Where it hurts the most: Peer interactions on social media and in person are differentially associated with emotional reactivity and sustained affect among adolescent girls

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Abstract

Social media (SM) use has increasingly changed how adolescents interact with their peers, yet it remains unclear how peer interactions on social media differ from in-person peer interactions. The current study evaluated whether the context (social media or in-person) of adolescent girls' worst and best peer interactions influenced their emotional responses to peer interactions and sustained affect in everyday life. In this study, a total of 110 adolescent girls (11–13 years old; mean age = 12.28 years) completed ecological momentary assessment (EMA) for 16 days following an initial baseline visit. Participants reported their worst (i.e., most negative) and best (i.e., most positive) interactions with peers since the last prompt, the context in which it occurred (social media or in-person), emotional reactivity during the interaction, and momentary affect. Multilevel models indicated that negative peer interactions that occurred on social media were more likely to be associated with sustained negative affect, but not negative emotional reactivity during the interaction. Positive interactions on social media were more likely to be associated with both lower positive emotional reactivity and lower sustained positive affect. Findings indicate that peer interactions on social media may differentially impact girls' emotional reactivity and sustained affect, particularly for positive interactions with peers. Findings highlight that social media and in-person peer interactions may impact how girls experience and respond to positive and negative peer interactions, which may have implications for peer relationships and onset of psychopathology during this vulnerable period.

Keywords: peers, social media, affect, emotional reactivity, adolescence, girls

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Adolescence is a critical developmental period during which there are a myriad of biological and psychosocial changes, particularly in the emphasis placed on peer relationships (Blakemore, 2008; Nelson, Leibenluft, McClure, & Pine, 2005; Schriber & Guyer, 2016). Adolescent girls are especially sensitive to the status and quality of peer relationships, including both socially-rewarding experiences and peer-related stressors (Rose & Rudolph, 2006; Silk et al., 2012). Perhaps not surprisingly, girls are more likely to experience peer stressors than boys during adolescence (Hamilton, Stange, Abramson, & Alloy, 2015), which contributes to an increased risk for poor mental health outcomes, such as depression, that emerge during adolescence (Hamilton, Stange, Abramson, & Alloy, 2015; Hankin, Mermelstein, & Roesch, 2007; Rudolph, 2002). In recent years, mobile technology and social media have transformed the adolescent environment and the context of peer interactions and relationships (Nesi, Choukas-Bradley, & Prinstein, 2018a, 2018b; Shapiro & Margolin, 2014). With the advent and rapid growth of social media, the majority of adolescents now prefer communicating with peers online compared to in-person communication (Pierce, 2009), which is particularly true for girls (Anderson & Jiang, 2018). Given the increasing pervasiveness of peer interactions on social media, it is critical to understand how youth respond to peer interactions that occur on social media compared to those that occur in person or face-to-face.

Most research and theory to date have focused on how social media has impacted in-person peer experiences and relationships, particularly on how social media displaces (i.e., takes away the amount of time in which youth interact in person) as well as stimulates and enhances in-person peer relationships (Nesi et al., 2018a; Valkenburg & Peter, 2011; Waytz & Gray, 2018). According

to the "cues-filtered-out" hypothesis (Walther, 2011), the absence of audio-visual and social cues might alter the experiences of peer interactions that occur online, which may heighten the ambiguity of peer interactions and also reduce the potential benefits derived from peer interactions. This illustrates the importance and complexity of social media as a platform for both negative and positive experiences (Weinstein, 2018) and social media's effect on adolescent well-being (Hamilton et al., 2020).

To date, most research comparing face-to-face and non-face-to-face interactions has focused on computer-mediated communication (CMC), which encompasses a variety of modalities such as text messaging, audio or visual phone calls, or social networking (DeClerck & Holtzman, 2018; Filipkowski & Smyth, 2012; Rains & Wright, 2016; Trepte, Dienlin, & Reinecke, 2015). These studies have investigated specific types of interactions, such as ostracism, criticism, and social support, and yielded mixed findings in how individuals perceive and respond to face-to-face as compared to CMC interactions. In an experimental paradigm with peer social support, young adults experienced fewer emotional benefits when receiving social support online as compared to support received in person (Holtzman, DeClerck, Turcotte, Lisi, & Woodworth, 2017). Recent research with adults also suggests that social support on social media versus in person may be differentially related to depression. For example, a recent national study with young adults aged 18–30 found perceived in-person social support to be associated with lower odds of depression, whereas social media-based social support was associated with higher odds of depression (Shensa et al., 2020). Other studies, however, have found social media-based support to be associated with lower depressive symptoms (Grieve, Indian, Witteveen, Anne Tolan, & Marrington, 2013; Nick et al., 2018). A laboratory experiment examining the effects of critical remarks made via text message compared to those made in person found that text messaging was

just as harmful as in-person criticism for young adults' negative affect and stress (DeClerck & Holtzman, 2018), with no differences observed between the two conditions. Importantly, experimental designs may not generalize to peer experiences in everyday life, where peer interactions will likely have greater meaning, emotional impact, and social consequences than those with a confederate. Thus, it is critical to understand peer interactions as they occur in everyday life to fully grasp how affective consequences may differ.

To date, two studies have used ecological momentary assessment (EMA) to examine the effects of in-person and CMC social interactions among young adults as they naturally occur in the real world (Kafetsios, Chatzakou, Tsigilis, & Vakali, 2017; Schwerdtfeger, Rominger, & Obser, 2020). Specifically, Kafetsios and colleagues (2017) found that women experienced more positive emotion and less negative emotion when the interaction occurred face-to-face as compared to CMC. These findings suggest that online interactions may have more negative effects than in-person interactions, whereas in-person interactions may have more positive effects than CMC. Of note, this study did not examine whether the social interaction was perceived as positive or negative, which cannot rule out the possibility that negative interactions simply occurred more often online than in person. To our knowledge, no EMA study has compared both positive and negative peer interactions among adolescents (as perceived by teens), which would provide more nuanced information about how modality influences the affective experience of peer interactions among a population for whom peer interactions are more salient and more likely to impact their emotional well-being. Further, it remains unclear whether online interactions and CMC are differentially associated with how individuals emotionally respond to interactions (i.e., emotional reactivity) or their lingering effects on mood (i.e., sustained affect), which may reflect different affective experiences and regulatory abilities.

Although prior research provides valuable information about differences between CMC and in-person social interactions, social media may have a distinct impact on how interactions occur even relative to other forms of CMC. According to the transformation framework (Nesi et al., 2018a, 2018b), social media has unique affordances that can impact peer relationships at both the dyadic and group level. Social media interactions can be asynchronous (i.e., allowing delays in when individuals receive and can respond to peers) as well as more permanent, public, readily accessible "24/7," and absent of cues as compared to in-person or other CMC social interactions (Nesi et al., 2018a). For instance, peer interactions on social media may be amplified compared to in-person peer interactions, such that more peers may bear witness to public interactions, thereby having more implications for peer status and relationships. Consistent with this, several studies found cyberbullying to have more negative effects on youth than traditional in-person bullying (Bonanno & Hymel, 2013; Kowalski, Giumetti, Schroeder, & Lattanner, 2014; Waasdorp & Bradshaw, 2015), with adolescents in an experimental manipulation perceiving cyberbullying as especially harmful when it is public (Sticca & Perren, 2013). The asynchronicity of peer interactions on social media may also lead to greater uncertainty and less immediate conflict resolution, thereby contributing to more intense or longer-lasting negative emotions. Further, the absence of certain nonverbal and verbal social cues in peer interactions may lead ambiguous interactions to be interpreted more negatively, as individuals have more difficulty decoding others' emotions (Derks, Bos, & von Grumbkow, 2008), and this absence may contribute to less effective problem solving (Nesi et al., 2018a). Although social media may enhance self-disclosure for girls (Valkenburg, Sumter, & Peter, 2011), it may lend itself to more informational support rather than the social and visual cues that affect warmth and intimacy. Thus, it is possible that the specific affordances of social media may serve to enhance the negative emotional impact of peer

interactions while simultaneously reducing its positive emotional benefits. In this sense, social media may elicit more negative responses or reactivity during the interaction and prolong the experiences of that negative emotion. In addition, it may also dampen positive emotions following peer interactions, resulting in sustained lower positive affect. This may be particularly true for peer interactions that adolescents perceive to be negative (i.e., the interaction that made them feel the 'worst') or peer interactions that are perceived to be positive (i.e., the interaction that made them feel the 'best'), which may elicit stronger emotional responses. To date, however, no known study has directly examined adolescents' affective responses to peer interactions on social media compared to those in person among adolescents as they occur in everyday life, particularly as they relate to adolescents' experiences of their most positive/best and negative/worst peer interactions.

Of note, differences between peer interactions and affective experiences on social media and face-to-face may be even more pronounced among adolescents who are at higher risk for anxiety and depression. First, youth with elevated depression or anxiety symptoms may be more likely to prefer communicating with peers online compared to in-person interactions (Erwin, Turk, Heimberg, Fresco, & Hantula, 2004), highlighting the importance of understanding how these experiences may differentially impact affective experiences. While some research suggests that online communication may be beneficial for youth with anxiety symptoms, particularly social anxiety (Pierce, 2009), individuals with anxiety may use social media as a means of regulating fears to social evaluations and rejection (Valkenburg & Peter, 2009) or spend more time passively browsing and engaging in social comparison (Thorisdottir, Sigurvinsdottir, Asgeirsdottir, Allegrante, & Sigfusdottir, 2019). In addition, youth with depression and anxiety may be particularly vulnerable to negative interpretation bias (Joormann & Quinn, 2014), which may heighten the potential for negative perceptions of ambiguous online communications. For

example, a study of youth with social anxiety, participants were more likely to perceive ambiguous responses online as more negative than those experienced in person (Kingsbury & Coplan, 2016), although it is unclear whether this finding generalizes to other forms of anxiety. Further, adolescent girls are more affected by peer interactions, particularly negative peer feedback (Silk et al., 2012) compared to boys, and are at heightened risk for developing depression and anxiety symptoms. Taken together, adolescent girls with elevated risk for anxiety and depression may be a particularly important population to examine the differential effect of perceived negative and positive peer interactions. Identifying whether there are different affective experiences resulting from peer interactions experienced on social media compared to those in person may shed light on longer-lasting effects on mental health and well-being.

The Current Study

To address gaps in prior research, the current study used ecological momentary assessment (EMA) to compare peer interactions that occurred via social media and in person and adolescent girls' affective experiences both during and after a peer interaction that they perceived as their 'best' (most positive) or 'worst' (most negative) interaction since the last assessment. Specifically, we sought to examine how adolescent girls' best and worst peer interactions on social media and in person related to their negative and positive emotional responses to the interactions (i.e., emotional reactivity) and their sustained positive and negative affect. By evaluating both their positive and negative responses to the peer interactions and sustained affect, our study aims to shed light on the full range of affective experiences across peer interactions. Further, given the importance of understanding the context of everyday peer interactions among adolescents at risk for depression and anxiety symptoms, we examined these relationships among a sample of girls enriched to have a shy/fearful temperament (without

current anxiety or depressive disorders) who may be more likely to be negatively affected by social media and to develop subsequent psychopathology (Chronis-Tuscano et al., 2009). Based on prior EMA studies (Kafetsios et al., 2017) indicating that CMC peer interactions were associated with less positive and more negative affect, we hypothesized that adolescent girls' worst/most negative peer interactions would be associated with more negative emotional reactivity during the interaction and sustained negative affect when they occurred on social media compared to in-person interactions. In contrast, we hypothesized that adolescent girls' best/most positive peer interactions would be associated with more positive emotional reactivity and sustained positive affect when occurring in person as compared to on social media, which would be associated with lower positive emotional reactivity and sustained positive affect. Further, given the complexity of emotional experiences, the current study also conducted exploratory analyses examining whether the context of the peer interaction differentially impacted specific emotional reactivity during girls' best and worst peer interactions.

Method

Participants

The current study's sample was drawn from the Girls Interactions in Real Life Study of Brain Development (GIRLS: Brain Study), which is a multi-wave, longitudinal study designed to investigate the socio-affective and neural processes influencing the development of depression and anxiety symptoms among adolescent girls. The study recruited 129 adolescent girls between the ages of 11 and 14 and their primary caregivers via online and community announcements. Specifically, the current study oversampled adolescent girls with shy and/or fearful temperament, as the extant literature indicates that youth with such temperament show increased vulnerability for developing depression and social anxiety (Chronis-Tuscano et al., 2009; Gladstone & Parker,

2006). The study used the Fear and Shyness subscales of the Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Capaldi & Rothbart, 1992; Ellis & Rothbart, 2001) as a screening measure completed by the parent and child to determine participant risk status, with two-thirds of the overall sample scoring 0.75 SD above the mean. The EATQ-R has demonstrated good convergent validity in prior samples of adolescents (Muris & Meesters, 2009), and the two subscales had adequate reliability in the current study (Parent: α = .80; Child: α = .75).

Participants were excluded from the study if they met current or lifetime DSM-5 diagnostic criteria for any anxiety disorder (with the exception of specific phobia), major depressive disorder, or any psychotic or autism spectrum disorder. Trained clinical interviewers administered the Kiddie-Schedule for Affective Disorders and Schizophrenia (KSADS-PL; Kaufman et al., 2016) to determine diagnostic criteria exclusion. Participants were excluded due to: the presence of acute suicidality or risk of harm to oneself or others; the presence of neurological anomalies or head injury; any lifetime presence of a neurological or serious medical condition; intellectual disability; the use of psychoactive or other medications interacting with brain functioning (with the exception of stimulants); the presence of MRI contraindications (e.g., metal in the body, including braces); and the presence of uncorrected ocular impairments that would interfere with eye-tracking measurements.

Of the 129 participants recruited, 3 withdrew prior to the baseline assessment and 4 participants dropped out of the EMA portion of the study. Six participants were removed from analysis because of providing unusable data (n = 4; technical issues; providing fake responses) and less than 25% of the EMA prompts (n = 2). Thus, a total of 116 participants completed EMA. However, four participants did not endorse any peer interactions and two did not complete

the anxiety measure; in turn, these participants were not included in the final sample. The final sample consisted of 110 girls (n = 72 (65%) high risk). The average age was 12.28 years (SD = .80 years). Girls self-identified as 68% White, 20% Black/African American, 8% Biracial, and 4% Asian, Native American, or 'Other'; 9 girls (8%) also identified as Hispanic/Latinx.

Procedure

The GIRLS: Brain Study is an ongoing, multi-wave, longitudinal study design including three time points for data collection. The current study includes only data from the initial study visit and EMA study period. Upon receiving informed consent and assent from both the participating parent and adolescent daughter, respectively, participants completed an in-person baseline visit followed by a 16-day EMA protocol. The EMA data comprised participants' responses to brief questions administered via study-provided smartphones. Participants began the EMA protocol during the weekend. It was administered for 16 consecutive days, with 3 prompts on weekdays and 4 prompts on weekends. For the first weekday prompt administration, participants indicated a time prior to the beginning of school hours; participants otherwise completed the two remaining prompts that were randomly administered after school hours. Importantly, no EMA prompts were administered during school hours. To capture representative assessments, weekday prompts occurred randomly within two blocks of time (i.e., morning and after school/evening hours) and weekend prompts occurred randomly within four blocks of time (i.e., morning, early afternoon, late afternoon, and evening hours). In total, participants received 54 EMA prompts throughout the course of data collection. The EMA protocol prompted participants to report information about their most positive and negative interactions with other kids their age, affective responses to each interaction, and momentary affect. The University of Pittsburgh Institutional Review Board approved all study procedures.

Ecological Momentary Assessment Measures

Peer interactions and emotional reactivity. Participants were asked to report their best and worst social interactions since the last EMA prompt, which are also referred to as positive and negative interactions, respectively. Using a free-text box, participants responded to the prompt: "*Think about the interaction with other kids your age that made you feel the worst since the last beep on (prior EMA collection time). What happened?*". Participants then indicated the context in which the interaction occurred, with options including: in person; over the phone; text message; social networking site (Facebook, Instagram, Snapchat, etc.); FaceTime, Skype, webcam; and other (allowing for further free-text specification). Next, participants reported others who were involved in the interaction, which included friends, romantic interests, other peers, and siblings and/or cousins within 2 years of participant age. To capture the recency of each interaction, participants were asked, "*When did this interaction occur?*" Response options ranged from 0–9, with higher numbers reflecting more time elapsed since the interaction: within the last 15 minutes, within 30 minutes, 1 hour ago, 2 hours ago, 3 hours ago, 4 hours ago, more than 4 hours ago, last night, yesterday, and before yesterday. To assess emotional reactivity, participants were then asked, "*Please rate how you felt during this interaction*." Participants rated their negative emotional responses (i.e., sadness, worry, stress, anger) to the perceived worst interaction on a sliding scale ranging from "*Not at all (0)*" to "*Extremely (100)*." Participants' negative affective rating scales were adapted from the Positive and Negative Affect Schedule for Children, which demonstrates good convergent and discriminant validity in prior studies with adolescents (PANAS-C; Laurent et al., 1999). In the current study, the mean of the negative emotions at each prompt was calculated for negative emotional reactivity. Exploratory analyses focused on each individual negative emotional response.

To examine positive interactions and emotional responses, participants were then prompted: "*Again, think about your interactions with other people since the last beep on (prior EMA collection time). Think about the interaction that made you feel best. What happened?*". Participants completed identical follow-up questions detailed above for the positive interactions (i.e., recency of interaction, involvement of others), with response options for those involved including friends, romantic interests, other peers, and siblings and/or cousins within 2 years of participant age. Positive affective ratings assessed the extent of positive emotional responses to the perceived best interaction on a 0–100 scale (happy, joyful, excited, interested). Similar to participants' negative affective ratings, the positive affective rating scales were adapted from the PANAS-C (Laurent et al., 1999). The mean of the positive emotions at each prompt was calculated for positive emotional reactivity to the interaction.

Given the focus on peer interactions and the difference between events that occur on social media and in person, only interactions that included peers (friends, boy/girlfriend, other peers) and interactions that occurred in person or on social media (i.e., text or social networking site) were included in the current study. Worst/best peer interaction type was coded as 0 (in-person) or 1 (social media: social networking sites or text). Information regarding the percentage of perceived negative and positive interactions that occurred by phone (audio or video) or other modalities (e.g., email, video games) are reported in Figure 1, but were not categorized as social media in the current study. The percentage of each person's peer interactions endorsed on social media relative to total peer interactions (occurring on social media or in person) was also calculated.

Sustained negative and positive affect. Participants reported their momentary state of negative emotions (sadness, worry, stress, anger) and positive emotions (happy, joyful, excited,

and interested) on a sliding scale from 0–100 for each emotion. Negative and positive affective states were calculated at each prompt by calculating the average of negative emotions and positive emotions, respectively. Although momentary affect may not be directly linked with the occurrence of the perceived best/worst peer interactions, the current study operationalized momentary affect as the extent to which positive and negative affective states were sustained following a peer interaction. These affective states were reported as preceding the current EMA prompt and affective state.

Baseline Anxiety Symptoms. Baseline anxiety symptoms were assessed during the initial study visit using the Screen for Anxiety Related Emotional Disorders (SCARED; Bodden, Bogels, & Muris, 2009), which is a 44-item questionnaire that assesses symptoms of panic disorder, generalized anxiety, separation anxiety, social anxiety, and school avoidance. The SCARED used in the study was a modified version of the longer 71-item SCARED. A higher total score indicates higher levels of anxiety, which was used in the current study as a covariate. The SCARED yielded excellent (α = .94) levels of internal consistency in the current study and has demonstrated good predictive (Bodden et al., 2009), discriminant, convergent, and divergent validity in prior studies with adolescents (Monga et al., 2000).

Pubertal Development. The Pubertal Development Scale (PDS; Petersen, Crockett, Richards, & Boxer, 1988) was used to assess youth pubertal status, which is a validated self-reported measure. The PDS yielded levels of internal consistency and has demonstrated good convergent validity with physician-rated stages of pubertal development in prior studies with adolescent samples (Petersen et al., 1988). PDS scores were converted to a 5-point scale using a coding system paralleling Tanner Stages (Shirtcliff, Dahl, & Pollak, 2009). The PDS had adequate internal reliability (α = .85) in this sample. The current study evaluated whether

pubertal development was associated with primary study variables and included it as a covariate in the event of a significant association.

Statistical Analyses

Preliminary analyses first examined EMA prompts endorsed for girls' perceived most negative and positive peer interaction. Using the final sample, descriptive statistics and bivariate correlations for primary variables were examined using mean-level study variables. Correlations and t-tests were conducted to examine primary study variables by sample demographics (age, pubertal development, race, and risk status [based on the initial recruitment procedures]). For the context of peer interactions, the percentage of best or worst peer interactions endorsed on social media relative to total peer interactions (occurring on social media or in person) was included as a mean-level variable for correlation analyses. Prior to conducting analyses, we tested for patterns of missingness of the final sample and examined the assumptions of multilevel modeling.

For all analyses, we conducted multilevel modeling to account for the hierarchical nature of the data (Raudenbush & Bryk, 2002), with EMA prompts (level 1) nested within subjects (level 2). First, unconditional models (without any predictors) were tested and there was adequate variance at both between- and within-person levels for affective outcomes (Supplemental Table 1). An autoregressive correlation structure was used for the data given that adjacent timepoints were expected to be more highly correlated. Fixed effects were entered for primary variables (interaction type) and all covariates (see below). Individuals were allowed to vary in their intercepts of affective outcomes (random intercept) and in the effect of peer interaction context on affective outcomes (random slope). Primary analyses focused on the: 1) fixed effect of negative peer interactions on social media compared to those in person on

negative emotional reactivity to that interaction and sustained negative affect, and 2) the fixed effect of positive peer interactions on social media compared to those in person on positive emotional reactivity to the interaction and sustained positive affect. Individual variability of random slopes of social media-affect outcomes were also examined.

Covariates were centered prior to analysis and included prior timepoint affective state or response (e.g., lagged/prior emotional reactivity or momentary affect), recency of the best/worst peer interaction, and study day (weekend/weekday). Given study recruitment procedures, group status and baseline anxiety symptoms also were included as covariates to account for individual differences in anxiety, which might influence engagement and responses to online and in-person peer interactions (Valkenburg & Peter, 2009; Vannucci, Flannery, & Ohannessian, 2017). To account for individual differences in total peer interactions endorsed on social media versus in person, person-level (level 2) percentages of negative and positive peer interactions endorsed on social media as compared to those in person were included. Multilevel analyses were conducted in R 3.6 using nlme function with Full Information Maximum Likelihood (FIML) for positive and negative emotional reactivity and sustained positive affect. Sustained negative affect violated the assumptions of normality of residuals (there were no other violations) and possessed a zero-inflated distribution in sustained negative affect. Consequently, a two-part fixed effects model for semi-continuous data (Olsen & Schafer, 2001) was used with the GLMMadaptive package in R. The models include a logistic model for the probability of a nonzero response and a conditional linear model for the mean response for nonzero data. A random intercept was specified for both the logistic and continuous steps, and a random slope for peer interaction type was included for the continuous data. To examine specific emotional responses for best and worst reactions to peer interactions, exploratory analyses were conducted using the same

procedure as above with each affective response as a dependent variable. Effect sizes (Cohen's *d)* were estimated using the "EMATools" package for linear mixed models in R, though caution is recommended when interpreting these effect estimates for multilevel models.

Results

Descriptive Statistics

The 110 participants completed an average of 43.5 EMA prompts (ranging from 20–54). On average, participants had nearly 80% of their positive or negative peer interactions occur in person as compared to social media interactions. Thus, girls reported that 19.86% of their positive peer interactions (ranging from 0–89%) and 19.92% of negative peer interactions (ranging from 0–97%) occurred on social media. There were no significant associations in the percentage of peer interactions (positive and negative) that occurred on social media (as compared to those in person) by risk status (t (108)= .65, p = .52), age (r = .16), pubertal development (r = .04), or race (White or Person of Color [collective grouping of individuals identifying as Black, Biracial, Latinx, Asian, Native American, or 'Other']: t (108) = 1.04, p = .30). In total, girls had an average of 17.50 (SD = 11.04; range = 2–45) prompts endorsing negative peer interactions and 22.86 (SD = 10.44, range = 1–46) prompts endorsing positive peer interactions that occurred in person or on social media. Girls with higher average positive affect (sustained and reactivity) were more likely to complete EMA prompts, with missing values estimated using FIML as noted above. There were no other observed patterns of missingness based on study or demographic information. See Figure 1 for information about inclusion and exclusion of EMA prompts.

Bivariate correlations for primary study variables (mean-level) are provided in Table 1. As expected, girls who reported more positive social media peer interactions also reported more

negative peer interactions on social media. Baseline anxiety was significantly associated with negative emotional reactivity and sustained negative affect. Similarly, corresponding affective states and reactivity were highly correlated with one another. Further, individuals with more negative emotional reactivity also tended to have more positive emotional reactivity. Sustained negative and positive affect were not correlated. There were no significant associations with pubertal development and primary study variables; thus, puberty was not included as a covariate in study analyses.

Context of Worst Peer Interactions and Negative Affective Outcomes

Negative Emotional Reactivity. For our model examining girls' negative emotional reactivity to the worst peer interaction, there was no significant fixed effect of the interaction type and whether it occurred on social media or in person (Table 2). Of the covariates, there were significant effects of baseline social anxiety, prior timepoint negative emotional reactivity, and peer interactions that were less recent. There was significant variability in girls' overall levels of negative emotional reactivity and the effect of peer interaction type on negative emotional reactivity. For exploratory analyses of the specific emotional responses to the worst peer interaction (Supplemental Table 2), there was a significant fixed effect of peer interaction context only on responses of sadness, such that negative peer interactions on social media elicited higher levels of sadness than negative peer interactions that occurred in person. There were no significant differences between social media or in-person peer interactions on feelings of anger, worry, or stress during the worst peer interaction.

Sustained Negative Affect. The two-part fixed effects model included a continuous and a zero-inflated portion. The continuous multilevel model indicated that negative peer interactions that occurred on social media compared to those in person were significantly associated with

higher levels of sustained negative affect (Table 2) when negative affect was above zero. However, the zero-inflated portion of the multilevel model indicated that social media peer interactions did not significantly predict the likelihood of having sustained negative affect (any versus none). Of the covariates, prior timepoint negative affect and baseline anxiety symptoms predicted sustained negative affect in both models. There was no significant effect of overall levels of peer interactions endorsed on social media compared to those in person on sustained negative affect.

Context of Best Peer Interaction and Affective Responses

Positive Emotional Reactivity. There was a significant effect of positive peer interactions that occurred on social media compared to those in person on positive emotional reactivity during the interaction (Table 3), such that girls had more positive emotional reactions during interactions that occurred in person compared to those on social media. Estimated effect size was small (Cohen's d =.10). More recent positive interactions with peers were also associated with higher levels of positive emotional reactivity. Of note, there were significant individual differences in levels of positive affect and in the effects of peer interaction type on positive emotional reactivity. For exploratory analyses of individual positive responses, best peer interactions that occurred in person predicted higher levels of happiness and excitement relative to social media peer interactions (Supplemental Table 3), but there were no significant effects on feeling more interested or joyful.

Sustained Positive Affect. Multilevel models indicated that the best (most positive) peer interactions that occurred on social media compared to those in person were associated with lower levels of sustained positive affect (Table 3). In other words, when positive peer interactions occurred in person, girls were more likely to report higher levels of sustained

positive affect (though estimated effect sizes were small with a Cohen's *d* of.12). Of the covariates, positive affective state at the prior timepoint, weekend days, and more recent positive interactions also were associated with higher levels of positive affect. There was no significant effect of overall levels of peer interactions endorsed on social media compared to those in person on sustained positive affect. Positive peer interactions that occurred in person were significantly associated with higher positive affect and interactions on social media were associated with lower levels of sustained positive affect. However, this did not appear to be accounted for by the proportion of peer interactions occurring on social media relative to those in person.

Discussion

Social media is increasingly becoming a prominent mode of communication among adolescents (Anderson & Jiang, 2018). Yet, it remains unclear how peer interactions that occur on social media affect adolescents' emotional experiences compared to when they occur in person. Using an EMA design to assess adolescents' naturally-occurring best and worst peer interactions across a 16-day period, the current study was the first to examine the associations between social media and in-person peer interactions with adolescent girls' emotional reactivity during the interaction and sustained affect. Consistent with our hypotheses, positive peer interactions (i.e., adolescents' reported best peer interactions) were significantly associated with both lower positive emotional reactivity to the interaction and sustained positive affect when they occurred on social media compared to in person. In partial support of our hypotheses, adolescent girls' most negative peer interactions (i.e., perceived worst peer interactions) were significantly associated with higher levels of sustained negative affect, but not negative emotional reactivity, when they occurred on social media rather than in person. Our exploratory analyses of specific emotional responses indicate that, compared to in-person interactions,

negative peer interactions on social media were only associated with sadness during the interaction; however, positive peer interactions in person were associated with both more happiness and excitement during the interaction. It is important to note that we controlled for individuals' overall percentage of reported social media as compared to in-person interactions, which were unrelated to affective states and reactivity. This further provides support for the within-person nature of our findings, such that compared to an individual's own interactions in person, social media appears to lessen the beneficial aspects of positive peer interactions and intensify the affective consequences of negative peer interactions.

There are several reasons why social media may differentially affect the positive and negative emotional experiences of peer interactions for adolescent girls. Consistent with the transformation framework (Nesi et al., 2018a, 2018b), negative and positive peer interactions that occur on social media may possess certain features or characteristics that impact how interactions occur and both the emotional experience and perception of interactions. In particular, cue absence may make people more likely to say things online that otherwise would not be said because they do not witness its social effects (Kelly et al., 2012; Reid & Reid, 2010). This could mean that actual negative interactions are worse when experienced through social media or text, thereby eliciting more sadness or contributing to sustained negative affect. Cue absence could also impact positive peer interactions by stripping away certain beneficial aspects of positive interactions, such as vocal and facial cues, which further reinforce positive emotions (Sauter, 2017). These findings are consistent with prior research that positive interactions on CMC generate less positive emotion and emotional bonding with others (Holtzman et al., 2017; Sherman, Michikyan, & Greenfield, 2013). Asynchronous communication also may allow negative interactions to linger without resolution or prevent synchronous experience of shared

positive emotionality. This could contribute to maladaptive emotion regulatory responses, such as ruminating over negative interactions leading to more negative affect over time or dampening positive emotion during and after positive interactions (Hamilton et al., 2017). It may further intensify its negative impact over time, even if not initially eliciting more overall negative emotional responses. Thus, it could be that peer interactions that are perceived as more negative are more salient and harmful when they occur on social media.

There are several considerations to discuss in light of these findings, which raise important questions for future research. First, despite our findings and public concern about social media, it is important to recognize that adolescent girls in the current study were more likely to report the majority of their best and worst peer interactions as occurring in person rather than on social media. Consistent with the Pew research surveys (Anderson & Jiang, 2018), youth who reported that their worst peer interactions were on social media also were more likely to report that their best peer interactions were on social media, suggesting that social media may be a source of both positive and negative peer experiences. Second, direct communication is typically considered to be a more adaptive use of social media than passive consumption of social media (Escobar-Viera et al., 2018; Verduyn et al., 2015). Thus, while peer interactions perceived as negative and positive may have different affective consequences than in-person experiences, active social media use that involves direct peer interactions (i.e., direct messaging through a social media platform) may still indicate more beneficial use. Further, there may be biased experiences in the events that adolescents report on social media compared to those occurring in person. Social media interactions are continuous in today's world; thus, adolescents may be biased in the interactions that they recall as negative or positive. For instance, more recent positive peer interactions were associated with more positive emotional reactivity,

whereas fewer recent negative peer interactions were associated with more negative emotional reactivity. Further, given that adolescents' best/worst interactions are based on subjective perception, there may be individual differences in how adolescents determine what constitutes as their best/worst interaction, which might not be uniform across individuals. Thus, it is possible that there was a recall bias in the types of events that were reported for their best and worst interactions on social media compared to those in person, which may not reflect events that could be defined more objectively as positive or negative interactions.

There are several key limitations and critical next steps for future research. As noted above, the specific characteristics of adolescents' best and worst peer interactions remain unknown, and social media peer interactions are likely varied in their occurrence and context (e.g., public versus private). Although our study is comparing the affective experiences of social media and in-person peer interactions, it is possible that this is akin to drawing comparisons between apples and oranges if the type, quality, and experience of these interactions are not similar. For instance, cyberbullying is not necessarily considered an extension of in-person peer experiences, but rather a unique form of victimization that has a more negative mental health impact (Landoll, La Greca, Lai, Chan, & Herge, 2015). Although a strength of our study is the use of EMA to assess naturally-occurring peer interactions, we did not exhaustively assess other peer interactions occurring in person or on social media. Other online and in-person interactions with peers or experiences on social media without direct interactions may have occurred and impacted emotional experiences, and our study did not examine the duration or quality of peer experiences in either context. In addition, overall levels of negative affect endorsed were low, which was surprising given that most girls were at high risk for depression and anxiety symptoms. Although we accounted for this with our analytic approach, it might limit generalizability to samples with higher levels of endorsed negative affect.

Although our study operationalized momentary affect as sustained affect following a positive or negative peer interaction, momentary affect also was not directly linked to the peer interaction; thus, other sources could have contributed to changes in negative or positive affect. Further, our study examined social media and text messages as one category given the interchangeability of texting and social media among adolescents. However, these may reflect distinct experiences given the unique affordances associated with different types of social networking sites and the variety of activities on these sites (Nesi et al., 2018a). Further, it is important to note that our findings may not generalize to adolescent girls who are not at risk for depression and anxiety symptoms. Girls in our study may be more likely to prefer online communication, which has been found to be associated with difficulties in emotion regulation (Myruski, Quintero, Denefrio, & Dennis-Tiwary, 2019), or be more likely to have other vulnerability factors that heighten risk (e.g., lower social status). There are also likely individual differences in the nature and closeness of relationships among the peers with whom they interacted. This study did not examine the valence or specific content of reported peer interactions, which may be subject to individual bias and have differential effects on affective states. Further, it is possible that the temporal ordering of EMA questions (with negative peer interactions assessed first) might have biased reporting of subsequent interactions and affective states. However, the idiographic approach to analyses mitigates the potential effects of bias within an individual, such that there may be some consistency within an individual of their perceptions of peers, the ordering of questions, and the best/worst peer interactions. While preliminary, our findings may indicate that higher-risk girls are more susceptible to the negative impact and less positively affected by peer interactions on social media.

In summary, social media can be beneficial in many ways. It can facilitate social communication and connection with peers by increasing access to new relationships, helping youth

express and form identities, and promote and strengthen peer and familial relationships (Hamilton, Coulter, & Radovic, 2020). However, our findings suggest that there may be key differences in how in-person and social media peer interactions are experienced by adolescent girls, such that social media may reduce the positive emotional benefits of positive peer interactions and amplify the latent impact of negative peer interactions and sustain negative affect. Although our study did not examine psychopathology, it is possible that these findings could have broader implications for the emergence of depression. It is also important to note that this study should be considered preliminary, and future research is needed to better understand *which* specific aspects of peer interactions on social media differently affect girls. Further, given that social media use is associated with prolonged cortisol responses following stress exposure (Rus & Tiemensma, 2017), future research is needed to identify the specific mechanisms through which these peer interactions are more likely to elicit sadness, sustain negative affect, and reduce positive emotionality during and after the interaction. Our study extends prior research and provides initial findings supporting the distinct effects of peer interactions on social media compared to in-person peer interactions among adolescent girls.

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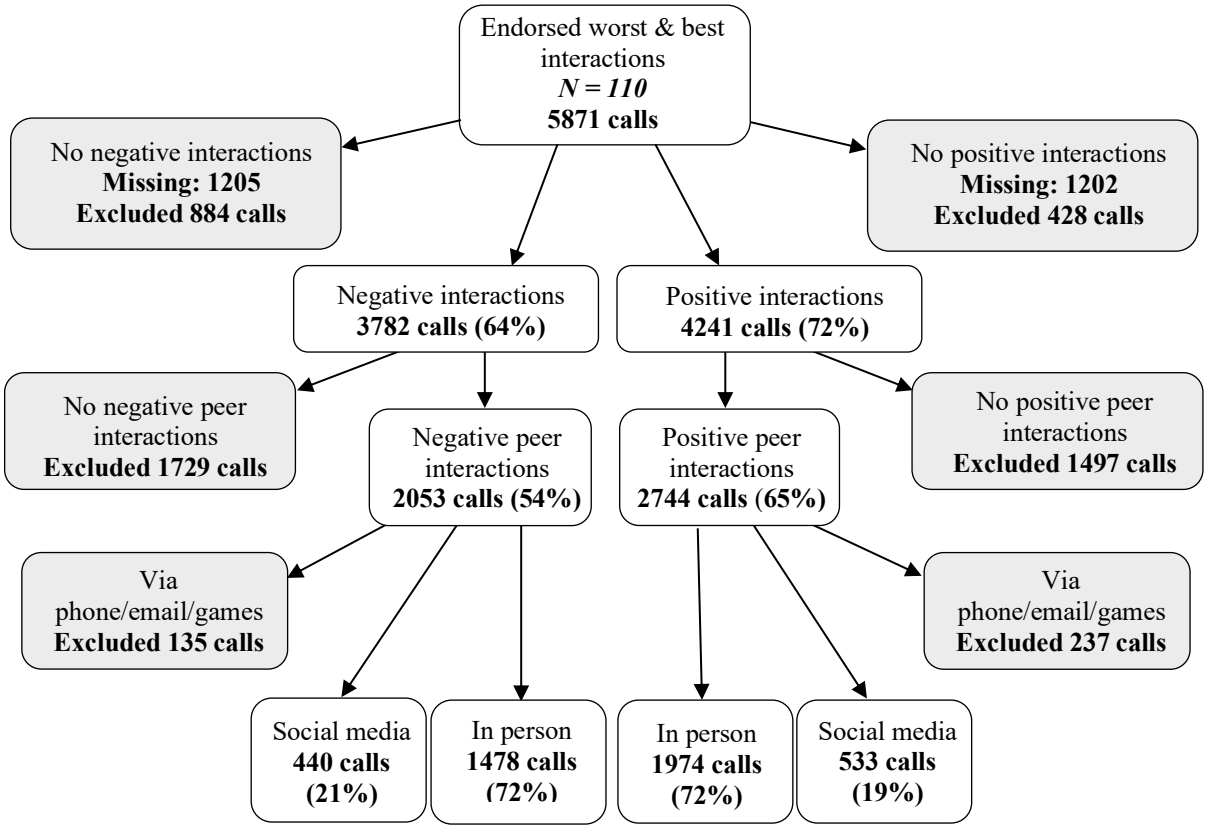
Figure 1. Ecological momentary assessment (EMA) of negative and positive peer interactions in person and on social media [*N*, Calls (%)]



Note. Reasons for initial EMA exclusion, included event endorsed was "nothing" or did not provide interaction with other (e.g., sleeping, eating). Interactions that were not with peers included family members (e.g., siblings, cousins, parents) or other adults.

Table 1. Means, standard deviations, and correlations of primary study variables

Variable	*M*	*SD*	1	2	3	4	5	6	7
1.Percent Worst Peer Int (SM)	20.52%	21.54							
2. Percent Best Peer Int (SM)	19.82%	19.66	**.67**						
3. NA mean	8.79	9.32	.04	-.07					
4. PA mean	49.76	23.06	-.11	-.17	-.03				
5. NA React mean (worst)	21.41	15.33	.06	-.01	**.68**	.06			
6. PA React mean (best)	61.73	23.17	-.07	-.07	.05	**.82**	**.26**		
7. Anxiety	16.57	11.57	.04	-.03	**.31**	.02	**.36**	-.01	
8. Puberty	3.46	1.05	-.06	-.00	.10	-.15	.07	-.02	.01

Note. M and *SD* are used to represent mean and standard deviation, respectively. Int = Interaction; SM = Social Media; NA = Negative Affect; PA = Positive Affect; React = Reactivity to best or worst peer interaction. Percent of Worst or Best Peer interaction reflects the overall percentage of interactions that occurred on social media compared to in-person. The means of NA and PA (overall and reactivity) reflect the grand mean reported on a scale from 0-100 (most negative/most positive). Anxiety = Baseline anxiety symptoms on the total score of the SCARED. Puberty = Pubertal development according to the PDS.

Table 2. Negative peer interactions on social media vs. in person and sustained negative affect and emotional reactivity

	Sustained Negative Affect			**Negative Emotional Reactivity**		
Predictors	Estimates	CI	***p***	Estimates	CI	***p***
(Intercept)	1.66	1.34 – 1.99	**<0.001**	24.96	20.47 – 29.58	**<0.001**
Neg Peer Int Type (SM)	0.27	0.01 – 0.53	**0.04**	0.62	-1.90 – 3.15	0.63
High Risk Status (1)	0.02	-0.36 – 0.41	0.90	-0.75	-6.52 – 5.03	0.80
Neg Peer Int Mean (SM)	-0.01	-0.02 – 0.00	0.09	-0.08	-0.21 – 0.06	0.26
Anxiety Symptoms	0.02	0.01 – 0.04	**0.01**	0.47	0.23 – 0.71	**<0.001**
Neg Event Recency	-0.03	-0.05 – 0.00	0.07	0.43	0.17 – 0.70	**0.002**
Weekend (1)	-0.10	-0.25 – 0.04	0.16	-0.33	-1.74 – 1.08	0.65
Prior NA	0.01	0.01 – 0.02	**<0.001**			
Prior NA Reactivity				0.20	0.16 – 0.24	**<0.001**
Zero-Inflated Model						
(Intercept)	-0.98	-1.57 – -0.39	**0.001**			
Neg Peer Int Type (SM)	-0.05	-0.37 – 0.27	0.74			
High Risk Status (1)	0.36	-0.36 – 1.09	0.33			
Neg Peer Int Mean (SM)	0.01	-0.01 – 0.02	0.48			
Anxiety Symptoms	-0.04	-0.07 – -0.01	**0.01**			
Neg Event Recency	0.03	-0.02 – 0.08	0.21			
Weekend	0.21	-0.05 – 0.46	0.11			
Prior NA	-0.03	-0.04 – -0.01	**<0.001**			
Random Effects						
σ^2 (Residual)		1.00			181.33	
τ_{00} (Intercept)		0.77			152.22	
τ_{11} (Random Slope)		0.29			50.61	
τ_{00} (Intercept: zero-inflated)		2.25				

Note. Significant effects are bolded. Neg = Negative; Int = Interaction; SM = Social Media;

Weekend (1) = Saturday/Sunday; NA = Negative Affect. Risk status is 0 = low risk; 1 = high risk. Percent of Worst or Best Peer interaction reflects the overall percentage of interactions that occurred on social media compared to in-person. Negative Affect represents sustained negative affect, whereas negative emotional reactivity reflects negative emotions during the worst peer interaction on EMA. Degrees of freedom are 105 for between-person (level 2) variables and 1674 for within-person/repeated measures (level 1) variables.

Table 3. Positive peer interaction on social media vs. in person and sustained positive affect and emotional reactivity

	Sustained Positive Affect			**Positive Emotional Reactivity**		
Predictors	Estimates	CI	***p***	Estimates	CI	***p***
(Intercept)	51.02	45.09 – 56.95	**<0.001**	65.72	59.20 – 72.24	**<0.001**
Pos Peer Int Type (SM)	-3.45	-5.84 – -1.05	**0.003**	-2.84	-5.12 – -0.56	**0.02**
High Risk Status (1)	1.22	-6.23 – 8.67	0.75	0.06	-8.23 – 8.36	0.99
Pos Peer Int Mean (SM)	-0.15	-0.32 – 0.03	0.10	-0.10	-0.30 – 0.10	0.30
Anxiety Symptoms	0.09	-0.23 – 0.40	0.58	0.16	-0.19 – 0.51	0.36
Pos Event Recency	-1.17	-1.46 – -0.89	**<0.001**	-0.32	-0.55 – -0.09	**0.01**
Weekend (1)	2.39	0.87 – 3.92	**0.002**	1.12	-0.27 – 2.52	0.12
Prior PA	0.22	0.18 – 0.26	**<0.001**			
Prior PA Reactivity				0.11	0.08 – 0.14	**<0.001**
Random Effects						
σ^2 (Residual)		290.70			207.89	
τ_{00} (Intercept)		312.28			354.80	
τ_{11} (Random Slope)		32.71			46.49	

Note. Significant effects are bolded. Pos = Positive; Int = Interaction; SM = Social Media; Weekend (1) = Saturday/Sunday; PA = Positive Affect. Risk status is 0 = low risk; 1 = high risk. Positive Affect represents sustained positive affect, whereas positive emotional reactivity reflects positive emotional responses during the best peer interaction on EMA. Degrees of freedom are 105 for between-person (level 2) variables and 2246 for within-person/repeated measures (level 1) variables.