



Attentional Biases and their Push and Pull with Rumination and Co-Rumination is Based on Depressive Symptoms: a Prospective Study of Adolescents

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Abstract

Emotion regulation (ER) is central to adolescent mental health and wellbeing. However, the mechanisms underlying two common ER strategies – rumination and its interpersonal counterpart, co-rumination – are insufficiently understood in youth. Past research has documented that attentional disengagement biases are associated with rumination in adults, particularly among individuals with elevated depressive symptoms. Extending this line of research, the current study investigated whether attentional disengagement biases predicted rumination and co-rumination in adolescents based on their symptoms of depression. Using a multi-wave prospective design, 91 early adolescents (47% female, $M_{age} = 12.87$) completed a measure of depressive symptoms and the Affective Posner Task to assess early and late attentional processes at baseline. Adolescents also completed measures of rumination and co-rumination at baseline and every 3-months for one year. A multivariate means-as-outcomes multilevel model indicated that early disengagement biases for sad and happy faces interacted with depressive symptoms to predict later rumination and co-rumination. Critically, the direction of findings across rumination and co-rumination differed based on depressive symptoms. Results are the first to delineate a distinct pattern of attentional disengagement biases that predict rumination versus co-rumination in early adolescents. Findings extend theoretical conceptualizations of rumination to youth and provide the first account of cognitive mechanisms underlying co-rumination.

Keywords Depression · Adolescence · Cognitive biases · Attentional disengagement biases · Co-rumination · Rumination

Adolescence is a period of rapid development, during which emotion regulation (ER) becomes increasingly important for wellbeing. Given the prevalence of stressful life events during adolescence coupled with the central role ER strategies play in modulating the stress response, ER is a crucial determinant of adolescent mental health (Riediger & Klipker, 2014). Early adolescence, in particular, is a developmental stage characterized by neural plasticity, following which neural systems – including those underlying ER – become increasingly embedded and resistant to change (Ahmed et al., 2015). Early adolescence is, therefore, a critical period of ER development that has long-term consequences on regulatory ability and mental health (Ahmed et al., 2015). Importantly, researchers have also documented significant

individual differences in the use of various ER strategies among youth (e.g., Gresham & Gullone, 2012). Thus, it is crucial to elucidate the mechanisms underlying individual differences in ER among early adolescents.

One ER strategy that is particularly important for adolescent mental health is rumination, an ER strategy characterized by repeatedly and passively dwelling on the causes, meaning, and consequences of negative feelings or problems (Nolen-Hoeksema, 1991; Smith & Alloy, 2009). The impaired disengagement hypothesis of rumination proposes that impaired attentional disengagement from negative information is the central bias that underlies the repetitive and prolonged processing of self-referent information that is characteristic of rumination (Koster et al., 2011). Difficulty disengaging attention from negative content is thought to allow this information to remain active in working memory for prolonged periods, thereby promoting ruminative thinking. Convincing evidence from studies of adults supports this theory (Grafton et al., 2016; Southworth et al., 2017), particularly among individuals with elevated depressive

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symptoms (Joormann & Gotlib, 2008; LeMoult et al., 2013). For example, Joormann and Gotlib (2008) found that difficulty disengaging from and removing negative words from working memory was associated with greater rumination among depressed adults, but not among healthy control participants. Similarly, rumination has been associated with poor attentional disengagement from negative or sad words – but not positive, happy, angry, or neutral words – among adults with depression (Donaldson et al., 2007; Joormann et al., 2006). Despite compelling evidence for the role of cognitive disengagement biases in promoting rumination among individuals with elevated depressive symptoms, the disengagement bias-rumination link has not yet been examined in adolescents. Investigating whether the impaired disengagement hypothesis of rumination extends to youth is crucial for informing theoretical models of ER and its development. Moreover, a downward extension of the impaired disengagement hypothesis to early adolescents will also have implications for identifying potential targets for early intervention before vulnerabilities become entrenched and difficult to change.

Researchers have become increasingly aware that rumination frequently occurs in the context of interpersonal relationships. The interpersonal counterpart to rumination is co-rumination, which is characterized by excessive discussions of personal problems with another individual (Rose, 2002). Like rumination, co-rumination involves the frequent and repetitive rehashing of problems, dwelling on negative feelings, and speculation about the causes and consequences of problems. Moreover, co-rumination has similarly been conceptualized as serving an emotion regulatory function (e.g., Battaglini et al., 2021; Waller et al., 2014) because its use is intended to modify emotional experiences (see Dixon-Gordon et al., 2015). Despite the negative implications co-rumination has for emotional wellbeing (e.g., increases in depression), particularly among girls (Rose et al., 2007), researchers have not yet investigated mechanisms underlying this interpersonal ER strategy. Given that co-rumination and rumination are associated concurrently and prospectively (Aldrich et al., 2019; Felton et al., 2019; Rose, 2002; Stone & Gibb, 2015) and show parallel gender differences (i.e., girls report greater use of rumination and co-rumination than do boys; e.g., Felton et al., 2019; Rose, 2021), an intriguing possibility is that the central cognitive bias that underlies rumination similarly promotes co-rumination. However, co-rumination also differs from rumination in key respects, both in terms of its defining characteristics and its outcomes, which suggests that the pattern of mechanisms underlying rumination and co-rumination may also differ in important ways. For example, unlike rumination, co-rumination occurs within the course of an interpersonal interaction, is characterized by self-disclosure and mutual encouragement to discuss problems (Rose, 2002), and has been associated

with enhanced friendship quality (Battaglini et al., 2021; Felton et al., 2019). Given that co-rumination is overlapping yet distinct from rumination, research is needed to elucidate whether attentional disengagement biases represent a shared mechanism underlying both rumination *and* co-rumination in youth.

As noted above, depression also plays an important role in determining whether attentional disengagement biases predict rumination (Joormann & Gotlib, 2008). Depression is characterized by anhedonia, reduced self-disclosure, and social withdrawal (Garrison et al., 2012; Setterfield et al., 2016). Thus, an intriguing possibility is that the relative presence or absence of depressive symptoms may determine whether difficulty disengaging from sad material (i.e., sad disengagement biases) promotes dwelling on feelings and problems in a solitary, *intrapersonal* context (i.e., rumination), versus an *interpersonal* context (i.e., co-rumination). Given that negative disengagement biases are positively associated with rumination specifically among adults with elevated depressive symptoms (Joormann & Gotlib, 2008), sad disengagement biases may be associated with greater rumination among youth with high depressive symptoms, but not among youth with low depressive symptoms. In contrast, sad disengagement biases may be associated with greater co-rumination among those with *low* depressive symptoms, but not among youth with elevated depressive symptoms (individuals with low depression are more likely to engage in social interactions with others, whereas individuals with high depression are more likely to socially withdraw; Nezelek et al., 1994). Critically, no research to our knowledge has investigated whether various types of disengagement biases differentially predict co-rumination, nor whether these biases interact with depressive symptoms.

The aim of the current study was to extend the literature on cognitive biases underlying rumination to early adolescents and to examine, for the first time, the cognitive mechanisms that promote co-rumination. Given that adolescence is a period across which cognitive and emotional vulnerabilities become embedded (Ganzel et al., 2013), understanding factors that underlie ER strategies early in this developmental stage is critical. Moreover, given the increasing importance of peer relationships in early adolescence (Furman & Rose, 2015), it is particularly valuable to investigate interpersonal ER strategies in tandem with intrapersonal ER. Thus, we examined whether sad, happy, and angry attentional disengagement biases are prospectively associated with average rumination and co-rumination in early adolescents based on their symptoms of depression. Moreover, given that research in adults has differentiated attentional biases occurring at early and late stages of attention (e.g., Kircanski et al., 2015), we assessed disengagement biases for stimuli presented at both short (200 ms) and long (1,000 ms) durations. There is considerable variability

across the attentional bias and depression literature in terms of the stimulus exposure durations used in studies of youth (Platt et al., 2017). Thus, assessing both short and long stimulus durations allowed us, for the first time, to systematically explore the role of early and late attentional processes on ER in early adolescents. In keeping with taxometric studies indicating that depression is best conceptualized as a continuous construct, we assessed depressive symptoms continuously (Hankin et al., 2005). Using a longitudinal, multi-wave design, disengagement biases and depressive symptoms were assessed at baseline, and rumination and co-rumination were assessed at baseline and across the following year. We hypothesized that depressive symptoms would moderate the association of sad disengagement biases with average levels of rumination. Specifically, we expected that disengagement biases for sad stimuli would predict greater rumination, but only for individuals with elevated depressive symptoms. In contrast, we predicted that sad disengagement biases would predict co-rumination specifically among youth with low depressive symptoms. We hypothesized that happy and angry biases would not be associated with levels of rumination, and we examined the association of happy and angry biases with co-rumination in an exploratory manner. Finally, given that early versus late attentional biases have not yet been systematically examined in early adolescents, we explored whether associations were observed across short and long stimulus exposure durations.

Method

Participants

Participants were recruited for the UBC Study on Adolescents from the Lower Mainland of British Columbia via flyers, online advertisements, and local media. Parents/guardians of adolescents were screened over the phone to assess participant eligibility, which was then confirmed when they arrived at the laboratory. Eligibility criteria for the UBC Study on Adolescents included being 11–13 years old, planning to begin high school in the upcoming fall (given the aims of the larger study), and being fluent in English. Ineligibility criteria included symptoms of a current substance use disorder, lifetime history of mania or psychosis, severe impairment caused by a learning disability, history of serious head trauma, and medical conditions or use of medications that would confound the analysis of biomarkers that were assessed as part of the larger study. Of the 109 participants who were initially recruited for the study, 91 provided the data needed to be included in the current study. Participants with sufficient data for inclusion did not differ from those without sufficient data in

Table 1 Participant Characteristics

Variable	Participants <i>n</i> = 91
Sex, <i>n</i>	
Male	48
Female	43
Gender, <i>n</i>	
Boy	48
Girl	42
Non-binary	1
Age, <i>M</i> (<i>SD</i>)	12.87 (.39)
Ethnicity ^a , <i>n</i>	
Chinese	14
European	69
Filipino	1
Indigenous	2
Japanese	5
Korean	3
Latinx	5
South Asian (e.g., Indian, Pakistani, Sri Lankan)	2
Southeast Asian (e.g., Vietnamese, Cambodian, Malaysian, Laotian)	1
West Asian (e.g., Iranian, Afghan)	3
Household Income ^a , <i>n</i>	
\$20,000 to \$59,999	8
\$60,000 to \$99,999	15
\$100,000 to \$119,999	14
\$120,000 to \$159,999	20
\$160,000 and over	25
Don't know	1
Prefer not to answer or Missing	8
Baseline Depressive Symptoms (CES-DC)	
Range	0–39
<i>M</i> (<i>SD</i>)	12.74 (7.83)

Parents were able to choose more than one option when reporting their child's ethnicity

CES-DC Centre for Epidemiologic Studies Depression Scale for Children, *CRQ-SF* Co-rumination Questionnaire-Short Form, *RRS-A* Ruminative Responses Scale-Adolescent Version

^aParent-reported

terms of gender, sex, ethnicity, or depressive symptoms, all $ps > 0.649$. However, participants in the current study were slightly older ($M = 12.87$, $SD = 0.39$) than individuals who were not included ($M = 12.66$, $SD = 0.37$), $t(106) = -2.07$, $p = 0.041$. Overall, the majority of participants in the present study were of European descent with an upper middle-class household income. The sample was evenly divided in terms of sex and gender. See Table 1 for participant characteristics.

Measures

Attentional Disengagement Biases

Attentional disengagement biases were assessed using an affective Posner paradigm (Koster et al., 2005). For each trial, participants were first presented with two side-by-side white frames with a fixation cross between them for 500 ms. Second, an emotional stimulus (i.e., the cue) was presented in the right or left frame. In half of the trials the cue was displayed for 200 ms, representing early attentional processes, and in the other half of trials it was presented for 1,000 ms, representing later attentional processes. Third, after the presentation of the cue ceased, the letters “E” or “F” were shown either in the frame the cue was presented in previously (valid cue trial) or in the other frame (invalid cue trial). Participants were instructed to press the computer key that matched the letter on the screen (“E” or “F”) as quickly and as accurately as possible. Finally, a black screen was presented for 700 ms, following which the subsequent trial began. Cue duration was held constant within each block, and cue valences and trial types (valid and invalid) were randomized within each block. Emotional stimuli were taken from a set of 32 faces expressing sad, happy, angry, and neutral affect from the NimStim Face Stimulus Set (Tottenham et al., 2009). An equal number of male and female faces were selected.

Error trials and outlier reaction times (RTs < 150 ms or > 1000 ms) were excluded from analyses, consistent with prior research (Jopling et al., 2021; Kircanski et al., 2015). This resulted in the exclusion of 13.6% of trials. Split-half reliability coefficients on critical trial RTs across cue durations and valences ranged from 0.74 to 0.87. Consistent with Koster et al. (2005, 2006), attentional disengagement bias scores were calculated separately for each valence (sad, happy, and angry) as the difference between reaction times (RTs) to invalid valenced cues and RTs to invalid neutral cues:

$$\text{Attentional Disengagement} = (\text{RT}_{\text{invalid valenced cue}} - \text{RT}_{\text{invalid neutral cue}})$$

Higher positive scores indicate slower disengagement of attention from the valenced cue, such that the participant took more time to shift attention away from the emotional material than from the neutral material.

Depressive Symptoms

The Centre for Epidemiologic Studies Depression Scale for Children (CES-DC; Weissman et al., 1980) is a 20-item measure that was used to assess depressive symptoms. Participants reported the degree to which they experienced symptoms on a 4-point Likert scale, with higher

scores indicating greater depressive symptoms. Items are summed to compute a total score. Example items include “I felt down and unhappy” and “I felt like crying.” Internal reliability in the current study was $\alpha = 0.84$.

Rumination

The 10-item Ruminative Responses Scale-Adolescent Version (RRS-A; Burwell & Shirk, 2007) was used to assess rumination. Participants were asked to indicate the degree to which they typically think or do each item. An example is: “Go someplace alone to think about your feelings.” Items are rated on a 4-point Likert scale, with higher scores indicative of greater rumination. Total scores were computed by summing items. Cronbach’s alpha ranged from 0.75–0.86 across baseline and the four follow-ups.

Co-Rumination

The 9-item Co-Rumination Questionnaire-Short Form (CRQ-SF; Hankin et al., 2010) was used to assess participants’ tendency to co-ruminate with their closest friend. For example, participants responded to items such as: “When my friend has a problem, I always try really hard to keep my friend talking about it” and “When I have a problem, my friend always tries to get me to tell every detail about what happened.” Participants reported the degree to which each item applied to them on a 5-point Likert scale. Total scores were computed by averaging across the 9-items. Cronbach’s alpha ranged from 0.91–0.95 across baseline and the four follow-ups.

Sex and Gender

Sex and gender were assessed using a demographic questionnaire developed in-house. To assess sex, participants responded to the question “What is your biological sex?”. To assess gender, participants responded to the question “What is your gender?”. Non-binary response options were offered for both.

Procedure

This study was approved by the UBC Behavioural Research Ethics Board and followed the ethical standards of the Declaration of Helsinki. Eligible participants were invited to the lab with their parent/guardian before the start of their first year of high school. Parents/guardians provided consent and adolescents provided assent to participate in the study. Baseline data were collected before the start of high school. Adolescents and their parents/guardians first came to the lab to complete demographic questionnaires. Adolescents also completed measures of depressive symptoms,

rumination, and co-rumination, the Affective Posner Task, and other measures administered as part of the larger study. The Affective Posner Task was completed on an ASUS 20 inch color computer monitor with a 60 Hz refresh rate. Given that cognitive biases can remain dormant until activated by a negative mood state (Teasdale, 1988), participants were administered a negative mood induction before completing the Affective Posner Task. The mood induction was comprised of watching one of three randomly assigned 6 min negative movie clips. To confirm the mood induction was successful in inducing a more negative, and less positive, mood state, participants completed self-report ratings of positive and negative affect before and after the movie clip. Finally, participants completed measures of rumination and co-rumination at four follow-up study sessions at home or in the lab over the following year. Follow-up sessions were held (1) at the start of high school and (2) every three months over the next nine months. Remuneration was provided to participants' parent/guardian for each session. Data was collected from July 2018 to June 2020.

Statistical Analysis

Manipulation Check

A repeated measures analysis of variance (ANOVA) was conducted as a manipulation check to confirm that the mood induction successfully induced the expected affective response of increased negative affect and reduced positive affect.

Main Analyses

A series of multivariate means-as-outcomes multilevel models (Raudenbush & Bryk, 2002) were conducted to examine the impact of disengagement biases, depressive symptoms, and their interaction on average levels of co-rumination and rumination over the year. A multilevel approach was chosen given the nested structure of the data (as recommended by Tabachnick & Fidell, 2007), with repeated measures of co-rumination and rumination nested within participants. Multilevel modeling allows for missing data (Snijders & Bosker, 1999) and for multiple outcomes, which has the advantage of reducing Type I error (Hox et al., 2017). A means-as-outcomes multilevel approach allowed us to examine rumination and co-rumination across follow-up, thereby reducing error as compared to examining rumination and co-rumination at a single point in time and enabling us to examine average levels of rumination and co-rumination rather

than modeling growth. The current sample size exceeds best-practice recommendations for sufficient sample sizes for the unbiased estimation of regression coefficients, variance components, and standard errors (Maas & Hox, 2005).

Analyses were conducted using maximum likelihood estimation with robust standard errors in the software program Mplus (Muthén & Muthén, 1998–2017). To examine within-person nesting of observations, intraclass correlation coefficients (ICCs) for each of rumination and co-rumination were computed, which indicate the proportion of variance attributed to within- and between-person levels. We conducted two multilevel models to examine the association of average co-rumination or rumination over the year (at Level 1) with baseline depressive symptoms, disengagement biases, and their interaction (at Level 2). Continuous predictors were grand mean-centered. Significant interactions were followed up with region of significance analyses, which were analyzed using the Johnson-Neyman Technique and visualized using Johnson-Neyman plots. Predictors were not mean-centered in Johnson-Neyman plots to facilitate interpretation. Region of significance analyses provide information on the direction and significance of the effect of the dependent variable on the independent variable across levels of the moderator. This technique is recommended in preference to examining simple slopes for continuous predictors (Finsaas & Goldstein, 2021), which are often based on arbitrary values selected to represent low and high values. Use of simple slopes can result in Type II error because only a segment of the interaction effect is examined. In contrast, the Johnson-Neyman approach provides complete information on how the slope of the effect of the predictor on the outcome variable varies across the full range of the moderator, with confidence bands across the entire range of the moderator which demarcate the region(s) of significance. Finally, given well-documented sex (Hankin et al., 2010; Lopez et al., 2009) and gender (Felton et al., 2019; Rose, 2021; Spindel et al., 2017) differences in co-rumination and rumination, we conducted models that included sex as a covariate. We were not able to control for gender given that inclusion of gender resulted in a nonidentified model, likely because the non-binary gender group included only one individual.

Results

Correlations among main study variables are presented in Table S1 of the supplement. Females reported significantly greater levels of co-rumination than males across all time points; however, there were no significant sex differences in rumination or depression (see Table S2).

Manipulation Check

To assess the effectiveness of the mood induction, we conducted a two-way Time by Valence (positive, negative) repeated measures analysis of variance (ANOVA). There was a significant time by valence interaction, $F(1, 86) = 83.18$, $p < 0.001$, partial $\eta^2 = 0.49$. Follow-up pairwise comparisons showed that the mood induction successfully induced an expected significant increase in negative mood, Wilks' $\lambda = 0.75$, $F(1, 86) = 29.50$, $p < 0.001$, and significant decrease in positive mood, Wilks' $\lambda = 0.46$, $F(1, 86) = 102.75$, $p < 0.001$.

Within- and Between-Person Variance

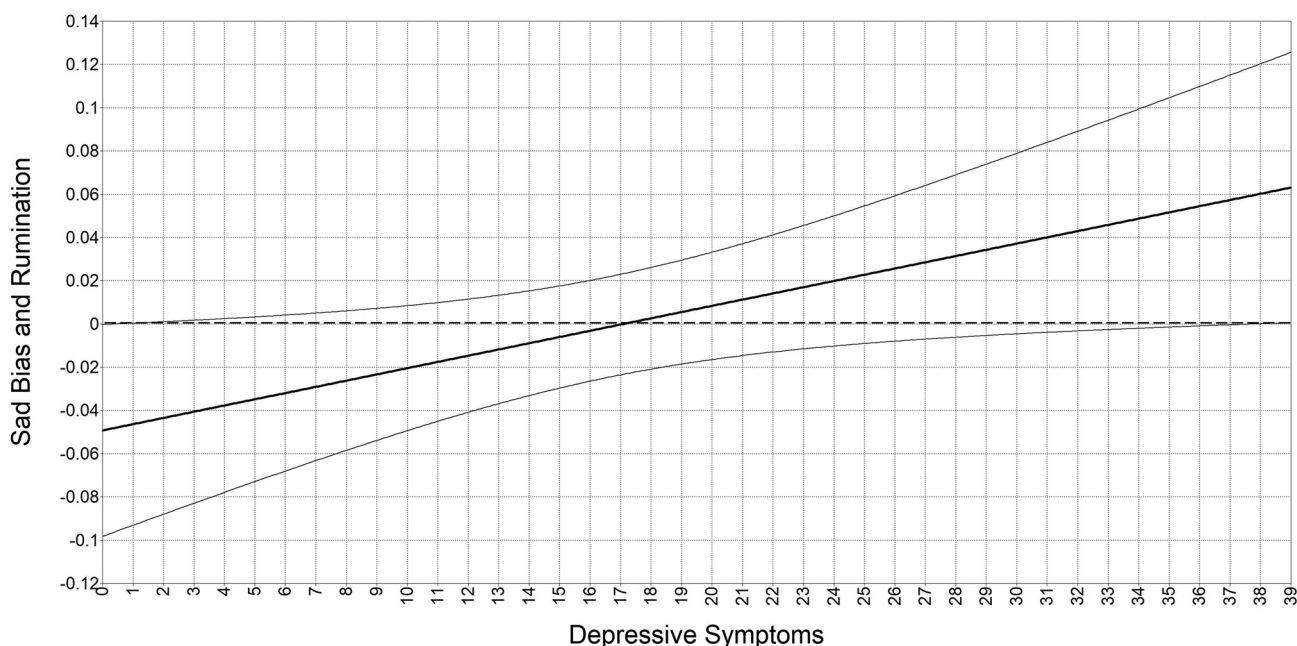
To examine the proportion of variance attributed to within- and between-person levels, we conducted a multivariate intercept-only model with rumination and co-rumination as the dependent variables and no Level 1 or 2 predictors. The ICC was 0.36 for rumination, indicating that 64% of variance was accounted for at the within-person level and 36% was at the between-person level. The ICC was 0.59 for co-rumination, indicating that 41% of variance was at the within-person level and 59% was at the between-person level.

Main Analyses

To examine whether the association of cognitive disengagement biases with rumination and co-rumination was moderated by depressive symptoms at early and late stages of attention, we conducted a multivariate means-as-outcomes multilevel model predicting average rumination and co-rumination for each cue duration (200 ms, representing early attentional processes, and 1,000 ms, representing later attentional processes). For each cue duration, the first model (Model 1) examined the main effects of baseline depressive symptoms, sad, angry, and happy disengagement biases at Level 2 on rumination and co-rumination, and the second model (Model 2) included these main effects as well as the interaction of each bias with depression at Level 2. Sex was included as a Level 2 covariate in both models.

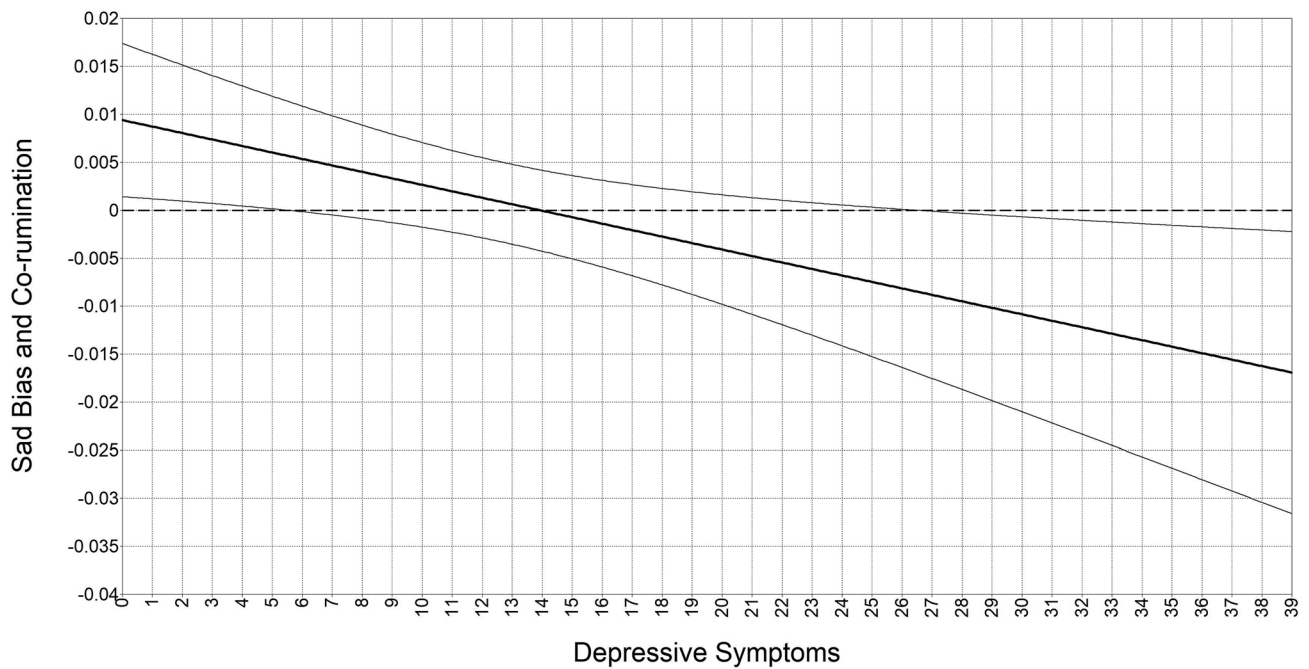
Early Attentional Processes

In predicting average rumination over the year, greater depressive symptoms were associated with greater levels of rumination, $B = 0.23$, $SE = 0.05$, $p < 0.001$, in Model 1. No other main effects significantly predicted rumination. In Model 2, however, there was a significant interaction of depressive symptoms with a sad attentional disengagement



Note. The thick solid line depicts the association of sad disengagement bias and rumination across levels of depressive symptoms observed in our data. Thin solid grey lines represent 95% confidence intervals, and the dashed line represents the 0 line on the y-axis. Regions of significance correspond to depressive symptoms $\leq .04$ and ≥ 37.9 , where the 95% confidence interval does not cross the 0-line on the y-axis.

Fig. 1 Moderating Effect of Depressive Symptoms on The Association of Sad Disengagement Bias and Rumination



Note. The thick solid line depicts the association of sad disengagement bias and co-rumination across levels of depressive symptoms observed in our data. Thin solid grey lines represent 95% confidence intervals, and the dashed line represents the 0 line on the y-axis. Regions of significance correspond to depressive symptoms ≤ 5.5 and ≥ 26.5 , where the 95% confidence interval does not cross the the 0-line on the y-axis.

Fig. 2 Moderating Effect of Depressive Symptoms on The Association of Sad Disengagement Bias and Co-Rumination

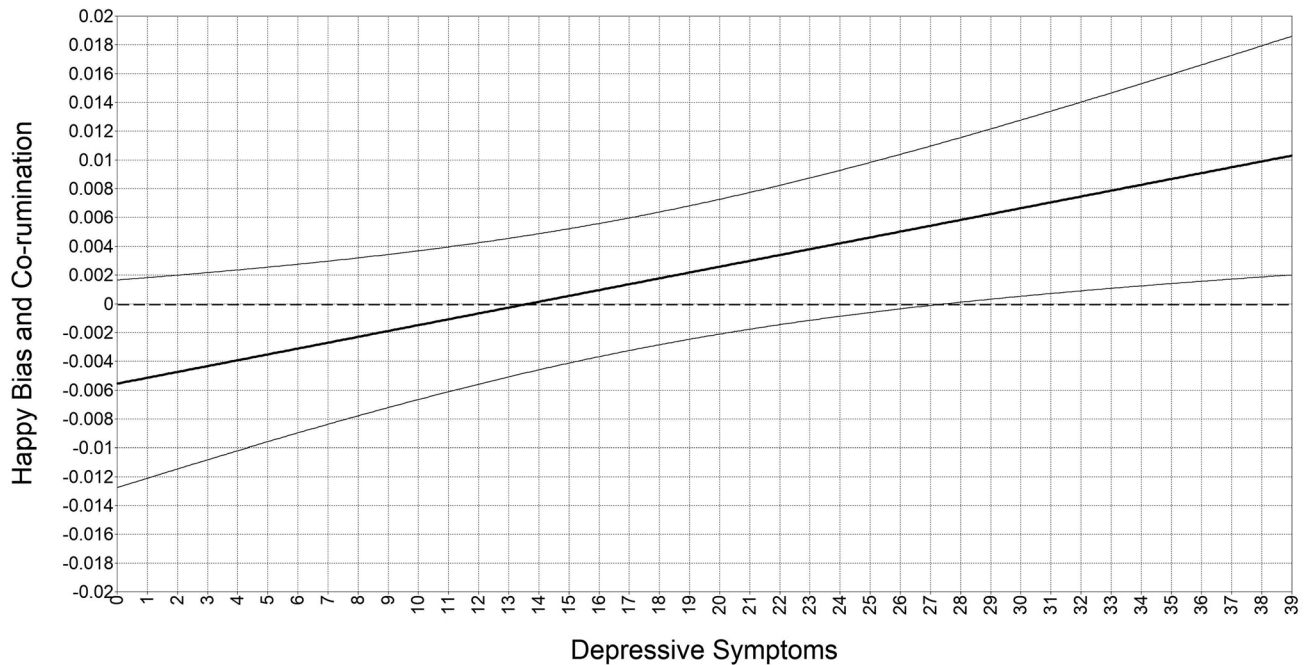
bias, $B = 0.003$, $SE = 0.001$, $p = 0.030$. Consistent with hypotheses, a follow-up region of significance analysis indicated that among individuals with very low depressive symptoms (CES-D scores ≤ 0.4), greater sad disengagement bias was associated with less rumination over the year. In direct contrast, among individuals with elevated depressive symptoms (CES-D scores ≥ 37.9), greater sad disengagement bias predicted greater rumination (see Fig. 1). No other interaction terms for predicting rumination were significant. All results are presented in Table S3 of the supplement.

In predicting average co-rumination, sex was associated with greater levels of co-rumination in Model 1, $B = -0.66$, $SE = 0.16$, $p < 0.001$, such that females co-ruminated more than males. No other main effects significantly predicted co-rumination in Model 1. However, two significant interactions were observed in Model 2. First, the interaction of depressive symptoms with a sad attentional disengagement bias was significant, $B = -0.001$, $SE = 0.0003$, $p = 0.014$. A region of significance analysis indicated that among individuals with depressive symptoms ≤ 5.5 , a greater sad disengagement bias was associated with *greater* co-rumination over the year. For those with symptoms ≥ 26.5 , a greater sad disengagement bias was associated with *lower* levels of co-rumination, see Fig. 2.

Second, there was a significant interaction of depressive symptoms with a positive disengagement bias, $B = 0.0004$, $SE = 0.0002$, $p = 0.013$. A follow-up region of significance analysis indicated that among individuals with depressive symptoms ≥ 27.6 , greater happy disengagement bias was associated with greater co-rumination, see Fig. 3. All other main effects and interaction terms predicting co-rumination were non-significant. All results are presented in Table S3 of the supplement.^{1,2}

¹ We also tested sex as a moderator. Sex was not a significant moderator of the association of disengagement biases, depressive symptoms, or disengagement biases by depressive symptoms with rumination or co-rumination, though findings were likely underpowered to detect a significant 3-way interaction. Findings are presented in Table S5 of the supplement.

² Given that data were collected over the course of the COVID-19 pandemic, we ran a supplemental analysis that controlled for the degree to which adolescents reported their lives became more negative and more positive across life domains as a result of the pandemic. The same pattern and direction of moderation findings emerged as in our original model.



Note. The thick solid black line depicts the association of happy disengagement bias and co-rumination across levels of depressive symptoms observed in our data. Thin solid grey lines represent 95% confidence intervals, and the dashed line represents the 0 line on the y-axis. The region of significance corresponds to depressive symptoms ≥ 27.6 , where the 95% confidence interval does not cross the the 0-line on the y-axis.

Fig. 3 Moderating Effect of Depressive Symptoms on the Association of Happy Disengagement Bias and Co-Rumination

Late Attentional Processes (1,000 ms Cue Duration)

In Model 1 there was a main effect of depressive symptoms on rumination over the year, $B=0.21$, $SE=0.05$, $p<0.001$, such that elevated depressive symptoms were associated with greater rumination. There was also a main effect of sex on co-rumination, $B=-0.67$, $SE=0.16$, $p<0.001$, indicating that girls co-ruminated more than boys. No other main effects were significant in Model 1, and no significant interactions emerged in Model 2, all $ps \geq 0.054$. Results are presented in Table S4 of the supplement.

Discussion

The current study was the first to investigate whether sad, angry, and happy disengagement biases predict rumination and its interpersonal counterpart, co-rumination, in early adolescents. Consistent with hypotheses, the direction of findings for each ER strategy differed based on depressive symptoms. Among adolescents with elevated depressive symptoms, a disengagement bias for sad stimuli presented for 200 ms was associated with *greater* rumination and *lower*

co-rumination over follow-up. In contrast, for youth with low depressive symptoms, a disengagement bias for sad stimuli presented for 200 ms was prospectively associated with *lower* rumination and *greater* co-rumination. Furthermore, happy disengagement biases, also for stimuli presented for 200 ms, were associated with greater co-rumination among youth with elevated depressive symptoms. The present findings emerged over and above effects of sex, which was included as a covariate. Interestingly, there were no main or interaction effects for later attentional processes (1,000 ms) predicting rumination or co-rumination.

Consistent with findings in the adult ER literature (Donaldson et al., 2007; Joormann & Gotlib, 2008; Joormann et al., 2006), and as hypothesized, sad disengagement biases predicted greater rumination among youth with high depressive symptoms. This finding is critical for advancing our understanding of processes underlying rumination among youth experiencing depressive symptoms during adolescence, a vulnerable period when depression and other forms of psychopathology linked with poor ER typically emerge (Kessler et al., 2007). Importantly, the association of disengagement biases with rumination was specific to stimuli of a sad valence. Given the self-referent

content of sad stimuli for individuals with elevated depressive symptoms, difficulty disengaging attention from *sad* stimuli is theorized to be the central cause of rumination (Koster et al., 2011). Disengagement biases for sad content prolongs processing of this information in working memory, thereby promoting ruminative thinking, which can maintain or exacerbate depressed mood (LeMoult & Gotlib, 2019; LeMoult et al., 2013; Nolen-Hoeksema et al., 2008; Watkins & Roberts, 2020). In contrast, angry and happy stimuli may be less self-referent for depressed individuals and may therefore be less likely to promote rumination. Thus, the current study indicates that attentional disengagement biases, specifically for sad information, may be an important mechanism underlying rumination in early adolescents with elevated symptoms of depression.

In direct contrast, sad disengagement biases predicted *lower* co-rumination in youth with elevated depressive symptoms and, consistent with hypotheses, *greater* co-rumination in youth with low depressive symptoms. Thus, although rumination and co-rumination are complementary ER strategies that share a defining perseverative focus on negative feelings and problems, the current findings suggest that rumination and co-rumination show distinct underlying cognitive mechanisms depending on the relative presence or absence of depressive symptoms. These differences may result from the interpersonal self-disclosure that distinguishes co-rumination from rumination. For those with high depressive symptoms, difficulty disengaging from negative information was associated with excessive *internal* rehashing of negative thoughts in the form of rumination, which may have reduced their need to rehash problems with others (i.e., co-ruminate). Indeed, the action tendency central to depression and rumination is for individuals to withdraw inward and away from others (Nolen-Hoeksema et al., 2008), which likely reduces social opportunities needed to engage in co-rumination. Conversely, findings suggest that individuals with low depressive symptoms and a sad disengagement bias tend to perseverate over negative information in communion with others (i.e., to co-ruminate). Moreover, a tendency for individuals with low depressive symptoms and sad disengagement biases to seek support with regulating their emotions via co-rumination may reduce their use of intrapersonal ER strategies such as rumination. This may explain why sad disengagement biases were associated with both higher co-rumination *and* lower rumination among individuals with low depressive symptoms.

In interpreting these findings, it is important to note that regions of significance for depressive symptoms varied across rumination and co-rumination. For rumination, “high” and “low” depressive symptoms corresponded to more extreme values of depressive symptoms as compared to findings for co-rumination, indicating that disengagement biases influence rumination at more extreme thresholds of depressive

symptoms among youth. For example, the interaction of sad disengagement biases with elevated depressive symptoms in predicting greater rumination was significant at values of depression over three standard deviations above the mean. This suggests that this effect may be especially relevant for individuals with particularly high levels of depression, and indicates a need for replication in clinical samples that report a higher upper limit in the range of CES-DC scores. Taken together, disengagement biases may influence co-rumination in a larger proportion of youth as compared to rumination, making the disengagement bias–co-rumination link more relevant for understanding ER in the general adolescent population.

It is interesting to interpret our work in light of recent evidence for unidirectional prospective associations between co-rumination and rumination, whereby co-rumination predicts greater rumination over time (Aldrich et al., 2019; Felton et al., 2019; Stone & Gibb, 2015). When considered in tandem with our finding that adolescents with both sad disengagement biases and low depressive symptoms engage in greater co-rumination, we would expect greater co-rumination to lead to greater rumination among these youth, which may in turn increase depression (Nolen-Hoeksema et al., 2008). Another possibility is that co-rumination among this group of individuals may also directly lead to greater depressive symptoms (Rose et al., 2007), which, as the current findings suggest, could potentially result in these youth subsequently turning to rumination as an ER strategy. Future multi-wave studies using large samples are needed to explore these potential pathways to depression and rumination.

Whereas the attentional disengagement bias-rumination link was specific to sad stimuli, co-rumination was associated with both sad and happy disengagement biases. Among individuals with elevated depressive symptoms, happy disengagement biases predicted *greater* co-rumination. This suggests that happy disengagement biases promoted co-rumination among individuals who might otherwise ruminate. Importantly, the Affective Posner Task used in the current study uses emotional faces as stimuli, which are highly interpersonally relevant. Difficulty disengaging attention from positive stimuli, and from happy faces specifically, may promote interpersonal interaction and facilitate support seeking in youth with elevated depressive symptoms, who may seek out others to assist in regulating their low mood via co-rumination. The finding that a positive cognitive bias was associated with greater interpersonal ER aligns with interpretation bias research documenting that a positive interpretation bias for emotionally ambiguous faces is associated with greater social connectedness (Neta & Brock, 2021). Moreover, this finding parallels the paradoxical nature of co-rumination in that, although co-rumination is associated with negative mental health outcomes including depression, it also predicts enhanced friendship quality (e.g., Battaglini et al., 2021; Rose et al., 2007, 2014).

Importantly, there is some evidence to indicate that, although boys and girls both experience the benefit of greater friendship quality as a result of co-rumination, the trade-off of also experiencing elevated depression may be more prominent among girls (Rose et al., 2007). We tested sex as a moderator in supplemental analyses, yet the current study was likely not powered to detect three-way interactions. Future research using larger samples is needed to investigate sex and gender differences in the association of disengagement biases with co-rumination. Moreover, given that gender differences in depression begin to emerge by middle adolescence, it is also possible that disengagement biases may play an even greater role in promoting higher levels of co-rumination and rumination among girls during this developmental period. This may, in turn, further reinforce higher rates of depressive symptoms in girls as compared to boys. Future research examining associations among disengagement biases, depression, rumination, and co-rumination in middle adolescence is needed.

In contrast to sad and happy disengagement biases, angry disengagement biases were not associated with rumination or co-rumination. This finding is consistent with past literature on rumination (Joormann et al., 2006). Instead, angry, threatening faces may be more self-relevant among individuals with social anxiety and may be more pertinent for predicting repetitive negative thinking styles that are more common among individuals with anxiety, such as post-event processing – defined as a repeated and detailed review of one's performance in social situations. Consistent with this idea, social anxiety is associated with an angry attentional disengagement bias (Schofield et al., 2012), and past research has documented that social anxiety is linked to post-event processing via an attentional bias to threatening faces expressing disgust (Çek et al., 2016).

Disengagement biases for stimuli presented for shorter durations (200 ms), but not for longer durations (1,000 ms), interacted with depressive symptoms to predict rumination and co-rumination. This suggests that, among early adolescents, biases in early attentional disengagement are specifically associated with rumination and co-rumination, and that later attentional processes may be less relevant for these types of ER. This finding is in contrast with the adult literature, whereby more robust and consistent findings for attentional biases in depression have been reported for longer stimulus durations (LeMoult & Gotlib, 2019). Although prior work has documented attentional biases associated with depression in youth across a range of stimulus exposure durations (Platt et al., 2017), the current study was the first to systematically assess both early and later attentional processes. As such, differences between the current findings and the adult literature may be due to developmental differences across samples, though future research is needed to investigate this possibility. Future experimental work using

cognitive bias modification is also needed to replicate this novel finding and to determine whether it holds for other age groups (e.g., young children) and clinical populations.

The current findings have important implications for theoretical conceptualizations of the cognitive basis of rumination and co-rumination in youth. Results extend our knowledge of the biases that underlie rumination to early adolescents and are the first to show that a distinct profile of sad and happy disengagement biases promote co-rumination, thereby emphasizing the influence that the interpersonal dimension has on mechanisms underlying intra- versus interpersonal ER. As the direction of findings differed based on depressive symptoms, findings also highlight the importance of taking depressive symptoms into account when investigating the association of cognitive biases with ER. This is particularly important for co-rumination given its paradoxical associations with both enhanced friendship quality and negative emotional outcomes (Rose et al., 2007, 2014). Moreover, given that adolescence is a critical developmental stage during which depression and other forms of psychopathology related to poor ER often emerge (Kessler et al., 2007), while also representing a period when vulnerabilities have not yet become deeply entrenched or resistant to change (Ganzel et al., 2013), identifying factors that promote ER among early adolescents is valuable as an initial first step for informing applied research that examines prevention and early intervention strategies. The current findings suggest that targeting cognitive disengagement biases may be a promising approach for modifying ER. Consistent with this idea, past research has documented that various cognitive control training paradigms result in reduced rumination among depressed adults (Hoorelbeke et al., 2015; Jopling et al., 2020). Mindfulness-based cognitive therapy represents another promising approach that has been found to improve attentional control and reduce rumination (see van der Velden et al., 2015). However, future work is needed to investigate cognitive control training and mindfulness-based approaches in youth and to assess their impact on rumination, co-rumination, and other ER strategies.

The present findings should be interpreted in the context of this study's limitations. The present study recruited a community sample of youth reporting a range of depressive symptoms. Although this allowed us to examine depression as a dimensional construct, consistent with how depression is conceptualized based on taxometric evidence (Hankin et al., 2005), our findings may not generalize to other populations. Given the elevated distress and impairment associated with diagnosed disorders, it would be especially valuable for findings to be replicated in a clinical sample. In addition, the current study did not assess characteristics of the friend with whom participants co-ruminated. Given

evidence that the negative effects of co-rumination are larger for same-sex friendships among adults (Rose, 2021), future research should take into account demographic characteristics of adolescents' friends. Furthermore, although we tested sex as a moderator, these findings were likely underpowered to detect three-way interactions. Future studies with large sample sizes are needed to conduct more fine-grained investigations into sex and gender differences in the links between disengagement biases and depressive symptoms with rumination and co-rumination. Finally, future investigations of rumination and co-rumination should also go beyond the assessment of trait ER strategies to examine the role of mood and disengagement biases in predicting fluctuations in ER strategy use across the day or from one day to the next. Thus, future research should examine the cognitive disengagement bias-ER link using intensive longitudinal designs such as ecological momentary assessment. This approach would also have the added benefit of enabling the investigation of factors predicting the preferential use of one strategy versus another at a given point in time.

The present study was the first to investigate cognitive biases underlying rumination in youth, as well as the first to examine the cognitive basis of co-rumination. Importantly, findings have implications on our understanding of ER in early adolescents, for whom rumination and co-rumination can have marked consequences on wellbeing. Sad disengagement biases predicted greater rumination and lower co-rumination in youth with elevated depressive symptoms. This suggests that youth with high depressive symptoms and cognitive biases for sad information tend to passively dwell on problems solitarily. Conversely, sad biases were associated with lower rumination and greater co-rumination in youth with low symptoms, indicating that healthy youth with negative cognitive biases may preferentially elicit the support of others to regulate their emotions. Furthermore, a bias for happy faces was associated with greater co-rumination among youth with elevated depressive symptoms. Positive cognitive biases may therefore promote the rehashing of negative information in an interpersonal context among adolescents experiencing depressive symptoms, who might otherwise ruminate, as they attempt to regulate emotions via social interactions. Sex was controlled for in analyses, ensuring that all findings emerged above and beyond any confounding effects of sex. Altogether, findings highlight the importance of examining interpersonal ER strategies as distinct forms of ER and of taking depressive symptoms into account in investigations of factors driving ER. By informing our understanding of the mechanisms underlying rumination and co-rumination, the current study extends theoretical conceptualizations of rumination to youth and provides the first account of cognitive mechanisms underlying co-rumination.

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Author Contribution JL acquired funding and all authors contributed to study conceptualization and design. Data collection was performed by KR, EJ, AT, and JL. KR performed analyses and prepared the original draft. All authors provided critical revisions of the manuscript and JL provided supervision. All authors read and approved the final manuscript.

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Data and Code Availability Data, materials, and code are available from the corresponding author, Katerina Rnic, Ph.D., upon request and execution of a data sharing agreement.

Compliance with Ethical Standards

Ethical Approval All procedures were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments and comparable ethical standards. This study was approved by the University of British Columbia's (UBC) Behavioural Research Ethics Board (BREB).

Informed Consent Written informed consent was obtained from parents/guardians, and written assent was obtained from adolescents.

Conflicts of Interest The authors have no conflicts of interest to disclose.

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