examining 30 studies on adolescent digital media use during COVID-19 highlighted that some but not all modes of digital media were helpful in mitigating loneliness (Marciano et al., 2022). Still, of those studies, only one utilized an EMA design (i.e., Arend et al., 2021) and to date no studies have examined the momentary links between mode of digital communication and connectedness during COVID-19.

With most EMA work focusing on social media, and little attention on texting, phone calling, or video chatting, the first aim of this study was to identify how various modes of digital communication relate to adolescents' reports of social connectedness. To address this aim, we examined phone calling, video chatting, text messaging, and social media communication with peers to examine if communicating with peers via these digital modes is linked to feelings of social connectedness, above and beyond in-person communication. Our first research question was:

RQ1: Controlling for in-person communication with peers, how does phone calling, video chatting, text messaging, and social media communication with peers in a given hour each relate to social connectedness, as reported in that hour?

We hypothesized that adolescents' use of different types of digital media to connect with peers would relate to increased

feelings of social connection. This is in line with recent theoretical work prescribing that researchers consider the unique affordances offered across varying modes of digital communication (Nesi et al., 2018). Specifically, this framework illuminates how across disparate modes of digital communication, adolescent peer interactions differ in key features like in synchrony (i.e., is the exchange occurring at the same time?) and visuality (i.e., how much visual information does the interaction contain?), which likely influences the social nature of the digital interaction (Nesi et al., 2018). We drew from this framework to hypothesize that all digital modes of communication (i.e., video chatting, text messaging, social media, phone calling) would be linked to more connectedness.

Since boys and girls tend to use different types of digital media to connect with peers and experience different gender socialization processes (Rideout et al., 2022; Rose & Rudolph, 2006), our second research question was:

RQ2: Are there gender differences in the communication modes (i.e., phone call, video chat, text message, social media) used to interact with peers, and does gender moderate associations between digital communication and social connectedness?

Following the gender differences in online disclosure to peers literature (Schouten et al., 2009) and well-established offline peer socialization literature (McNelles & Connolly, 1999; Rose & Rudolph, 2006), we hypothesized that in general, girls would engage in digital communication more frequently than boys. Though boys report spending more time using digital media, much of this time is spent watching videos, television, and playing video games which may or may not involve other peers (Rideout et al., 2022). Girls report using social media as an activity that they enjoy 'a lot' and girls report using their smartphones for texting and talking on the phone more frequently than boys (Cocorada et al., 2018; Rideout et al., 2022). Digital media likely extends opportunities to engage with peers who are not physically together (Valkenburg et al., 2011). As girls exert more attention toward maintaining peer relationships and appraise the importance of social relationships more than boys (Rose & Rudolph, 2006), they likely capitalize on digital modes of communication more frequently than boys. Finally, we examined if gender would moderate the link between digital media communication and social connectedness. According to the online self-disclosure model (Schouten et al., 2009), we hypothesized that boys' use of digital communication to connect with peers would be linked to more social connectedness than for girls.

METHOD

Participants

Participants included 207 racially and ethnically diverse adolescents (M = 15.45 years, SD = 0.664; *range* = 14–17; *female* = 113; *male* = 89; *non-binary* = 3; *not reported* = 2;

39% White, 32% Latine, 23% Black/African American, 5% Multiracial/Other Race). Based on parental report of family income, participants came from relatively low socioeconomic status backgrounds; median household income was: M = \$45,648, SD = \$15,461, *Min* = \$15,714; *Max* = \$77,313.

Procedures

Participants in this study were recruited from a larger longitudinal study that was administered in four waves across four school years (N = 922 consented, N = 873 provided data first wave, N = 687 provided data at fourth wave). The current study uses data which were collected in wave four. During the fourth year of the longitudinal study, EMAs were collected virtually over the course of two weeks. This was from May to September 2020, during the COVID-19 pandemic. Specifically, during the fourth wave of the study, 338 participants were contacted (based on providing contact information and permission to be contacted for future studies) and 217 participants volunteered to participate in the follow up EMA study. Caregivers of participants were contacted virtually via email, text, and/or phone and invited to have their child participate. Caregivers and adolescents consented and assented online. Participants were compensated \$50 for completing a minimum of 70% of the surveys, \$35 for completing 50%–70% of the surveys, and \$25 for completing fewer than 50% of the surveys. The final analytic sample included 207 adolescents after excluding 10 participants with no EMA data on the constructs of interest. All procedures were approved by the university human subjects committee.

The EMA data were collected over the course of a two-week period using ExpiWell (app.expiwell.com), an application which they downloaded to their personal phone with the virtual assistance of study personnel. For the EMAs, participants received a notification on their smartphone. Specifically, the EMAs were randomly sent during three time-blocks: 9 am–1 pm, 1 pm–5 pm, and 5 pm–10 pm. Participants were able to complete each EMA within two hours of the notification. After two hours, the notification disappeared. The EMAs each took approximately 1 min to complete. Data were collected on both weekdays and weekends.

Morning surveys were less likely to be completed (65% of prompts answered) than afternoon (72% of prompts answered) and evening surveys (72% of prompts answered), p < .001. Completion rates were in part contingent on time of year. During the summer months (early June—early August; 6766 total possible prompts), morning (66% of prompts answered) and afternoon (72% of prompts answered) surveys were more likely to be completed compared to morning (60% of prompts answered) and afternoon (68% of prompts answered) surveys delivered during the school year (1515 total possible prompts), ps < .030. There was no difference for evening surveys (p = .848). On average, participants completed 70% of their EMAs across the 14 days, with 50% completing over 80% of their surveys

(SD = 27%, Range = 5%–100%). Number of surveys completed was positively correlated with social connectedness (averaged across the EMA; $r = .27$, $p < .001$) and negatively correlated with rates of phone calling (averaged across the EMA; $r = -.15$, $p = .027$); otherwise, number of surveys completed was unrelated to key study variables or demographics.

Measures

Gender

Participants reported their gender with the following options: "Male," "Female," "Non-binary (please describe)." Gender was effect-coded as −1 = female, 1 = male. Nonbinary and missing gender were excluded for analyses that compared gender differences.

Peer interactions

Participants indicated via EMA whether they had interacted with their best friend, other friends, or a romantic partner in the past hour. If the adolescent had interacted with any of these individuals in the past hour, they were prompted to select the mode of their interaction, including talked on the phone, video chatted (e.g., FaceTime, Google Duo, Skype, and Zoom), text messaged, social media (e.g., messaged or chatted via Instagram, TikTok, Twitter, and Facebook), and in-person. For example, participants were asked "Did you interact with your best friend in the last hour?" If yes was selected, participants then indicated yes/no for the mode by which the interaction took place, including in person and the four different types of digital media outlined above. Identical questions were asked for other friends and romantic partners. We collapsed together their digital social interactions across the three people (best friend, other friends, and romantic partners). Accordingly, each of the four different digital media types reflect use of that media when interacting with peers in the last hour, and these were each a dichotomous measurement, such that 1 indicated they had interacted using the specific digital communication mode with anyone in the past hour, and 0 indicated they had not interacted using that specific digital communication mode with anyone in the past hour. We also created a dichotomous variable for interaction with peers in person.

Social connectedness

Participants indicated via EMA the extent to which they felt socially connected to others at that moment. Participants were asked: "How distant or disconnected do you feel with your close others right now?" Participants indicated their connectedness using a continuous slider scale ranging from 0 to 100. Higher values indicated "very close to others" and lower values indicated "very distant to others."

Data analytic plan

Primary analyses were conducted in *Mplus* Version 8.8 (Muthén & Muthén, 1998–2017). Three-level multilevel models were run in which hourly assessments (Level 1) were nested within days (Level 2) which were nested within participants (Level 3). Variables were standardized in *Mplus* prior to analysis. Daily variables were aggregated within each day, and person-level variables were aggregated across the 14-day EMA period. Hourly variables and daily variables were person-centered in which the aggregated person-level variable was subtracted from the raw variables (Curran & Bauer, 2011; Yaremych et al., 2021). Model 1 examined hourly, daily, and person-level associations between each digital communication variable of interest controlling for in-person interactions. Separate models were run for each mode of digital communication.

Level 1: Social Connect$_{ijk}$ = β_{0jk} + β_{1jk}(hInPers$_{ijk}$) + β_{2jk}(hDigComm$_{ijk}$) + r_{ijk}

Level 2: β_{0jk} = β_{00k} + β_{01k}(dInPers$_{jk}$) + β_{02k}(dDigComm$_{jk}$) + u_{0jk}

β_{1jk} = β_{10k}

β_{2jk} = β_{20k}

Level 3: β_{00k} = γ_{000} + γ_{001}(mInPers$_k$) + γ_{002}(mDigComm$_k$) + u_{00k}

β_{01k} = γ_{010}

β_{02k} = γ_{020}

β_{10k} = γ_{100}

β_{11k} = γ_{110}

β_{21k} = γ_{2w10}

At Level 1, social connection for hour i, day j, and person k was modeled as a function of the intercept term (β_{0jk}), hourly in-person interaction (hInPers$_{ijk}$), hourly digital communication (hDigComm$_{ijk}$), and the residual (ε_{ijk}). Level 2 included daily in-person interactions (dInPers$_{jk}$) and daily digital communication (dDigComm$_{jk}$) as predictors of the intercept. Level 3 included person-average in person interactions (mInPers$_j$) and digital communication (mDigComm$_j$) as predictors of the intercept.

Model 2 included the same equations but included gender as a person-level covariate (effect-coded −1 = girls, 1 = boys). Models also included cross-level interactions between gender and both the hourly and daily digital communication variables, and an interaction between gender and the person-level digital communication variable. Interaction terms were formed by computing the cross-product between digital communication and gender. Significant interactions were probed by swapping the effect-coded gender variable with dummy codes in two steps. First, models were rerun with a dummy code reflecting female as the reference group, to examine specific associations for girls. Second, models were rerun with a dummy code reflecting male as the reference group, to examine specific associations for boys. Participants who identified as non-binary or who did not report gender were omitted from these analyses.

Maximum likelihood with robust standard estimation was used, and full information maximum likelihood was used to account for missingness on the social connectedness variable (31% missing). Benjamini–Hochberg corrections were used to adjust for multiple testing (Benjamini & Hochberg, 1995), since four separate models were run for each mode of communication. Supplemental tables, syntax, and output can be found on Open Science Framework: https://osf.io/b7dkf/?view_only=a79183078d674b4ab19e3d79383223fa.

RESULTS

Descriptives

In-person interactions were more likely to be reported in the evening (14% of evening observations) compared to the afternoon (10% of afternoon observations), which were in turn more likely to be reported compared to the morning (6% of morning observations; $p < .001$). The same pattern was observed for phone calls (evening: 9%; afternoon 7%; morning 4%), video chatting (evening: 11%; afternoon: 8%; morning: 5%), and texting (evening: 29%; afternoon: 25%; morning: 17%; all ps $< .001$). Social media interactions were more likely to occur in the afternoon (23%) and the evening (24%) compared to the morning (13%; $p < .001$), but did not differ from each other ($p > .05$).

Descriptive statistics and correlations are presented in Table 1. Of note, the most common mode of communication across both observations and participants was text messaging, followed by social media. All modes of communication demonstrated weak, positive correlations with social connectedness except for social media, which was not significant. The percentages of EMA assessments reflecting each mode of communication by interaction partner are reported in Table 2. Texting and social media were the dominant forms of communication for best friend, other friend, and romantic partner interactions. Gender differences are presented in Table 3. Boys reported more phone call communication, but less text messaging and social

media communication. Girls reported more friend and romantic partner interaction.

Associations between digital communication and social connectedness

Results are in Table 4. Except for phone calling, each mode of digital communication was linked to greater social connectedness at the hourly level, above and beyond in-person communication. Daily and person-level associations were not significant or not robust to statistical correction. Gender was not a robust moderator for any hourly or daily associations. Gender was a significant moderator at the person-level. Specifically, boys who engaged in greater phone calling ($b = 0.20$, $p = .005$), video chatting ($b = 0.26$, $p < .001$), and texting ($b = 0.25$, $p = .001$) than their peers had greater social connectedness (see Figure 1). These associations were not significant for girls (ps $> .150$). See Supporting Information for analyses that examine all associations split by interaction partner (i.e., best friend, other friend, and romantic partner).

DISCUSSION

This study used a 14-day EMA design to examine how connecting with peers using different types of digital media relate to adolescents' feeling of social connectedness in the same hour and whether the momentary link between using digital media to connect with peers and social connectedness varied for boys and girls. When controlling for in-person interactions, hourly-level associations reveal that in hours where adolescents used social media, video chat, or text to interact with peers, they felt more social connectedness. This association was not significant for phone calls. We also found that girls used social media and text to communicate with peers more than boys, which was consistent with our hypotheses. Interestingly, results indicated that boys talked on the phone with peers more than girls. Gender was

TABLE 1 Descriptive statistics and correlations for key study variables.

	1	2	3	4	5	6	Perc
1. Conn	–	.11	.14	.16*	.05	−.02	–
2. Person	.17***	–	.12	.08	.18**	.14*	60%
3. Phone	.09***	.08***	–	.40***	.29***	.07	56%
4. Video	.11***	.02	.27***	–	.43***	.25***	49%
5. Text	.07***	.03*	.22***	.26***	–	.30***	78%
6. SM	.01	.03*	.11***	.18***	.28***	–	64%
M	53.19	0.10	0.07	0.08	0.24	0.20	
SD	29.71	0.30	0.25	0.28	0.43	0.40	

Note: "Conn" refers to social connectedness, "SM" refers to using social media with peers. Correlations below the diagonal are within-person ($n = 4213$ observations for correlations with connectedness; $n = 6072$ observations for remaining correlations). Within-person means and standard deviations reported. Correlations above the diagonal are between-person ($N = 207$). Percentages depict the percentage of participants who reported a given method of communication at least once during the EMA period. Means for modes of communication represent averaged proportion of cases in which each mode was reported; for example, in-person communication was reported 10% of the time.

*$p < .05$. **$p < .01$. ***$p < .001$.

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TABLE 2 Frequencies of modes of communication by partner.

	In-person (%)	Phone (%)	Video chat (%)	Texting (%)	Social media (%)
Best friend, $n = 1585$	20	11	13	47	41
Other friend, $n = 1548$	17	11	12	42	51
Rom partner, $n = 1001$	17	15	20	65	35

Note: Percentages represent the percent of observations in which each mode of communication was reported for each communication partner. For example, across all best friend interactions ($n = 1585$), in-person communication was reported 20% of the time. Percentages within each interaction partner are not mutually exclusive. For example, participants could report both in-person and phone communication with their best friend at a single assessment point.

TABLE 3 Gender differences for key study variables.

	Girls ($n = 113$)		Boys ($n = 89$)				
	Mean	**SD**	**Mean**	**SD**	t	p	**Cohen's d**
Mode of communication							
Connect	49.89	22.96	49.86	23.32	0.01	.994	0.00
In-person	0.13	0.17	0.09	0.16	1.43	.155	0.20
Phone	0.06	0.09	0.10	0.16	−2.71	.007	0.38
Video	0.09	0.14	0.09	0.16	−0.14	.890	0.02
Text	0.29	0.28	0.19	0.23	2.75	.006	0.39
Social media	0.26	0.29	0.13	0.19	3.48	<.001	0.49
Interaction partner							
Best friend	0.28	0.26	0.23	0.23	1.58	.115	0.22
Friend	0.31	0.28	0.22	0.22	2.31	.022	0.33
Rom partner	0.38	0.35	0.25	0.33	2.05	.043	0.38

Note: Associations with romantic partners were limited to 118 adolescents (62 female, 56 male) who reported having a romantic partner during the EMA.

a significant person-level moderator—specifically, boys who called, video chatted, and texted more than their peers reported higher social connectedness. Together, these findings suggest that different types of digital media are divergently associated with adolescents' social well-being, and furthermore that gender is related to the mode of digital communication. In all cases, when associations were found, digital communication was related to higher social connectedness above and beyond in-person interactions, indicating that digital interacts with peers provides adolescents a sense of social connectedness. Furthermore, the links to improved social connectedness were only present on the hourly-level and not the daily-level, our results also suggest these effects are momentary and fleeting in nature.

Video chatting, social media, and text messaging linked to higher social connectedness in the same hour

First, we found that adolescents felt more socially connected in hours where they video chatted, used social media, or text messaged to interact with peers. In contrast, talking on the phone with peers was not related to feelings of social connectedness in the same hour. These associations were consistent for both boys and girls. These links suggest

that varying modes of digital communication afford unique opportunities for peer social interactions among adolescents (Nesi et al., 2018). In two prior studies, adolescents felt less lonely and more socially connected after texting via iMessage and WhatsApp the same hour (Fumagalli et al., 2021; Pouwels et al., 2021). Our study extends with work by systematically examining the links between four modes of digital communication and social connectedness.
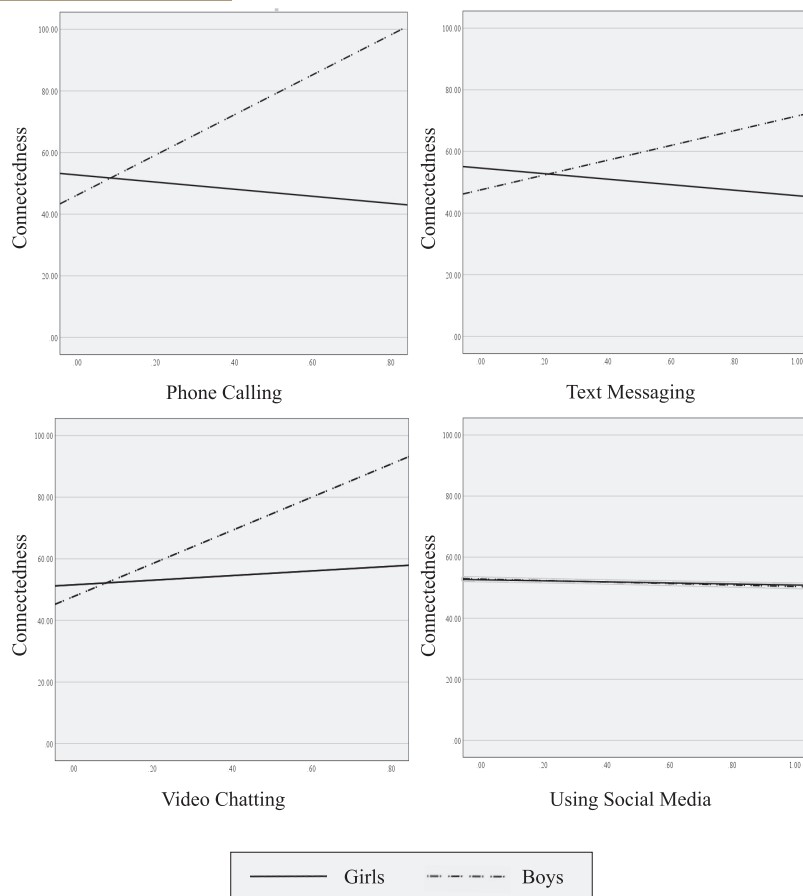
Several possibilities may explain these findings. First, video chatting, using social media, and texting (e.g., written messages, emojis, and gifs) may offer visual cues which have been implicated in adolescent digital communication by helping to convey tone, emotion, and expression (Nesi et al., 2018). Since digital modes of interaction lack social cues typical within in-person interaction (e.g., facial expression and gestures), these such modes present visual and textual information (Valkenburg & Peter, 2013). As such, these interpersonal cues (e.g., facial expressions, pictures, and emojis) may help in facilitating more social connectedness. Though phone calling offers auditory information which may convey tone and emotion, the absence of visual information may explain why phone calling was not found to be linked to social connectedness. Consistent with existing literature (Rideout et al., 2022), talking on the phone was the least prevalent mode of digital communication with peers. The lack of a link between social connectedness and talking on the phone may be reflective of recent popular

TABLE 4 Results from multilevel regressions examining modes of communication predicting social connectedness.

	Hourly			Daily			Person		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Phone									
Model 1									
IP	**0.09**	**0.01**	**<.001**	0.03	0.02	.217	0.08	0.05	.092
PHN	0.02	0.01	.112	−0.03	0.01	.025	0.10	0.05	.048
Intercept							−0.11	0.05	.033
Model 2									
IP	**0.09**	**0.01**	**<.001**	0.03	0.02	.211	0.09	0.05	.090
PHN	0.02	0.02	.248	−0.03	0.01	.030	0.03	0.07	.619
GEN							−0.01	0.05	.898
GEN×PHN	0.01	0.02	.726	0.02	0.01	.258	**0.17**	**0.07**	**.013**
Intercept							−0.10	0.05	.047
Video									
Model 1									
IP	**0.09**	**0.01**	**<.001**	0.02	0.02	.250	0.08	0.05	.089
VID	**0.05**	**0.01**	**<.001**	−0.03	0.02	.160	0.11	0.05	.031
Intercept							−0.11	0.05	.036
Model 2									
IP	**0.09**	**0.01**	**<.001**	0.02	0.02	.272	0.09	0.05	.106
VID	**0.05**	**0.02**	**<.001**	−0.03	0.02	.103	0.13	0.05	.016
GEN							0.01	0.05	.880
GEN×VID	0.01	0.01	.680	−0.03	0.02	.076	**0.13**	**0.05**	**.011**
Intercept							−0.10	0.05	.045
Text									
Model 1									
IP	**0.09**	**0.01**	**<.001**	0.03	0.02	.215	0.09	0.05	.083
TXT	**0.06**	**0.01**	**<.001**	−0.02	0.02	.198	0.03	0.06	.642
Intercept							−0.11	0.05	.045
Model 2									
IP	**0.09**	**0.01**	**<.001**	0.03	0.02	.203	0.11	0.05	.039
TXT	**0.07**	**0.01**	**<.001**	−0.03	0.02	.113	0.08	0.05	.160
GEN							0.03	0.05	.533
GEN×TXT	0.02	0.01	.229	−0.03	0.02	.142	**0.18**	**0.05**	**.001**
Intercept							−0.10	0.05	.045
Soc media									
Model 1									
IP	**0.09**	**0.01**	**<.001**	0.02	0.02	.238	0.10	0.05	.049
SM	**0.05**	**0.02**	**.002**	−0.04	0.02	.020	−0.03	0.05	.531
Intercept							−0.10	0.05	.047
Model 2									
IP	**0.09**	**0.01**	**<.001**	0.03	0.02	.233	0.11	0.05	.052
SM	**0.05**	**0.02**	**.002**	**−0.05**	**0.02**	**.005**	−0.02	0.07	.796
GEN							0.01	0.06	.811
GEN×SM	0.01	0.02	.495	−0.03	0.02	.085	0.03	0.06	.689
Intercept							−0.10	0.05	.056

Note: "IP" refers to in-person interaction, "GEN" refers to gender, "PHN" refers to talking on the phone with peers, "VID" refers to video chatting with peers, "TXT" refers to text messaging with peers, "SM" refers to using social media with peers. Each mode of communication represents a separate analysis. Bolded associations survived Benjamini-Hochberg correction. With the exception of social media (*p* = .052), hourly, within-person results did not change when all communication modes were included in the same model.

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FIGURE 1 Person-level gender differences in the links between social connectedness and mode of digital communication. Slopes represent the standardized coefficient (i.e., betas).

media assertions that contemporary adolescents and emerging adults are reluctant to use their smartphones for phone calls (Cohn, 2022; Rousselle, 2022). Social norms may thus inhibit the link between talking on the phone and increased social connectedness. For example, because talking on the phone is not widely accepted, perhaps social interactions mediated via phone calling may be awkward and not conducive of social connection.

Girls use text messaging and social media with peers more than boys

Our second research question examined the role of gender in adolescents' modes of digital communication with their peers. We hypothesized that girls would use text, social media, video chat, and phone calls to interact with their peers more than boys. We found that girls used text and social media to interact with peers more than boys. Alternatively, we found that boys talked on the phone with peers more than girls, and no such differences in video chatting. These effects are consistent with prior work on gendered online communication and several possible explanations may explain these gender differences. First, boys and girls may have different motivations for digital communication. Specifically, girls often use text for emotional functions like facilitating relationship intimacy, passing time, and communicating feelings, whereas boys have been found to digitally communicate with peers to accomplish instrumental functions (e.g., organize a future meet up; Morrill et al., 2013). Boys may rely on frequently talking on the phone to facilitate instrumental purposes, like quickly asking a question or planning an activity. Another possible explanation is that these findings may reflect the features of offline differences in peer social interactions. For example, the peer-socialization model suggests that girls appraise social relationships higher, place more value on social goals, and spend more time in social conversation than boys (Rose & Rudolph, 2006). Since social media and text messaging are the most quantifiable and accessible of the four digital modes (Nesi et al., 2018), girls may draw upon platform features to aid in their pursuit of social goals. For example, as opposed to phone calling and video chatting, adolescents can more readily view quantifiable metrics like the number of messages, likes, and comments exchanged with peers to facilitate social comparison and feedback-seeking (Nesi & Prinstein, 2015). Further, social media and text messaging allow adolescents to communicate with more than two parties simultaneously. Rather than interacting with one

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peer at a time via video chat or talking on the phone—which is not public to other peers—girls may opt for these modes because they can be engaged with more peers at once, thus also increasing their number of quantified public social exchanges. Finally, these findings may be explained by boys and girls having different perceptions of what counts as digital communication. For instance, boys report spending more time playing video games than girls (Rideout et al., 2022). Like social media, video games often involve exchanging messages, audio, and visual information with other peers; however, boys may not consider this a form of using social media with peers.

Boys who talk on the phone, video chat, or text more than their peers report higher social connectedness

We found that boys who talked on the phone, video chatted, or text messaged more on average than their peers reported higher average social connectedness, whereas these associations were not significant for girls. These person-level associations are consistent with prior work (Rideout et al., 2022) on gendered online communication and several possible explanations may explain these gender differences. Boys are more likely to use online modes of communication instead of in-person communications for personal disclosure (Valkenburg et al., 2011), so boys who talk on the phone, video chat, or text more may feel more socially connected because they may be disclosing personal thoughts, feelings, and bonding with their peers, which may occur less in person. Another possible explanation is that these findings may reflect the features of offline differences in peer social interactions. For example, the peer-socialization model suggests that boys demonstrate more agency- and status-seeking goal orientations (Rose & Rudolph, 2006). Consistent with our findings, boys who talk on the phone, video chat, or text more than peers, may have more social connectedness because they are using digital communication to extend their opportunities for agency- and status-seeking more than other peers. Furthermore, these findings align with other cross-sectional and self-report work indicating that the impact of COVID-19 in adolescents' lives was gender-specific and that girls experienced more negative impacts of the pandemic (Kerekes et al., 2021).

Study implications

This study contributes to literature on adolescents' digital media use in four ways. First, we demonstrated that using different types of digital media to connect with peers is divergently associated with adolescents' sense of connectedness. Where a few prior EMA studies have compared types of social networking apps (Beyens et al., 2020; Pouwels et al., 2021) and two types of digital media (i.e., social networking vs. text messaging; Fumagalli et al., 2021) on social connectedness, our study examines four different types of digital media (i.e., text messaging, social media, phone calling, video chatting) showing unique effects of each type. This approach is consistent with recent theoretical recommendations for future research to go beyond examining time spent on social media to test specific digital media behaviors (Nesi et al., 2020) and provides a more comprehensive and nuanced understanding of adolescents' digital behaviors as they navigate their ever-evolving digital and social landscapes. Importantly, as we found positive associations with digital media and connectedness on the hourly-level, and null associations on the daily-level, these patterns contribute to literature indicating that the effects of digital media are fleeting (Bayer et al., 2016; Bentley et al., 2015).

Second, we elucidate the link between using digital media to connect with peers and momentary social experiences by using a robust, within-subject research design that controls for between-subject associations. We build on a body of literature that has focused on between-subject associations for adolescents' digital media use (Ang et al., 2019; Barker, 2018; Sampasa-Kanyinga et al., 2019), with a few notable recent exceptions (Achterhof et al., 2022; Anderl et al., 2023; Armstrong-Carter et al., 2022; Beyens et al., 2020; Pouwels et al., 2021). This supports examining the momentary associations between adolescents' use of digital media for interactions and their corresponding sense of social connection within the same hour, instead of examining daily level associations or associations between adolescents.

Third, this study makes several notable contributions to the transformation model and disclosure hypothesis (Nesi et al., 2018; Schouten et al., 2009), as it is one of the first to characterize gender differences in adolescents' digital communication patterns using an EMA design (Pouwels et al., 2021). This work complements and follows emergent theory that offline individual characteristics extend into digital spaces (Nesi et al., 2020; Nesi & Prinstein, 2015). Specifically, the current study extends prior work by revealing that gender may moderate between-person links between using digital media to connect with peers and social connectedness. Further, by identifying that boys who use the phone, text, and video chat to interact with peer more report higher social connectedness, suggests that certain digital behaviors may support boys' self-disclosure.

Our study was conducted during the initial stages of lockdown during the COVID-19 pandemic when adolescents were socially distanced and often lonely (Fumagalli et al., 2021; Magis-Weinberg et al., 2021). These findings contribute to the growing body of working seeking to understand how adolescents drew upon digital media to navigate COVID-19 (Marciano et al., 2022). Rather than context-specific effects emerging, the context of COVID-19 likely augmented existing patterns with adolescent digital media use (Hamilton et al., 2022). Still, by situating our study within this context, we provide valuable insight into

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understanding how adolescents maintained social well-being during COVID-19. These findings offer further insights into self-report work suggesting that adolescents used social media to stay connected with peers (Kerekes et al., 2021). Specifically, these data suggest that throughout the day, adolescents relied on using digital communication with peers to momentarily maintain social well-being; however, there was no evidence to suggest the effects of increased digital communication with peers improved overall daily social well-being. As such, these findings have implications for policymakers, educators, parents, teens, and other stakeholders who aim to harness digital media to promote adolescents' positive development. The COVID-19 pandemic necessitated educators and students to integrate digital media into their daily instructions. For example, increasing hybrid education incorporates digital media forms such as social media and video chatting. In line with other recent studies, our results suggest that these digital modes of communication may be leveraged to support increased social connectedness (James et al., 2023). In structuring safe and healthy learning environments promotive of positive youth development, stakeholders should take these patterns into account. Youth who are most at risk for low social connectedness may benefit from structured opportunities that cultivate digital forms of social connections. Further, since our analyses were focused on social connectedness and digital interactions during the initial lockdown, many nonhousehold interactions were likely digitally mediated—indeed, it is possible that the pattern of our results are specific to this early pandemic period. As such, it is important that future research investigates how digital media use relates to boys' and girls' feelings of connectedness in post-pandemic times.

Limitations and future directions

The current study has several limitations. Although we examined momentary correlations using robust within-subject analyses, causal inferences are not possible. Still, the links between digital communication and social connectedness are likely bidirectional. According to the Belonging Regulation model, individuals use their Social Monitoring System (SMS) to maintain their current belonging needs (Gardner et al., 2005). It is plausible that the SMS detects low values of connectedness (Gardner et al., 2005), thereby prompting increased digital communication to improve one's social connectedness. As such, social belonging needs may enhance adolescents' digital communication with their peers as a means to increase their subsequent sense of belonging. Second, digital media effects are likely fleeting and the temporal resolution at the hour level may obfuscate important information about the plurality, duration, sequencing, and synchrony of social interactions. Future research should consider improving the granularity of hourly associations by having participants approximate the time preceding social interactions and by increasing the number of assessments throughout the day. Third, social connectedness was captured using a single item. Though, momentary designs necessitate that researchers limit the number of items included within the repeated assessment, multi-item construct measures generally outperform single-item construct measures and offer modest benefits (Song et al., 2022). This is evidenced in other recent EMA studies with adolescents where only one item was used to assessed momentary experiences like well-being, friendship closeness, and social connectedness (Armstrong-Carter et al., 2022; Beyens et al., 2020; James et al., 2023; Pouwels et al., 2021). Still, in asking how close or distant adolescents feel with their "close others," it is possible that adolescents may have interpreted who counts as "close others" differently.

Future research should also explore how engaging in specific digital media behaviors impact adolescents' social connectedness. While we differentiated between four types of digital media, we did not have information about specific digital behaviors, communications, or content exchanged. For example, one adolescent may have used a social networking site to passively like pictures posted of a friend, whereas another adolescent may have used the same social networking site to host a video chat with their friend—both of these teens would report using social media to interact with a friend in our study. However, these different digital behaviors may divergently impact adolescents' feelings of social connectedness. Future studies should pursue novel ways to objectively measure the specific behaviors used within different digital media contexts, for example, using real-time screenshots of adolescents' smartphones.

CONCLUSION

Adolescents increasingly use digital media as a modality for peer social interactions (Rideout et al., 2022), so understanding how different modes of digital media use relate to adolescents' social connectedness is crucial for informing efforts to promote well-being and positive development. Accordingly, our robust multilevel models revealed how different types of digitally mediated peer interactions relate to adolescents' feelings of social connectedness on an hourly level and whether this differed based on gender. Together, this study highlights how modes of digital communication shape the extent to which digital media use may be linked to adolescents' social connectedness and well-being, and that these effects are likely fleeting in nature.

CONFLICT OF INTEREST STATEMENT
The authors have no conflict of interest to declare.

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DATA AVAILABILITY STATEMENT

Data and syntax are available upon request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.