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Co-rumination across in-person and digital communication: Associations with affect and relationship closeness in adolescents

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ABSTRACT

Introduction: Despite the prominence of interpersonal emotion regulation, particularly during adolescence, it is a relatively understudied area of investigation. Co-rumination is an interpersonal emotion regulation strategy that is frequently used by adolescents. Traditional examinations of co-rumination have focused on its occurrence in person, while largely overlooking digital modes of communication. This study was the first to investigate adolescents' co-rumination across multiple communication modalities (i.e., in person, text, social media, phone) and its downstream association with affect and relationship closeness. Specifically, we examined: (1) the frequency of co-rumination across modalities, (2) the effect of co-rumination in one modality on the future use of co-rumination within that same modality (i.e., stability) and across other modalities (i.e., generalization); and (3) the prospective relation of co-rumination on negative affect, positive affect, and relationship closeness.

Methods: Adolescents ($n = 71$; 33 girls and 38 boys; $M_{\text{age}} = 12.70$ years) residing in Canada completed twice-daily diary surveys for 14 days.

Results: Findings indicated that adolescents co-ruminate across all modes of communication, particularly in person. There also was evidence of co-rumination stability and generalization over time for some modes of communication (within phone and from social media to in-person interactions), but not for others. Co-rumination through text and over the phone had affective and/or social benefits, whereas co-rumination through social media predicted diminished positive affect. We also identified ways these findings differed by gender.

Conclusions: Implications for adolescents' emotional and social development and the field of co-rumination are discussed.

It is common to encounter stressors in our everyday lives. To effectively respond to such stressors, emotions must be modulated regularly, a process known as emotion regulation (Gross, 1998). Research to date has focused predominantly on emotion regulation as an intrapersonal process; however, researchers are increasingly recognizing that emotion regulation often occurs in an interpersonal context (Dixon-Gordon et al., 2015; Zaki & Williams, 2013). Interpersonal emotion regulation is particularly salient during adolescence when youth's social networks expand, resulting in more communication with, and dependency on, peers (Steinberg & Silverberg, 1986; Wray-Lake et al., 2010). Despite the importance of interpersonal emotion regulation, particularly during adolescence, it is a relatively understudied area of investigation.

One important interpersonal emotion regulation strategy is co-rumination. It is characterized by dwelling on negative feelings and

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problems in the context of a dyadic interaction (Dixon-Gordon et al., 2015; Rose, 2002). Co-rumination is associated with cross-sectional and longitudinal increases in negative affect and internalizing symptoms (i.e., anxiety and depression; Spendelow et al., 2017; Stone et al., 2019). However, in contrast to its mental health risks, co-rumination has significant interpersonal advantages, such as promoting greater friendship quality (Boren, 2014; Calmes & Roberts, 2008; Moreira et al., 2016; Rose, 2002). The social benefits of co-rumination may be explained by high levels of self-disclosure (sharing one's thoughts and feelings with another; Wei et al., 2005), which has been found to increase intimacy (Camarena et al., 1990; Wei et al., 2005).

The majority of co-rumination research to date has studied the effects of co-rumination through in-person interactions. In fact, research on co-rumination through other modalities of communication is sparse. This is surprising considering that digital technology has significantly diversified how people, particularly adolescents, communicate (Katz, 2008). Compared to other age groups, youth use digital technology at the highest rate (an average of 7.5 hours a day; Lenhart et al., 2010; Rideout et al., 2010). Approximately 95% of adolescents use a cell phone, and 90% of adolescents with a cell phone engage in texting (Anderson & Jiang, 2018; Lenhart, 2015). On average, adolescents send and receive 30 texts per day (Lenhart, 2015). Social media is also highly prevalent, with new platform releases and increases in platform popularity creating an important social environment for youth. Indeed, approximately 9 out of 10 teens appear online daily (Anderson & Jiang, 2018). Although the advancement of modern technology has facilitated the ease and accessibility through which adolescents communicate with peers, research to date has focused almost exclusively on investigating co-rumination as it occurs in person. Thus, the prevalence and downstream effects of co-rumination through other communication modalities remain unclear.

Only two longitudinal studies to date have investigated co-rumination through digital technology in adolescents (Frison et al., 2019; Van Zalk & Tillfors, 2017). Frison and colleagues investigated the prospective influence of co-rumination during private Facebook interactions on depressive symptoms. This study found that co-rumination through Facebook interactions was associated concurrently with depression symptoms but was not associated with depressive symptoms 6-months later. Conversely, Van Zalk and Tillfors (2017) found that among adolescents with social anxiety, online co-rumination with friends not known offline, buffered the association between social anxiety and depressive symptoms 8-months later. Because both studies measured co-rumination in one modality of digital technology, researchers were unable to test the relative prevalence of co-rumination across modalities. In addition, in both studies, assessments occurred at extended intervals (i.e., 6–8 months apart), which prevents detection of daily fluctuations in co-rumination that influence changes in affect and relationship closeness (Guntherth & Wenzel, 2012). This design also prevented researchers from examining stability and generalization effects of co-rumination, whereby co-rumination in one modality could influence later co-rumination in the same modality (i.e., stability of co-rumination in one modality over time) or in other modalities (i.e., the generalization of co-rumination across modalities over time). Momentary assessment methods (i.e., daily diary assessments) allow day-to-day changes to be examined and generalization effects to be tested while reducing recall bias and enabling naturalistic and real-time assessments (Miron-Shatz et al., 2009). However, researchers have not yet examined the day-to-day prevalence and downstream effects of co-rumination across a variety of communication modalities.

In the current pre-registered study, we used a twice-daily-diary approach to assess the amount of co-rumination across multiple communication modalities (i.e., in person, text, social media, phone), and its downstream, proximal association with affect and relationship closeness during early adolescence. In order to examine co-rumination during a time of stress, when emotion regulation is particularly crucial, we tested our hypotheses during a stressful period for adolescents: the transition to high school (Benner, 2011; Isakson & Jarvis, 1999). Participants completed twice-daily diaries (assessing co-rumination, affect, and perceived closeness with a best friend) during the first two weeks of high school.

The current study had three main objectives. First, we examined whether adolescents spent different amounts of time co-ruminating across communication modalities. Given that youth communicate in comparable ways across modalities (e.g., Anderson & Jiang, 2018), we hypothesized that adolescents would engage in co-rumination during in-person, text, social media, and phone interactions. Despite the popularity of digital technology for youth (Lenhart, 2015), in-person communication is still prominent for adolescents (Kuntsche et al., 2009) and self-disclosure is higher during in-person communication compared to other modalities (e.g., online; Ruppel et al., 2017). Thus, we also hypothesized that adolescents would spend more time co-ruminating in person compared to during digital interactions. The second objective was to examine the stability and generalizability of co-rumination across in-person, text, social media, and phone interactions over time. Given the recurring nature of co-rumination and other forms of repetitive thought (Joormann et al., 2011; Watkins, 2008), we hypothesized that more time spent co-ruminating in one modality would predict more time co-ruminating in that same modality, as well as in other modalities. The final aim was to examine the prospective association of co-rumination across communication modalities with affect and relationship closeness. Given that the majority of evidence documents that co-rumination through in-person and digital interactions predicts greater negative affect and interpersonal benefits (Rose, 2002; Spendelow et al., 2017; Van Zalk & Tillfors, 2017), we hypothesized that more time co-ruminating during in-person, text, social media, and phone interactions would prospectively increase negative affect and relationship closeness. To our knowledge, the association between co-rumination and positive affect has not previously been examined in a naturalistic context; thus, we examined this association in an exploratory manner.

In addition to our main objectives, we conducted multiple pre-registered secondary analyses. First, we investigated whether gender moderated our three hypotheses. Interestingly, research on co-rumination highlights a gender difference whereby girls typically report higher levels of co-rumination and experience greater changes in affect and relationship quality than boys (Calmes & Roberts, 2008; Spendelow et al., 2017). Hence, we predicted that findings would be greater for adolescents that identified as girls compared to those that identified as boys or non-binary. Second, we analyzed the results of our hypotheses using the percentage of time participants spent co-ruminating with their best friend in each communication modality as a function of total time spent communicating with their best friend in that modality. This was done to account for individual differences in the absolute duration of communication time and to

provide a marker of the pervasiveness of co-rumination relative to other forms of communication (see online supplement).

Method

Participants

Of the original 72 participants that consented to the daily diary study, one participant chose to withdraw their consent before completing any of the daily diary assessments. Thus, 71 participants who resided in the Lower Mainland of British Columbia, Canada, were included in our main analyses ($M_{\text{age}} = 12.70$ years, $SD = 0.46$). Of those individuals, 33 identified as girls, 38 identified as boys, and none identified as non-binary. The Lower Mainland of British Columbia is an ethnically and economically diverse, urban/suburban area (Statistics Canada, 2017). Participants were recruited from multiple schools throughout the community using flyers posted in public places (e.g., coffee shops, community centers), local media, and online advertisements (e.g., Facebook). We first spoke with interested participants' parents/guardians over the phone to assess study eligibility. Adolescents were eligible if they were expected to begin high school in the upcoming fall and were fluent in English. Adolescents were ineligible for the study if they reported symptoms of a current substance use disorder, lifetime history of mania or psychosis, severe impairment caused by a learning disability, or a history of serious head trauma. This study is part of a larger study, which also assessed various biological measures; thus, participants were excluded if they reported having an endocrine disorder.

Measures

Demographic measures

Youth completed a measure that asked them to provide demographic information including date of birth and ethnic origin. Youth also reported their biological sex separately from their self-identified gender by answering the following questions: (1) *What was your sex assigned at birth?* (2) *What is your gender?* Participants were able to select from both binary (e.g., male, female) and non-binary options (e.g., intersex, non-binary). Youth's parent/guardian reported their (and their partner's) highest level of education and their annual household income.

Daily diary measures

Youth received emails with a link to the daily diary questionnaires, which they completed twice each day: once at 3 p.m. and once before bed. After receiving the prompt, participants had 3 hours to complete the questionnaires. Some constructs were assessed using single-item measures to minimize participant burden (Laurenceau et al., 2005; Starr, 2015).

Co-rumination. Levels of co-rumination during the daily diaries were derived by asking participants two questions. First, participants were asked to report the amount of time (i.e., hours, minutes) they spent interacting with their best friend within each modality (i.e., in person, text, social media, phone) since that morning (assessed during the 3 p.m. questionnaire) or since they last completed the survey (assessed during the bedtime questionnaire). Second, participants indicated the percentage of time they spent dwelling on their negative feelings or problems during those interactions,¹ which was derived from the Co-Rumination Questionnaire (Rose, 2002). Each modality was defined for participants: text was defined as texting or direct messaging (e.g., Facebook Messenger, What's App), social media was defined as public posting on social media platforms (e.g., Facebook, Instagram, Snapchat), and phone was defined to include audio or video calling (e.g., telephone, Skype, Facetime). The mean of the intraclass correlation (ICC) across modalities was 0.31, similar to previous intensive longitudinal studies investigating related constructs (i.e., rumination use over time, ICC was 0.34; Moberly & Watkins, 2008).

Affect. Items from the extended Positive and Negative Affect Schedule for Children (PANAS-C; Laurent et al., 1999) were used to assess state-level affect. The positive affect items were *happy*, *excited*, *proud*, and *calm*. The negative affect items were *upset*, *nervous*, and *ashamed*; plus, we added *stressed* given it is a common emotion during the transition to high school (e.g., Benner, 2011). Participants were asked to report how they felt just before they started the survey and to rate each emotion on a scale from 1 (*Very slightly or not at all*) to 5 (*Extremely*). ICCs were 0.62 for positive affect and 0.57 for negative affect.

Relationship Closeness. To assess relationship closeness, participants were asked how close they would describe their relationship with their best friend at that moment, on a scale from 1 (*Not at all close*) to 5 (*Very close*). This item was derived from the Unidimensional Relationship Closeness Scale (URCS; Dibble et al., 2012) and is consistent with previous daily diary assessments of closeness (Lavee & Ben-Ari, 2007). The ICC was 0.65.

Procedure

This study was approved by the University's Research Ethics Board and complied with the Declaration of Helsinki for research involving humans. After participants' parents/guardians completed a phone screen assessing eligibility for the study, participants were

¹ State levels of co-rumination reported across the 14 days of daily diaries was significantly associated with levels of trait co-rumination as assessed based on baseline scores on the Co-Rumination Questionnaire (CRQ; Rose, 2002) averaged across communication modalities, $r(69) = 0.29$, $p = .015$.

invited to the university-based academic research lab before the start of their first year of high school (i.e., grade 8). Participants arrived at the lab with their primary caregiver, who provided consent. Adolescents then provided assent and completed a demographic questionnaire. Families were told that the study was about how the transition to high school affects mental health and well-being in youth. After this initial session in the lab, participants were provided instructions for completing the twice-daily diaries. For 14 days, starting on the first day of high school in September 2019, participants received two daily diary surveys each day. To maximize compliance, participants were sent an email reminder if they had failed to complete four consecutive surveys. Participants received remuneration for the initial lab session and prorated remuneration for the daily diaries based on the percentage of diaries they completed.

Data analytic approach

Given the nested structure of the data (diaries nested within persons), hypotheses were tested using multilevel modeling. Multilevel modeling simultaneously estimates within- and between-person effects, which is particularly useful for intensive longitudinal designs (e.g., daily diaries). It allows for variable time intervals between prompts and it is robust to missing data. Models used maximum likelihood estimation with robust standard errors. The first analysis, which assessed differences in time spent co-ruminating across communication domains, used a random intercept model in Mplus Version 8.4 (Muthen & Muthen, 1998–2019). Wald chi-square tests were conducted to assess differences across intercepts for co-rumination domains. Analyses for the second and third hypotheses, which examined how co-rumination prospectively predicted subsequent co-rumination, affect, and relationship closeness, were run in HLM

Table 1
Demographic characteristics.

Variable	
Sex (%)	
Male	56
Female	44
Gender (%)	
Boy	54
Girl	47
Age (M, SD)	12.70, 0.46
Ethnic Origin (n) ^a	
African	2
Chinese	8
European-Canadian	26
Japanese	3
Korean	2
Latin American/Hispanic	6
South Asian (e.g., Indian, Pakistani, Sri Lankan)	2
Other ^b	15
Don't know	20
Prefer not to answer	1
Parents' or Guardians' Education (n) ^c	
Less than high school	1
High school diploma	6
College diploma/certificate	28
Bachelor's degree	57
Master's degree	26
Doctorate degree	17
Annual Household Income (n) ^d	
\$20,000-\$59,000	7
\$60,000-\$99,999	14
\$100,000-\$199,999	10
\$120,000-\$159,999	13
\$160,000 and over	21
Don't know	1
Prefer not to answer	4

Note. Youth reported their sex, gender, age, and ethnic origin. Youth's parent/guardian reported their highest level of education and annual household income.

^a Youth were able to choose more than one option when reporting their ethnic origin. One participant did not report their ethnic origin.

^b Other ethnic origins were identified as: Aboriginal (i.e. First Nations, Metis, Inuit), Asian-Canadian, Australian-English, Canadian, Chinese-Canadian, English-Irish-Canadian-Filipino-Spanish-Chinese, Filipino, Irish, Israeli, Polish, Scottish, and West Asian (i.e. Iranian, Afghan).

^c One parent or guardian did not report their highest level of education and six parents or guardians did not report their partner's highest level of education.

^d One parent or guardian did not report their annual household income.

Version 7.03 (Raudenbush et al., 2011) using random-effect models in which intercepts and slopes were allowed to vary. All Level 1 variables were person-centred. Gender was included as a Level 2 variable. No participants in our sample identified as non-binary; thus, gender was dummy-coded with 0 = girl and 1 = boy. In all equations reported below, i denotes prompts and j denotes participants.

Results

Demographic characteristics of the sample are presented in Table 1. Participants completed an average of 21.55 out of 28 diary assessments. The number of diary assessments completed was not associated with any of the youth's demographic characteristics such as sex, $t(69) = 1.10, p = .277$, gender, $t(69) = 0.84, p = .404$, age, $r(69) = -0.04, p = .770$, or ethnic origin, $F(4, 65) = 1.38, p = .252$.

Differences in time co-ruminating across modes of communication

Descriptive statistics for the total amount of time participants spent communicating in each communication modality across the 14-days is presented in Table S1 (see online supplement). Fig. 1 depicts rates of co-rumination in each modality. An intercept-only multilevel model was conducted to assess average number of minutes spent co-ruminating across in-person, text, social media, and phone interactions. Average number of minutes spent co-ruminating was significantly different than zero for all modes of communication ($ps < .012$), meaning that participants co-ruminated in each modality. Participants spent the most time co-ruminating in person ($M = 10.83, SE = 3.09, p < .001$), followed by text ($M = 1.46, SE = 0.49, p = .003$), social media ($M = 1.38, SE = 0.49, p = .012$), and phone ($M = 0.61, SE = 0.24, p = .009$). An omnibus Wald chi-square test indicated adolescents spent more time co-ruminating in person than in the other modes of communication, $\chi^2(3) = 12.47, p = .006$. Follow-up tests indicated time co-ruminating in person was significantly greater than time co-ruminating via text, $\chi^2(1) = 9.67, p = .002$, social media, $\chi^2(1) = 9.64, p = .002$, and phone interactions, $\chi^2(1) = 11.04, p = .001$.

Moderation by gender

We next examined whether gender moderated the amount of time spent co-ruminating in each modality. Gender did not moderate time spent co-ruminating in person, $B = -6.53, SE = 6.07, p = .282$, or over the phone, $B = -0.77, SE = 0.40, p = .054$. However, girls co-ruminated significantly more than boys over text, $B = -1.89, SE = 0.92, p = .041$, and social media, $B = -2.40, SE = 1.10, p = .029$.

Influence of co-rumination on subsequent levels of co-rumination in same and other modes of communication

We conducted multilevel analyses predicting the amount of time spent co-ruminating in each modality at a given prompt (t) as a function of the time spent co-ruminating in that modality and each of the other three modalities at the previous prompt ($t - 1$). This allowed us to examine the unique association of co-rumination in each communication modality with the subsequent amount of co-rumination. The Level 1 model below is for in-person co-rumination as an example. The same model was conducted with each communication modality as the outcome. No variables were entered at Level 2.

Level 1 model

Co-rumination(in-person) $_{ij(t)} = \beta_{0j} + \beta_{1j}(\text{in-person co-rumination}_{t-1}) + \beta_{2j}(\text{texting co-rumination}_{t-1}) + \beta_{3j}(\text{social media co-rumination}_{t-1}) + \beta_{4j}(\text{phone co-rumination}_{t-1}) + r_{ij}$

Time spent co-ruminating in person was predicted by greater time spent co-ruminating over social media at the previous time prompt, $\beta = 0.51, SE = 0.20, p = .013$. Time spent co-ruminating over the phone was predicted by the autocorrelation of time spent co-ruminating over the phone at the previous prompt, $\beta = -0.15, SE = 0.04, p < .001$. No other effects were significant, $ps > .066$ (see

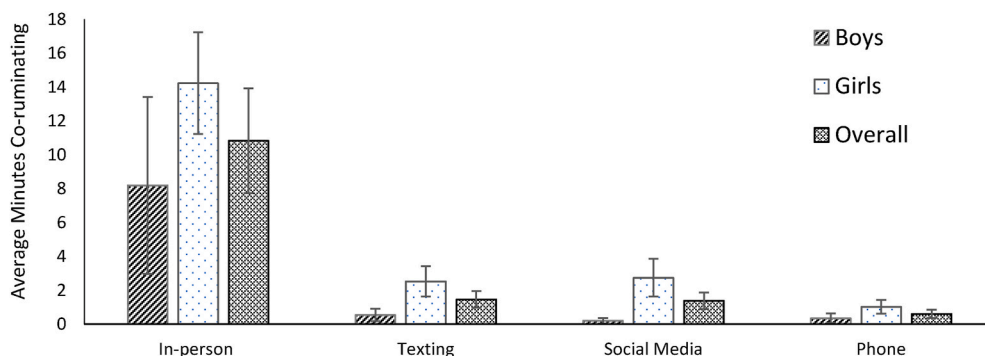


Fig. 1. Average Minutes Spent Co-ruminating at Each Prompt Across Communication Modalities. Note. Error bars indicate ± 1 standard error.

Table S2 in the online supplement).

Moderation by gender

Retaining the same Level 1 models, four multilevel models were run with gender entered as a Level 2 predictor to examine gender differences in the effect of each type of co-rumination on the same and other types of co-rumination at the next prompt.

Gender moderated the association between social media co-rumination and subsequent in-person co-rumination, $\beta = 1.17$, $SE = 0.56$, $p = .040$. Specifically, social media co-rumination predicted subsequent in-person co-rumination among girls, $\beta = 0.62$, $SE = 0.29$, $p = .040$, but not among boys, $\beta = 0.14$, $SE = 0.33$, $p = .659$. Gender also moderated the association between phone co-rumination and subsequent in-person co-rumination, $\beta = 7.59$, $SE = 2.51$, $p = .004$. Specifically, phone co-rumination predicted less subsequent in-person co-rumination among boys, $\beta = -2.67$, $SE = 0.92$, $p = .004$, but not among girls, $\beta = 0.86$, $SE = 2.17$, $p = .693$. No other moderation effects were significant, $ps > .069$ (see Table S3 in the online supplement).

Associations of co-rumination on affect and relationship closeness

We conducted multilevel analyses to examine the association of time spent co-ruminating via in-person_{t-1}, text_{t-1}, social media_{t-1}, and phone_{t-1} interactions at the previous prompt with each of negative affect_t, positive affect_t, and relationship closeness_t at a given prompt. In each model, the dependent variable was included in the model as assessed at the previous prompt ($t-1$; i.e., negative affect_{t-1}, positive affect_{t-1}, or relationship closeness_{t-1}). Doing this allowed us to control for the autocorrelation (i.e., stability) of each variable and to, therefore, examine the unique contribution of each type of co-rumination on prompt-to-prompt changes in affect or relationship closeness. The Level 1 model is depicted here for negative affect as an example. Parallel models were conducted for positive affect and relationship closeness. No variables were entered at Level 2.

Level-1 model (prompt level)

$$\text{Negative Affect}_{ij(t)} = \beta_{0j} + \beta_{1j}(\text{negative affect}_{t-1}) + \beta_{2j}(\text{in-person co-rumination}_{t-1}) + \beta_{3j}(\text{texting co-rumination}_{t-1}) + \beta_{4j}(\text{social media co-rumination}_{t-1}) + \beta_{5j}(\text{phone co-rumination}_{t-1}) + r_{ij}$$

Results are presented in Table 2. In the model predicting negative affect, there was a significant stability effect for negative affect, whereby greater negative affect at a given prompt predicted greater negative affect at the subsequent prompt, $p = .006$. No types of co-rumination significantly predicted negative affect at the following prompt, $ps > .085$.

With respect to positive affect, there was also a significant stability effect, $p < .001$, whereby positive affect predicted greater positive affect at the following prompt. Moreover, time spent co-ruminating via text predicted increases in positive affect at the subsequent prompt, $p < .001$. In contrast, time spent co-ruminating via social media predicted decreases in positive affect at the following prompt, $p = .009$. No other associations were significant, $ps > .121$.

In the model predicting relationship closeness at a given prompt, there was a significant stability effect whereby relationship closeness predicted greater relationship closeness at the subsequent prompt, $p < .001$. Furthermore, time spent co-ruminating via text, $p < .001$, and via phone, $p = .003$, predicted greater relationship closeness at the following prompt. No other associations were significant, $ps > .127$.

Moderation by gender

We next examined whether gender moderated the effect of each type of co-rumination on negative affect, positive affect, or relationship closeness at the next prompt. The same models were retained at Level 1 and gender was entered at Level 2.

Gender moderated the association of time spent co-ruminating via text on later positive affect, $\beta = 0.12$, $SE = 0.02$, $p < .001$.

Table 2
Co-Rumination Predicting Changes in Negative Affect, Positive Affect, and Relationship Closeness at Subsequent Prompts.

	Negative Affect _t (df = 67)	Positive Affect _t (df = 67)	Relationship Closeness _t (df = 66)
Intercept (γ_{00})	6.33 (0.25)***	10.72 (0.33)***	4.02 (0.09)***
Stability Effect _{t-1} (γ_{10})			
Negative Affect _{t-1} (γ_{10})	0.14 (0.05)**	-	-
Positive Affect _{t-1} (γ_{10})	-	0.11 (0.03)***	-
Relationship Closeness _{t-1} (γ_{10})	-	-	0.31 (0.05)***
In-person Co-rumination _{t-1} (γ_{20})	0.01 (0.00)	-0.00 (0.00)	0.00 (0.00)
Texting Co-rumination _{t-1} (γ_{30})	-0.01 (0.01)	0.03 (0.01)***	0.01 (0.00)***
Social Media Co-rumination _{t-1} (γ_{40})	0.00 (0.00)	-0.02 (0.01)**	-0.01 (0.01)
Phone Co-rumination _{t-1} (γ_{50})	-0.08 (0.09)	0.02 (0.01)	0.01 (0.00)**

Note: t denotes the current prompt and $t-1$ denotes the previous prompt. Unstandardized coefficients are reported, and standard errors are in brackets. Statistically significant ($p < .05$) findings are bolded.

* $p < .05$; ** $p \leq .01$; *** $p < .001$.

Follow-up tests indicated that, for girls, time co-ruminating via text predicted greater positive affect at the following prompt, $\beta = 0.06$, $SE = 0.01$, $p < .001$, whereas for boys, time co-ruminating via text predicted less positive affect at the following prompt, $\beta = -0.05$, $SE = 0.02$, $p = .003$. No other moderation effects were significant, $ps > .052$ (see Table S4 in the online supplement).

Discussion

Developments in digital communication have augmented opportunities to communicate with others. Adolescence is a period when there is a significant uptick in both the use of digital communication (Anderson & Jiang, 2018) and the prevalence of interpersonal emotion regulation, particularly co-rumination (Dixon-Gordon et al., 2015; Rose, 2002). The present study investigates the intersection of the two. This study is the first to examine adolescents' use of co-rumination via in-person and digital communication modalities (i.e., text, social media, phone), stability and generalization effects of co-rumination over time, and co-rumination's downstream association with affect and relationship closeness.

Consistent with our first hypothesis, adolescents co-ruminated across all modes of communication. This suggests that digital forms of communication provide additional avenues for adolescents to co-ruminate, and it is consistent with findings in adult samples (Keshishian et al., 2016; Murdock et al., 2015). The current study extends our understanding of this phenomenon into adolescence, thereby providing insights into the developmental trajectory of co-rumination. As hypothesized, we also found adolescents spent more time co-ruminating in person compared to in all other modalities (i.e., text, social media, phone). In-person communication allows greater non-verbal signals (e.g., facial expression, body movements; Tracy et al., 2015) and thus may provide a reinforcing and engaging context that is particularly conducive for interpersonal emotion regulation such as co-rumination.

Our second objective was to examine the stability and generalizability of co-rumination across modalities. Although we expected that co-rumination in one modality would predict subsequent increases in co-rumination in the same (i.e., stability) and other modalities (i.e., generalizability), we found mixed evidence for this hypothesis. Regarding stability, co-rumination over the phone (i.e., audio and video calls) predicted more co-rumination over the phone at the subsequent timepoint. Phone conversations offer contextual similarities to in-person communication (e.g., real-time interaction; more natural reciprocity), which may facilitate co-rumination. Yet unlike in-person interactions, phone calls are more readily accessible given that almost all adolescents have access to a cell phone (Anderson & Jiang, 2018; Lenhart, 2015). Together, the contextual similarities to in-person communication and greater accessibility may contribute to the stability of co-rumination over the phone. Regarding generalization, more time spent co-ruminating over social media predicted subsequent increases in time spent co-ruminating in person. Considering that social media posts are public and have length or character restrictions, adolescents who co-ruminate using social media platforms may seek subsequent in-person interactions for a more private or in-depth discussion. Surprisingly, we did not observe additional stability or generalization effects in other modalities. Although investigating co-rumination as it occurs with a specific best friend is a methodological strength of the study that is consistent with past research (specific and measurable change over time within a relationship; Calmes & Roberts, 2008), we did not assess co-rumination in other relationships and that may have limited the stability or generalization effects that could have been observed. Additional research is needed that examines co-rumination across multiple relationships.

The results for our third hypothesis were more nuanced than expected. We predicted that co-rumination through all modalities of communication would prospectively increase negative affect. However, co-rumination did not significantly predict negative affect. Although our findings contrast with past research that documents co-rumination through digital technology increases negative mood for adults (e.g., Keshishian et al., 2016; Murdock et al., 2015), Frison et al. (2019) and Van Zalk et al. (2017) found that online co-rumination did not prospectively predict worse negative emotional outcomes for adolescents over time. Researchers have also documented that co-rumination predicts negative (i.e., depressed) mood in low-quality relationships, but not in high-quality relationships (perhaps because high-quality relationships are typified by more empathetic responding; Moreira et al., 2016). Thus, our finding may be explained by our assessment of co-rumination with participants' best friend, which may constitute a higher quality relationship (Cleary et al., 2002).

To our knowledge, we are the first to assess the association of co-rumination with positive affect in a naturalistic context. We found that time spent co-ruminating via text predicted higher levels of positive affect over time. Succinct forms of co-rumination, such as through text, might only address a summary of one's feelings and problems, lacking the depth or the ruminative component of co-rumination needed to produce negative affect, but allowing enough disclosure to enhance positive affect. Interestingly, time spent co-ruminating via social media was associated with decreases in positive affect, which may be in part because of the content of social media posts. For example, adolescents' posts often focus on upward social comparisons (e.g., Fardouly et al., 2015; Vogel et al., 2014), which are associated with reduced positive affect (Lyubomirsky et al., 2001). Furthermore, emotional support through social media is related to harmful affective consequences when compared to other modalities of communication, perhaps indicating lower quality support (Shensa et al., 2020). As such, whereas social media appears to be a maladaptive forum for co-rumination, texting may represent a more adaptive communication modality.

Consistent with that proposition, we found that time spent co-ruminating via text and phone interactions was prospectively associated with higher levels of relationship closeness, which is consistent with cross-sectional research conducted in a young adult sample (Keshishian et al., 2016). The current findings that co-rumination via some digital modalities is associated with higher positive affect and relationship closeness suggests one important process through which co-rumination may be reinforced between friends. It is noteworthy that co-rumination during in-person interactions was not significantly associated with relationship closeness. It is possible that this association was not detected because the relation of co-rumination and relationship closeness (and affect) may be more transient and therefore not captured by the current study's twice-daily diary design.

We also explored several secondary pre-registered analyses, including the moderating effects of gender. Compared to boys, girls co-

ruminated more over social media and text. Greater co-rumination over social media has important implications for girls' potential vulnerability for reduced well-being given that co-ruminating through social media was associated with reduced positive affect. Furthermore, co-rumination over social media was associated with greater subsequent in-person co-rumination for girls, but not for boys. For boys only, co-rumination over the phone was associated with less co-rumination in person, suggesting a gender-specific preference to co-ruminate over the phone. Future research should investigate gender differences in preference and motivation for co-ruminating through some modalities and not others. Interestingly, texting predicted higher levels of positive affect for girls and lower levels of positive affect for boys. This may be because girls have more personal conversations through text and are more likely to communicate with friends online than boys (Anderson & Jiang, 2018; Baron, 2004; Lenhart et al., 2010). Future research might also investigate potential gender differences in the depth or content of co-rumination through text that could explain this finding.

In addition to our main analyses, we also examined the percentage of time adolescents spent co-ruminating with their best friend in each communication modality (see online supplement). The proportion of time spent co-ruminating may index the pervasiveness of co-rumination compared to other styles of communication. For instance, adolescents may spend the same amount of time (e.g., 1 hour) co-ruminating, but this may take up different proportions of their time interacting with their best friend (e.g., 20% versus 90%). When considering percentage of time spent co-ruminating, a different pattern of results emerged. For example, co-rumination over text did not significantly predict higher levels of positive affect. This suggests that the downstream outcomes associated with co-rumination are less pronounced when assessing the proportion of time rather than the absolute duration of time adolescents spent co-ruminating, potentially because other communication styles may dampen the effects of co-rumination. These findings underscore the importance of assessing both total time and proportion of time spent co-ruminating.

Despite the strengths of this study, there are limitations and future research directions. First, the sample size was relatively small. Although we pre-registered all analyses and conducted them using robust standard errors to reduce bias (Raudenbush & Bryk, 2002), our findings should be replicated in larger samples. Even though twice-daily diary designs offer numerous strengths (DeLongis et al., 1992), future research could also incorporate intensive longitudinal designs with multiple assessments per day (i.e., ecological momentary assessment) to capture moment-to-moment fluctuations in co-rumination use, affect, and relationship closeness. Furthermore, the field would benefit from examining the content and process of co-rumination across modalities. Some digital modalities may differ from others based on the duration of interactions or immediacy of responses. These differences may explain the preferential use of co-rumination in one modality over another and the modality-specific effects of co-rumination on affect and relationship closeness.

This study expands the examination of co-rumination to multiple communication modalities that are relevant to adolescents. Findings indicated that co-rumination occurs across all communication modalities, and adolescents spend most time co-ruminating in person. Furthermore, stability and generalization effects of co-rumination and downstream effects on affect and relationship closeness are uniquely attributed to specific modalities and not others. Importantly, these findings have critical implications for adolescents' emotional and social development. Our findings, underscore the importance of interventions designed to help youth engage in more adaptive social media interactions. Additional research designed to understand the mechanisms underlying the beneficial effects of co-rumination via text and phone may inform more specific clinical recommendations. Future research should expand this investigation to contribute to the dearth of literature examining co-rumination across multiple communication modalities.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.adolescence.2021.04.011>.

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