



Associations Among Early Life Stress, Rumination, Symptoms of Psychopathology, and Sex in Youth in the Early Stages of Puberty: a Moderated Mediation Analysis

Joelle LeMoult¹ · Kathryn L. Humphreys² · Lucy S. King² · Natalie L. Colich² · Alexandria N. Price² · Sarah J. Ordaz² · Ian H. Gotlib²

© Springer Science+Business Media, LLC, part of Springer Nature 2018

Abstract

Despite the high prevalence and substantial costs of early life stress (ELS), the mechanisms through which ELS confers risk for psychopathology are poorly understood, particularly among youth who are in an earlier stage of the transition through puberty. We sought to advance our understanding of the link between ELS and psychopathology by testing whether rumination mediates the relation between ELS and symptoms of psychopathology in youth in the early stages of puberty, and whether sex moderates this mediation. We assessed levels of ELS, both brooding and reflection subtypes of rumination, and internalizing and externalizing symptoms in 170 youth in the early stages of puberty (56% girls) ages 9–13 years. Brooding, but not reflection, mediated the relation between ELS and both internalizing and externalizing symptoms. Importantly, however, sex moderated the relation among ELS, brooding, and symptoms. Specifically, brooding mediated the relation between ELS and both internalizing and externalizing symptoms for girls, but not for boys. Findings support the formulation that brooding is a mechanism linking ELS to multiple forms of behavioral and emotional problems exclusively in girls in the early stages of puberty.

Keywords Early life stress · Rumination · Sex differences · Psychopathology

An estimated 70% of children experience early life stress (ELS), including exposure to domestic or neighborhood violence, bullying, separation from family, or maltreatment (Cohen et al. 2006). ELS is a well-established risk factor for symptoms of psychopathology such as posttraumatic stress disorder, depression, anxiety, and substance use (e.g., Michl et al. 2013). Thus, it is not surprising that the World Health Organization has emphasized the need to draw public attention to the health consequences of ELS and has called for research that informs clinical interventions (Horswell and Istfan 2006). Identifying factors that increase risk for the development of psychopathology following ELS is critical to advancing these goals.

Cognitive theories of psychopathology posit that a central vulnerability factor linking stress with symptoms of psychopathology is the tendency to use maladaptive strategies to regulate negative emotions (Nolen-Hoeksema and Watkins 2011; Nolen-Hoeksema et al. 2008; Watkins 2009). Rumination is a particularly maladaptive emotion regulation strategy in which individuals perseverate passively about their symptoms of distress and/or about the causes and consequences of those symptoms. Rumination has been linked to various forms of psychopathology (Aldao and Nolen-Hoeksema 2010; Aldao et al. 2010), particularly for females (Nolen-Hoeksema et al. 2008). For example, individuals who ruminate in response to distress are more likely to endorse symptoms of internalizing disorders, such as depression and anxiety (e.g., Broderick 2004; Jenness et al. 2016; Michl et al. 2013; Rood et al. 2009), and externalizing disorders, such as substance abuse and conduct problems (e.g., Nolen-Hoeksema et al. 2007). Researchers have begun to examine rumination in the context of ELS and have documented that individuals exposed to ELS are more likely than are non-exposed individuals to use problematic coping styles such as rumination, which in turn, has been associated with clinical symptoms (e.g., Heleniak et al. 2016; Michl et al. 2013).

✉ Joelle LeMoult
jlemoult@psych.ubc.ca

¹ University of British Columbia, 2136 West Mall, Vancouver, BC V6T 1Z4, Canada

² Stanford University, Bldg. 420, Jordan Hall, Stanford, CA 94305, USA

Importantly, in the broader rumination literature, researchers have identified two subcomponents of rumination: brooding and reflection (Treyner et al. 2003). Whereas brooding, or passively focusing on symptoms, predicts heightened symptoms of psychopathology, reflection, or actively attempting to gain insight into problems, rarely predicts symptoms of psychopathology and may even promote resilience (Treyner et al. 2003). Despite the importance of distinguishing between these subcomponents of rumination, few studies have examined whether brooding versus reflection predicts symptoms of psychopathology following ELS, and all of them have focused on adult samples (O'Mahen et al. 2015; Wu et al. 2015). In fact, only a handful of studies have examined whether rumination mediates the relation between ELS and symptoms of psychopathology in children or adolescents (Felton et al. 2013; Heleniak et al. 2016; Jenness et al. 2016; Michl et al. 2013). Not only have studies on children or adolescents not examined the differential effects of brooding versus reflection, but in addition, most have been limited by their exclusive focus on internalizing symptoms and/or their use of questionnaire and/or subjective assessments of ELS. Thus, while there is a burgeoning literature examining rumination as a mechanism through which ELS confers risk for psychopathology in adults, we know much less about cognitive mechanisms of risk in children and adolescents.

In addition, research examining ELS, rumination, and psychopathology has not considered the role of sex. This is particularly surprising given documented sex differences in levels of rumination (Nolen-Hoeksema et al. 2008), in the prevalence of internalizing and externalizing symptoms (Zahn-Waxler et al. 2008), and in the relation between ELS and clinical symptoms (Evans et al. 2017). Thus, it is possible that the mechanisms through which ELS confers risk for psychopathology are different for boys and girls. For example, girls are more likely than are boys to ruminate in response to stress (Tamres et al. 2002) and to experience higher rates of internalizing symptoms yet lower rates of externalizing symptoms (Kessler et al. 2005). In addition, ELS is more likely to predict symptoms of internalizing problems for girls (Furr et al. 2010) and of externalizing problems for boys (Evans et al. 2017). Thus, rumination may be salient principally for girls and, therefore, might be a mechanism that links ELS with psychopathology, namely internalizing disorders, for girls, but not for boys.

What remains particularly unclear, however, is whether we would observe sex differences in the associations among ELS, rumination (brooding and reflection), and symptoms of psychopathology in youth who are in an earlier stage of the transition through puberty. Pubertal development is associated with biological, psychological, and social changes (Hayward 2003; Susman and Dorn 2006) that increase risk for psychopathology in youth later in the pubertal transition (Angold et al. 1998; Ge et al. 2001). Moreover, sex differences in rates

of internalizing and externalizing symptoms do not emerge until later stages of puberty (e.g., Paus et al. 2008). Thus, it is not clear whether brooding and/or reflection are associated with the development of sex differences in the prevalence of symptoms of psychopathology in youth who are still early in the transition through puberty. Understanding the associations among ELS, rumination, and symptoms in the early stages of puberty, when youth are more likely to experience subclinical levels of psychopathology, may elucidate a developmental period during which early interventions may be maximally effective in reducing the effects of ELS on the subsequent development of psychopathology. Given the gap in the literature and the potential this developmental period offers for early intervention, we were interested in examining the relations among ELS, brooding versus reflection, and symptoms of psychopathology in youth who were in the early stages of puberty.

The current study extends the existing literature by using an interview-based assessment of ELS to examine whether brooding and reflection mediate the relation between ELS and internalizing and externalizing symptoms, and by testing whether sex moderates the relations among ELS, rumination, and symptoms in a sample of youth in the early stages of puberty. We hypothesized that brooding, but not reflection, would mediate the relation between ELS and both internalizing and externalizing symptoms such that higher levels of ELS would be associated with higher levels of brooding, which in turn, would be associated with higher levels of internalizing and externalizing symptoms. Moreover, we expected that, even in this sample of youth in the early stages of puberty, sex would moderate the strength of brooding as a mediator linking ELS and symptoms; specifically, we expected that brooding would mediate the relation between ELS and internalizing symptoms for girls but not for boys.

Method

Participants

Participants (56% female) were 170 youth in the early stages of puberty (Tanner Stage 3 or below, Morris and Udry 1980, as is consistent with previous research, McCartney et al. 2007; McKay et al. 2005; Ordaz et al. 2017; Travers et al. 1995). Youth ranged in age from 9 to 13 years ($M = 10.88$, $SD = 1.03$) and were recruited as part of a larger study examining psychological effects of ELS across the transition through puberty. Participants were recruited using media and online advertisements. Children were excluded if they had major medical complications, head trauma, or a severe learning disability. Given the goals of the larger study, exclusion factors also included the onset of menses for girls and the inability to participate in a magnetic resonance imaging (MRI) scan

(e.g., metal implants, braces) for all participants. Boys and girls were matched on the basis of their pubertal status, as determined by self-reported average Tanner Staging. Youth rated their physical development based on a series of drawings illustrating stages of physical development (Marshall and Tanner 1970a, b; Morris and Udry 1980; see Table 1). The racial and ethnic demographics were representative of the surrounding community: 42% Caucasian, 13% Asian, 9% Black, 9% Hispanic, 2%, Native American, 1% Pacific Islander, and 24% other.

Measures

Early Life Stress The severity of ELS was assessed via a modified version of the Traumatic Events Screening Inventory for Children (TESI-C; Ribbe 1996). Youth were interviewed about their lifetime exposure to more than 30 types of stressful experiences. For each type of ELS endorsed, the interviewer asked follow-up questions in order to gather detailed information about the experience and participants' perceived severity of it. The interviewer then presented participants' descriptions of each stressor to a panel of three raters who were blind to participants' reactions during the interview or subjective perceptions of stress severity. The coders used a modified version of the UCLA Life Stress Interview coding system (Hammen and Rudolph 1999; Rudolph et al. 2000) to rate the objective severity of each stressor on a 5-point Likert scale ranging from 0 = *non-event or no impact* to 4 = *extremely severe impact* (ICC = 0.99). In order to index the cumulative severity of ELS, we summed the objective ratings for each stressor endorsed. Total severity ratings ranged from 0 to 26 ($M = 6.49$; $SD = 4.84$). Using panel-rated scores of the severity of ELS addresses criticisms of count-based measures of ELS (e.g., Hammen 2016); specifically, panel-rated severity scores account for both the number and severity of each stressor, and they overcome limitations of subjective ratings of ELS.

Rumination Rumination was assessed via the well-established 10-item Ruminative Response Scale (RRS; Nolen-Hoeksema et al. 1999), which has demonstrated strong psychometric properties in adolescent samples (Burwell and Shirk 2007). Consistent with Treynor et al.'s (2003) distinction of maladaptive and adaptive forms of rumination, we calculated scores separately for the brooding and reflection subscales ($\alpha_s = 0.81$ and 0.68).

Clinical Symptoms Adopting a dimensional conceptualization of child emotional and behavioral problems, we used the Youth Self-Report (Achenbach 1991) to assess participants' clinical symptoms. The YSR is a widely-used self-report questionnaire assessing the presence of 112 different symptoms or behaviors experienced during the last six months. Participants rate each symptom or behavior on a three-point

Table 1 Participant characteristics

Variable, $M(SD)$	Boys ($n = 75$)	Girls ($n = 95$)
Age	11.32 (0.99)	10.54 (0.93)
Tanner stage	1.87 (0.63)	2.03 (0.67)
Income, %		
< \$50,000	15%	17%
\$50,000–\$100,000	17%	20%
\$100,000–\$150,000	25%	25%
> \$150,000	43%	38%
ELS Severity	6.49 (4.56)	6.49 (5.07)
Brooding	10.20 (3.77)	9.87 (3.22)
Reflection	8.89 (2.91)	9.12 (2.96)
Internalizing symptoms (Total Score)	10.87 (8.04)	12.56 (9.91)
Externalizing symptoms (Total Score)	10.76 (6.42)	8.44 (6.91)

ELS early life stress

scale, with higher scores indicating increased frequency. The internalizing scale is composed of the withdrawn, somatic complaints, and anxious/depressed subscales. The externalizing scale is composed of the delinquent behavior and aggressive behavior subscales. Total scores were used for the internalizing and externalizing scale, which showed excellent reliability ($\alpha_s = 0.92$ and 0.86, respectively).

Procedure

The study was approved by the Stanford University Institutional Review Board. Inclusion and exclusion criteria were assessed over the phone initially and were confirmed during the laboratory session. Participants and their parents gave assent and informed consent, respectively, and were compensated for their participation. Youth completed interviews and self-report questionnaires independently of their parents.

Data Analytic Approach

Mediation and moderated-mediation analyses were conducted using PROCESS for SPSS (Hayes 2013). The PROCESS macro has advantages over other analytic approaches, including the ability to test moderated mediation models and the ability to quantify moderated mediation effects (Hayes 2013). Estimates are presented with bootstrapped standard errors and 95% bootstrapped confidence intervals (CI). The index of the indirect effect and of the moderated mediation are considered statistically significant if the 95% CI does not include zero. In order to predict internalizing and externalizing symptoms simultaneously and to account for the covariation between them, we ran two PROCESS commands for each analysis and seeded the random number generator with a common seed for bootstrap sampling at each run. This approach is

equivalent to correlating the outcome variables in a structural equation modeling (SEM) analysis, and SEM analyses conducted in Mplus (Muthén and Muthén 2014) yield results consistent with those reported here. Importantly, brooding and reflection were entered as simultaneous mediators, allowing us to examine the role of brooding over and above reflection, and vice versa. Sex was dummy coded, and continuous data were z-scored.

Results

Demographic and Clinical Characteristics

Demographic and clinical characteristics of the participants are presented separately for girls and boys in Table 1. Girls did not differ from boys in pubertal stage, $t(168) = -1.61$, race, $\chi^2(N = 170, 6) = 4.50$, household income, $\chi^2(N = 165, 10) = 5.55$, the severity of ELS, $t(168) = -0.01$, levels of brooding, $t(168) = 0.61$, levels of reflection, $t(168) = -0.49$, or levels of internalizing symptoms, $t(168) = -1.20$, all $ps > 0.05$. Boys, however, endorsed more externalizing symptoms than did girls, $t(168) = 2.24$, $p = 0.026$. Moreover, because pubertal stage was matched across sexes, boys were older than girls, $t(168) = 5.30$, $p < 0.001$.

First-Order Correlations

We examined first-order correlations among the severity of ELS, levels of brooding and reflection, and internalizing and externalizing symptoms (see Table 2). ELS was significantly positively correlated with internalizing symptoms, externalizing symptoms, and brooding, but not with reflection. Higher levels of brooding were correlated with higher levels of reflection, and both brooding and reflection were correlated with higher levels of internalizing symptoms and externalizing symptoms. Finally, internalizing and externalizing symptoms were positively correlated with each other.

Mediation Analyses

We next tested whether brooding and reflection mediated the relation between ELS and internalizing and externalizing symptoms. For internalizing symptoms, the relation between ELS and symptoms was mediated by brooding, effect = 0.14, SE = 0.06, 95% CI [0.04, 0.28], but not by reflection, effect = -0.01, SE = 0.02, 95% CI [-0.06, 0.01]. Parallel results were found for externalizing symptoms: brooding, effect = 0.12, SE = 0.05, 95% CI [0.04, 0.25], but not reflection, effect = -0.01, SE = 0.02, 95% CI [-0.06, 0.01], mediated the relation between ELS and externalizing symptoms. Specifically, ELS was positively associated with levels of brooding, $\beta = 0.23$, SE = 0.09, $t(168) = 2.73$, $p = 0.007$, which in turn was

Table 2 First-order correlations

Variable	Brooding	ELS	Internalizing	Externalizing
Reflection	0.56**	0.15	0.28**	0.24**
Brooding	–	0.21**	0.59**	0.52**
ELS		–	0.31**	0.32**
Internalizing			–	0.64**

ELS early life stress

** $p < 0.01$

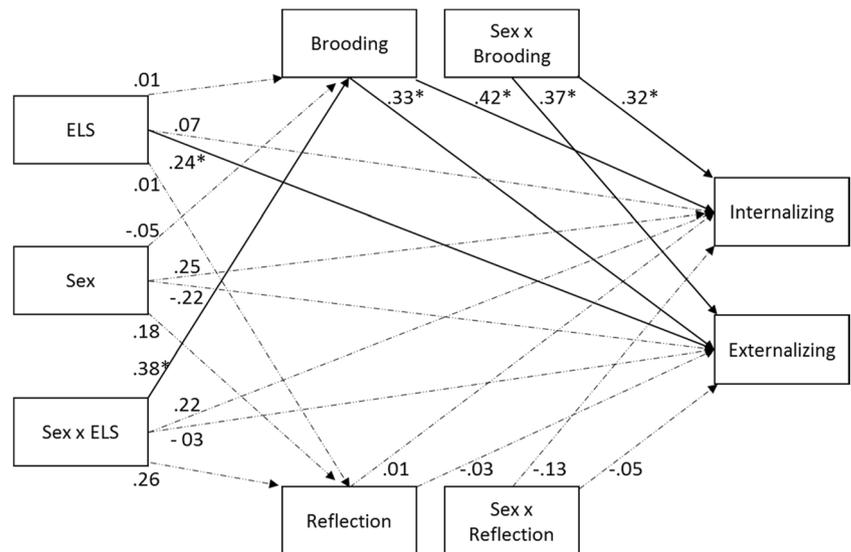
positively associated with levels of internalizing, $\beta = 0.60$, SE = 0.08, $t(166) = 7.96$, $p < 0.001$, or externalizing symptoms, $\beta = 0.53$, SE = 0.08, $t(166) = 6.65$, $p < 0.001$. In contrast, although ELS was associated at a trend level with levels of reflection, $\beta = 0.17$, SE = 0.09, $t(168) = 1.90$, $p = .060$, levels of reflection in turn was not associated significantly with internalizing, $\beta = -0.07$, SE = 0.07, $t(166) = -1.00$, $p = 0.319$, or externalizing symptoms, $\beta = -0.09$, SE = 0.08, $t(166) = -1.11$, $p = 0.267$. When brooding and reflection were included in the model, the direct effect of ELS on internalizing symptoms remained significant, $\beta = 0.23$, SE = 0.07, $t(166) = 3.21$, and the direct effect of ELS on externalizing symptoms remained significant, $\beta = 0.26$, SE = 0.08, $t(166) = 3.48$, $ps \leq 0.002$. Thus, brooding, but not reflection, partially mediated the relation between ELS and both internalizing and externalizing symptoms.

Moderated-Mediation Analyses

In order to test whether sex moderated the effects of rumination as a mechanism linking ELS with internalizing and externalizing symptoms, we tested the moderated-mediation model depicted in Fig. 1. Specifically, we examined whether sex moderated both the direct and indirect associations among ELS, rumination (brooding and reflection), and symptoms (Model 59; Hayes 2013). We included age as a covariate in these analyses.

For internalizing symptoms, the overall test of moderated mediation was significant for brooding, index = 0.28, SE = 0.13, 95% CI [0.07, 0.57], but not for reflection, index = -0.03, SE = 0.04, 95% CI [-0.11, 0.03]. Specifically, as we predicted, brooding mediated the relation between ELS and internalizing symptoms for girls, effect = 0.28, SE = 0.11, 95% CI [0.13, 0.54], but not for boys, effect = 0.002, SE = 0.07, 95% CI [-0.14, 0.13]. For externalizing symptoms, the overall test of moderated mediation was significant for brooding, index = 0.26, SE = 0.13, 95% CI [0.07, 0.57], but not for reflection, index = -0.02, SE = 0.04, 95% CI [-0.11, 0.05]. Specifically, brooding mediated the relation between ELS and externalizing symptoms for girls, effect = 0.27, SE = 0.11, 95% CI [0.11, 0.55], but not for boys, effect = 0.002, SE = 0.06, 95% CI [-0.12, 0.12].

Fig. 1 Moderated-mediation model testing whether sex moderates the direct and indirect effects among early life stress (ELS), levels of brooding and reflection, and internalizing and externalizing symptoms in youth. Age, not depicted here, was included as a covariate. Significant paths are presented in bold. Note: * $p < 0.05$



Sex moderated the relation between ELS and brooding, $\beta = 0.38$, $SE = 0.18$, $t(165) = 2.13$, $p = 0.034$, between brooding and internalizing symptoms, $\beta = 0.32$, $SE = 0.15$, $t(161) = 2.07$, $p = 0.040$, and between brooding and externalizing symptoms $\beta = 0.37$, $SE = 0.16$, $t(161) = 2.27$, $p = 0.025$. Sex did not moderate the direct effect of ELS on internalizing symptoms, $\beta = 0.22$, $SE = 0.15$, $t(161) = 1.48$, $p = 0.142$, and the path between ELS and internalizing symptoms was not significant, $\beta = 0.07$, $SE = 0.11$, $t(161) = 0.64$, $p = 0.521$. Sex also did not moderate the direct effect of ELS on externalizing symptoms, $\beta = -0.03$, $SE = 0.15$, $t(161) = -0.17$, $p = 0.867$, which remained significant, $\beta = 0.24$, $SE = 0.12$, $t(161) = 2.07$, $p = 0.040$. In contrast, reflection did not mediate the relation between ELS and internalizing symptoms for girls, effect = -0.03 , $SE = 0.03$, 95% CI $[-0.10, 0.01]$, or for boys, effect = 0.0001 , $SE = 0.03$, 95% CI $[-0.06, 0.05]$. Similarly, reflection did not mediate the relation between ELS and externalizing symptoms for girls, effect = -0.02 , $SE = 0.03$, 95% CI $[-0.10, 0.02]$, or for boys, effect = -0.0004 , $SE = 0.03$, 95% CI $[-0.06, 0.05]$. No significant effects were found for age, all $ps > 0.10$. Thus, only brooding mediated the relation between ELS and internalizing symptoms for girls, but not for boys. Similarly, only brooding partially mediated the relation between ELS and externalizing symptoms for girls, but not for boys.

Discussion

The current study advances our understanding of the association between ELS and symptoms of psychopathology by using an objective interview-based assessment of ELS, distinguishing between brooding and reflection, examining both internalizing and externalizing symptoms, and testing the moderating effect of sex in a sample of youth in the early

stages of puberty. Although ELS was associated with both brooding and, at trend level, reflection, only brooding mediated the relation between ELS and symptoms of psychopathology. In addition, the relation among ELS, brooding, and symptoms was moderated by sex. Specifically, brooding mediated the relation between ELS and both internalizing and externalizing symptoms for girls, but not for boys. Findings support the formulation that brooding is a mechanism linking ELS to multiple emotional and behavioral problems exclusively for girls in the early stages of puberty. By documenting sex differences in the mechanisms through which ELS confers risk for symptoms of psychopathology in youth in the early stages of puberty, these results inform etiological models of psychopathology and have implications for prevention and intervention.

Consistent with recent conceptualizations of rumination (e.g., Treynor et al. 2003; Watkins and Teasdale 2004), we found that brooding, but not reflection, mediated the relation between ELS and symptoms of psychopathology. Higher levels of ELS were associated with higher levels of both brooding and, at a trend level, reflection; it was only brooding, however, that in turn was associated higher levels of symptoms. When researchers have examined rumination as a mechanism through which ELS confers risk for symptoms of psychopathology, they have typically combined brooding and reflection (e.g., Felton et al. 2013; Michl et al. 2013) or have examined only one subtype (Heleniak et al. 2016). By separating and simultaneously examining the brooding and reflection subtypes, we are able to draw two important conclusions. First, our data suggest that ELS is associated with higher levels of the repetitive and reflective style of thought that characterize both brooding and reflection subtypes of rumination. There are a number of biological and cognitive factors that might explain why stress early in life is related to later rumination. For example, ELS can influence neural and

physiological changes that may hinder the ability to use other coping strategies (Fareri and Tottenham 2016; King et al. 2016). In addition, the cognitive or emotional effort required to manage the negative affect elicited by ELS might tax regulatory resources needed to use more adaptive coping styles (Baumeister et al. 2006). Second, although ELS is associated with higher levels of both the brooding and reflection subtypes of rumination, only the passive brooding subtype had consequences for youth's psychological health. This conclusion supports a broader literature that documents important differences between the brooding and reflection subtypes of rumination (e.g., Joormann et al. 2006; Raes and Hermans 2008) and that implicates brooding as the more maladaptive of the two subtypes. Interestingly, our findings call into question the conceptualization of the reflection subtype as an adaptive process. Although reflection may be more adaptive than brooding, in the current study reflection did not mitigate risk for symptoms of psychopathology, as has been found by other researchers (Treyner et al. 2003; Wu et al. 2015). For example, Wu et al. (2015) examined whether brooding versus reflection was associated with posttraumatic stress disorder versus posttraumatic growth following an earthquake. Whereas Wu et al. focused on late adolescents and adults (aged 16 and older), the current study focused on youth in the early stages of puberty, all of whom were aged 13 or younger. Thus, it might not be until later in maturation that youth develop the metacognitive skills that allow reflection to promote wellbeing (Papageorgiou and Wells 2003).

It is noteworthy that our findings held for both internalizing and externalizing symptoms and, thus, support the formulation that brooding is associated with symptoms of multiple forms of difficulty. Cross-cutting models of psychopathology are increasingly prominent in the literature (e.g., Barlow et al. 2004; Ehring and Watkins 2008). Such models aim to identify fundamental processes underlying multiple psychiatric disorders, and offer important theoretical and clinical advantages (Nolen-Hoeksema and Watkins 2011). For example, to the extent that we can identify a set of vulnerability factors common to multiple forms of psychopathology, we can take a more parsimonious approach to prevention and intervention.

Using moderated-mediation analyses, we found that brooding mediated the relation between ELS and symptoms only for girls. This finding is consistent with sex differences in rates of rumination and internalizing symptoms, and in the association between ELS and symptoms (Evans et al. 2017; Nolen-Hoeksema et al. 2008; Tamres et al. 2002). Importantly, our findings extend this research by documenting that sex did not moderate the effect of ELS on internalizing or externalizing symptoms when rumination was included in the model, suggesting that sex differences in the relation between ELS and symptoms can be explained via sex differences in brooding. Importantly, we found that boys and girls did not differ significantly in levels of brooding (a finding reported in

other studies of youth in the early stages of puberty; Arney et al. 2009). Thus, our results suggest that it is not simply the level of rumination that is harmful; rather, that brooding is particularly pernicious in girls, possibly because, unlike boys, girls are not also engaging in other, more adaptive, emotion regulation strategies (Hopfinger et al. 2016). These results stand in contrast, however, to findings reported by Michl et al. (2013), who found that sex did not moderate the relation between stressful life events, rumination (collapsed across brooding and reflection), and symptoms of depression and anxiety in a large sample of 6th to 8th Grade adolescents. It is possible that our findings differed from those reported by Michl and colleagues because of important methodological differences between the two studies. For example, evidence of moderation may have been masked in Michl et al. because they examined rumination as a unitary construct.

Our findings also provide new insights regarding the mechanisms through which ELS might increase risk for psychopathology. Given that the early stage of puberty is a critical period of risk for psychopathology during which subclinical symptoms often present that increase risk for the onset of later disorders (Eaton et al. 1995; Herman-Giddens 2006; Pine et al. 1999), findings from the current study have implications for both theory and intervention. More specifically, our findings indicate that sex differences in the mechanisms through which ELS confers risk for clinical symptoms during the early stages of puberty might be a precursor to the later sex differences observed in the prevalence of clinical symptoms (Zahn-Waxler et al. 2008), and in the relation between ELS and clinical symptoms (Evans et al. 2017). This is consistent with suggestions that the early stage of puberty is a critical time for network reorganization (Sisk and Zehr 2005). For example, research suggests that, during the early stages of puberty, sex-specific associations emerge between coherence in the salience network and brooding in females (Ordaz et al. 2017), which may underlie the findings reported here. Targeting brooding in early interventions might weaken the association between ELS and psychopathology and reduce the higher prevalence of psychopathology, particularly internalizing disorders, that has been documented in later stages of puberty (Mendle 2014). It is interesting to consider whether parallel sex differences would be observed in adults or in youth who are later in the transition through puberty. Given that, later in development, sex differences have been reported in levels of rumination, rates of internalizing and externalizing disorders, and the relation between ELS and clinical symptoms (Evans et al. 2017; Nolen-Hoeksema et al. 2008; Zahn-Waxler et al. 2008), we might expect the effects of both brooding and reflection to strengthen across development as cognitive maturation continues. However, because we did not test whether pubertal stage moderates the relations among ELS, rumination, and psychopathology, additional research is needed to examine whether these associations remain consistent across the transition through puberty and into adulthood.

We should note two limitations of this study. First, the study is cross-sectional. Although we took multiple steps to test the directionality of the posited relations among sex, ELS, symptoms and rumination, including conducting a detailed interview-based assessment of ELS, assessing subsequent levels of rumination, and using moderated-mediation analytic approach, future work should test the longitudinal associations among these constructs. Second, we adopted a dimensional conceptualization of child psychiatric problems that likely includes subclinical levels of psychopathology. Although a strength of our study is that our findings implicate brooding as an early phenotype of psychiatric disorders in girls, future research should explore whether these findings hold when predicting membership in diagnostic categories.

Despite these limitations, this study advances our understanding of pathways through which ELS confers risk for symptoms of psychopathology in the early stages of puberty by documenting, for the first time, that brooding, but not reflection, mediates the link between ELS and symptoms for girls, but not for boys. These findings contribute to the response styles theory of rumination and to models of psychopathology. Not only do they elucidate the role of rumination in potentiating risk for symptoms of psychopathology in the context of ELS, but they also suggest that girls and boys differ in the mechanisms through which ELS increases risk for psychopathology. Identifying brooding as a potential mechanism through which ELS contributes to symptoms exclusively in girls suggests that girls, but not boys, who experience ELS are likely to benefit from preventions that target brooding. Additional research is needed to clarify the mechanisms through which ELS confers risk for psychopathology in boys; our findings suggest that sex-specific mechanisms should be considered in this research.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

- Achenbach, T. (1991). Manual for the youth self-report and 1991 profile.
- Aldao, A., & Nolen-Hoeksema, S. (2010). Specificity of cognitive emotion regulation strategies: A transdiagnostic examination. *Behaviour Research and Therapy*, 48(10), 974–983. <https://doi.org/10.1016/j.brat.2010.06.002>.
- Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review*, 30, 217–237. <https://doi.org/10.1016/j.cpr.2009.11.004>.
- Angold, A., Costello, E. J., & Worthman, C. M. (1998). Puberty and depression: The roles of age, pubertal status and pubertal timing. *Psychological Medicine*, 28(28), 51–61. <https://doi.org/10.1017/S003329179700593X>.
- Arney, M. F., Fresco, D. M., Moore, M. T., Mennin, D. S., Turk, C. L., Heimberg, R. G., ... Alloy, L. B. (2009). Brooding and pondering: Isolating the active ingredients of depressive rumination with exploratory factor analysis and structural equation modeling. *Assessment*, 16(4), 315–327. doi:<https://doi.org/10.1177/1073191109340388>.
- Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Toward a unified treatment for emotional disorders. *Behavior Therapy*, 35(2), 205–230. [https://doi.org/10.1016/S0005-7894\(04\)80036-4](https://doi.org/10.1016/S0005-7894(04)80036-4).
- Baumeister, R. F., Gailliot, M., DeWall, C. N., & Oaten, M. (2006). Self-regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior. *Journal of Personality*, 74(6), 1773–1802. <https://doi.org/10.1111/j.1467-6494.2006.00428.x>.
- Broderick, P. C. (2004). A prospective study of rumination and depression in early adolescence. *Clinical Child Psychology and Psychiatry*, 9(3), 383–394. <https://doi.org/10.1177/1359104504043920>.
- Burwell, R. A., & Shirk, S. R. (2007). Subtypes of rumination in adolescence: Associations between brooding, reflection, depressive symptoms, and coping. *Journal of Clinical Child & Adolescent Psychology*, 36(1), 56–65. <https://doi.org/10.1080/15374410709336568>.
- Cohen, R. A., Paul, R. H., Stroud, L., Gunstad, J., Hitsman, B. L., McCaffery, J., et al. (2006). Early life stress and adult emotional experience: An international perspective. *International Journal of Psychiatry in Medicine*, 36(1), 35–52. <https://doi.org/10.2190/5R62-9PQY-0NEL-TLPA>.
- Eaton, W. W., Badawi, M., & Melton, B. (1995). Prodromes and precursors: Epidemiologic data for primary prevention of disorder. *American Journal of Psychiatry*, 152(152), 967–972.
- Ehring, T., & Watkins, E. R. (2008). Repetitive negative thinking as a transdiagnostic process. *International journal of cognitive therapy*. Retrieved from <http://guilfordjournals.com/doi/abs/10.1521/ijct.2008.1.3.192>, 1, 192–205.
- Evans, E. A., Grella, C. E., & Upchurch, D. M. (2017). Gender differences in the effects of childhood adversity on alcohol, drug, and polysubstance-related disorders. *Social Psychiatry and Psychiatric Epidemiology*, 1–12. Springer Berlin Heidelberg. doi:<https://doi.org/10.1007/s00127-017-1355-3>.
- Fareri, D. S., & Tottenham, N. (2016). Effects of early life stress on amygdala and striatal development. *Developmental Cognitive Neuroscience*, 19, 233–247.
- Felton, J. W., Cole, D. A., & Martin, N. C. (2013). Effects of rumination on child and adolescent depressive reactions to a natural disaster: The 2010 Nashville flood. *Journal of Abnormal Psychology*, 122(1), 64–73. <https://doi.org/10.1037/a0029303>.
- Furr, J. M., Comer, J. S., Edmunds, J. M., & Kendall, P. C. (2010). Disasters and youth: A meta-analytic examination of posttraumatic stress. *Journal of Consulting and Clinical Psychology*, 78(6), 765–780. <https://doi.org/10.1037/a0021482>.
- Ge, X., Conger, R. D., & Elder, G. H. (2001). Pubertal transition, stressful life events, and the emergence of gender differences in adolescent depressive symptoms. *Developmental Psychology*, 37(3), 404–417. <https://doi.org/10.1037/0012-1649.37.3.404>.
- Hammen, C. L. (2016). Depression and stressful environments: Identifying gaps in conceptualization and measurement. *Anxiety*,

- Stress, and Coping*, 29(4), 335–351. <https://doi.org/10.1080/10615806.2015.1134788>.
- Hammen, C. L., & Rudolph, K. (1999). UCLA life stress interview for children: Chronic stress and episodic life events. Manual. University of Illinois. Retrieved from https://scholar.google.ca/scholar?q=Rudolph+%26+Hammen+life+stress+interview&btnG=&hl=en&as_sdt=0%2C5.
- Hayes, A. F. (2013). *Introduction to meditation, moderation, and conditional process analysis: A regression-based approach*. New York: Guilford Press. <https://doi.org/10.5539/ass.v11n9p207>.
- Hayward, C. (2003). *Gender Differences at Puberty*. New York: Cambridge University Press.
- Heleniak, C., Jenness, J. L., Vander Stoep, A., McCauley, E., & McLaughlin, K. A. (2016). Childhood maltreatment exposure and disruptions in emotion regulation : A Transdiagnostic pathway to adolescent internalizing and externalizing psychopathology. *Cognitive Therapy and Research*, 40(3), 394–415. <https://doi.org/10.1007/s10608-015-9735-z>.
- Herman-Giddens, M. E. (2006). Recent data on pubertal milestones in United States children: The secular trend toward earlier development. *International Journal of Andrology*, 29, 241–246. <https://doi.org/10.1111/j.1365-2605.2005.00575.x>.
- Hopfinger, L., Berking, M., Bockting, C. L. H., & Ebert, D. D. (2016). Emotion regulation mediates the effect of childhood trauma on depression. *Journal of Affective Disorders*, 198, 189–197. <https://doi.org/10.1016/j.jad.2016.03.050>.
- Horswell, B. B., & Istfan, S. (2006). Preventing child maltreatment: A guide to taking action and generating evidence. *World Health Organization*, 24, 1–89. <https://doi.org/10.1016/j.coms.2012.04.002>.
- Jenness, J. L., Jager-Hyman, S., Heleniak, C., Beck, A. T., Sheridan, M. A., & McLaughlin, K. A. (2016). Catastrophizing, rumination, and reappraisal prospectively predict adolescent PTSD symptom onset following a terrorist attack. *Depression and Anxiety*, 33(11), 1039–1047. <https://doi.org/10.1002/da.22548>.
- Joormann, J., Dkane, M., & Gotlib, I. H. (2006). Adaptive and maladaptive components of rumination? Diagnostic specificity and relation to depressive biases. *Behavior Therapy*, 37(3), 269–280. <https://doi.org/10.1016/j.beth.2006.01.002>.
- Kessler, R. C., Chiu, W. T., Demler, O., Merikangas, K. R., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, 62(6), 617–627. <https://doi.org/10.1001/archpsyc.62.6.617>.
- King, L. S., Colich, N. L., LeMoult, J., Humphreys, K. L., Ordaz, S. J., Price, A. N., & Gotlib, I. H. (2016). The impact of the severity of early life stress on diurnal cortisol: The role of puberty. *Psychoneuroendocrinology*, 77(November), 68–74. <https://doi.org/10.1016/j.psyneuen.2016.11.024>.
- Marshall, W. A., & Tanner, J. M. (1970a). Variations in pattern of pubertal changes in girls. *Archives of Disease in Childhood*, 44, 291–303. <https://doi.org/10.1136/adc.45.239.13>.
- Marshall, W. A., & Tanner, J. M. (1970b). Variations in the pattern of pubertal changes in boys. *Archives of Disease in Childhood*, 45(239), 13–23. <https://doi.org/10.1136/adc.45.239.13>.
- McCartney, C.R., Blank, S.K., Prendergast, K.A., Chhabra, S., Eagleson, C.A., Helm, K.D., Yoo, R., Chang, R.J., Foster, C.M., Caprio, S., Marshall, J.C. (2007). Obesity and sex steroid changes across puberty: Evidence for marked hyperandrogenemia in pre- and early pubertal obese girls. *Journal of Clinical Endocrinology and Metabolism*, 92(2), 430–436. <https://doi.org/10.1210/jc.2006-2002>.
- McKay, H.A., MacLean, L., Petit, M., MacKelvie-O'Brien, K., Janssen, P., Beck, T., & Khan, K. M. (2005). “Bounce at the Bell”: A novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children. *British Journal of Sports Medicine*, 39(8), 521–526.
- Mendle, J. (2014). Why puberty matters for psychopathology. *Child Development Perspectives*, 8(4), 218–222. <https://doi.org/10.1111/cdep.12092>.
- Michl, L. C., McLaughlin, K. A., Shepherd, K., & Nolen-Hoeksema, S. (2013). Rumination as a mechanism linking stressful life events to symptoms of depression and anxiety: Longitudinal evidence in early adolescents and adults. *Journal of Abnormal Psychology*, 122(2), 339–352. <https://doi.org/10.1037/a0031994>.
- Morris, N. M., & Udry, J. R. (1980). Validation of a self-administered instrument to assess stage of adolescent development. *Journal of Youth and Adolescence*, 9(3), 271–280. <https://doi.org/10.1007/BF02088471>.
- Muthén, L., & Muthén, B. (2014). *Mplus user's guide* (7th ed.). Los Angeles.
- Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing Transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science*, 6(6), 589–609. <https://doi.org/10.1177/1745691611419672>.
- Nolen-Hoeksema, S., Larson, J., & Grayson, C. (1999). Explaining the gender difference in depressive symptoms. *Journal of Personality and Social Psychology*, 77(5), 1061–1072. <https://doi.org/10.1037/0022-3514.77.5.1061>.
- Nolen-Hoeksema, S., Stice, E., Wade, E., & Bohon, C. (2007). Reciprocal relations between rumination and bulimic, substance abuse, and depressive symptoms in female adolescents. *Journal of Abnormal Psychology*, 116(1), 198–207. <https://doi.org/10.1037/0021-843X.116.1.198>.
- Nolen-Hoeksema, S., Wisco, B. E., & Lyubomirsky, S. (2008). Rethinking rumination. *Perspectives on Psychological Science*, 3(5), 400–424. <https://doi.org/10.1111/j.1745-6924.2008.00088.x>.
- Ordaz, S. J., LeMoult, J., Colich, N. L., Prasad, G., Pollak, M., Popolizio, M., Price, A., Greicius, M., Gotlib, I. H. (2017). Ruminative brooding is associated with salience network coherence in early pubertal girls. *Social Cognitive Affective & Behavioral Neuroscience*, 12(2), 298–310. <https://doi.org/10.1093/scan/nsw133>.
- O'Mahen, H. A., Karl, A., Moberly, N., & Fedock, G. (2015). The association between childhood maltreatment and emotion regulation: Two different mechanisms contributing to depression? *Journal of Affective Disorders*, 174, 287–295. <https://doi.org/10.1016/j.jad.2014.11.028>.
- Papageorgiou, C., & Wells, A. (2003). An empirical test of a clinical metacognitive model of rumination and depression. *Cognitive Therapy and Research*, 27(3), 261–273. <https://doi.org/10.1023/A:1023962332399>.
- Paus, T., Keshavan, M., & Giedd, J. N. (2008). Why do many psychiatric disorders emerge during adolescence? *Nature Reviews Neuroscience*, 9, 947–957. <https://doi.org/10.1038/nm2513>.
- Pine, D. S., Cohen, E., Cohen, P., & Brook, J. (1999). Adolescent depressive symptoms as predictors of adult depression: Moodiness or mood disorder? *American Journal of Psychiatry*, 156(1), 133–135. <https://doi.org/10.1176/ajp.156.1.133>.
- Raes, F., & Hermans, D. (2008). On the mediating role of subtypes of rumination in the relationship between childhood emotional abuse and depressed mood: Brooding versus reflection. *Depression and Anxiety*, 25(12), 1067–1070. <https://doi.org/10.1002/da.20447>.
- Ribbe, D. (1996). Psychometric review of traumatic event screening instrument for children (TESI-C). In B. H. Stamm (Ed.), *Measurement of stress, trauma, and adaptation* (pp. 386–387). Lutherville: Sidran Press.
- Rood, L., Roelofs, J., Bögels, S. M., Nolen-Hoeksema, S., & Schouten, E. (2009). The influence of emotion-focused rumination and distraction on depressive symptoms in non-clinical youth: A meta-analytic review. *Clinical Psychology Review*, 29(7), 607–616. <https://doi.org/10.1016/j.cpr.2009.07.001>.

- Rudolph, K. D., Hammen, C., Burge, D., Lindberg, N., Herzberg, D., & Daley, S. E. (2000). Toward an interpersonal life-stress model of depression: The developmental context of stress generation. *Development and Psychopathology*, *12*, 215–234. <https://doi.org/10.1017/S0954579400002066>.
- Sisk, C. L., & Zehr, J. L. (2005). Pubertal hormones organize the adolescent brain and behavior. *Frontiers in Neuroendocrinology*, *26*, 163–174. <https://doi.org/10.1016/j.yfne.2005.10.003>.
- Susman, E. J., & Dorn, L. D. (2006). Puberty: Its role in development. In L. M. Lerner & L. D. Steinberg (Eds.), *Handbook of adolescent psychology* (pp. 115–150). Hoboken, NJ: Wiley. <https://doi.org/10.1002/9780470479193.adlpsy001006>.
- Tamres, L. K., Janicki, D., & Helgeson, V. S. (2002). Sex differences in coping behavior: A meta-analytic review and an examination of relative coping. *Personality and Social Psychology Review*, *6*(1), 2–30. https://doi.org/10.1207/S15327957PSPR0601_1.
- Travers, S.H., Jeffers, B.W., Bloch, C.A., Hill, J.O., & Eckel, R.H. (1995). Gender and Tanner stage differences in body composition and insulin sensitivity in early pubertal children. *Journal of Clinical Endocrinology and Metabolism*, *80*(1), 172–178.
- Treynor, W., Gonzalez, R., & Nolen-Hoeksema, S. (2003). Rumination reconsidered: A psychometric analysis. *Cognitive Therapy and Research*, *27*(3), 247–259. <https://doi.org/10.1023/A:1023910315561>.
- Watkins, E. R. (2009). Depressive rumination and co-morbidity: Evidence for brooding as a transdiagnostic process. *Journal of Rational-Emotive & Cognitive-Behavior Therapy*, *27*(3), 160–175. <https://doi.org/10.1007/s10942-009-0098-9>.
- Watkins, E. R., & Teasdale, J. D. (2004). Adaptive and maladaptive self-focus in depression. *Journal of Affective Disorders*, *82*(1), 1–8. <https://doi.org/10.1016/j.jad.2003.10.006>.
- Wu, K., Zhang, Y., Liu, Z., Zhou, P., & Wei, C. (2015). Coexistence and different determinants of posttraumatic stress disorder and posttraumatic growth among Chinese survivors after earthquake: role of resilience and rumination. *Frontiers in Psychology*, *6*, 1–9. <https://doi.org/10.3389/fpsyg.2015.01043>.
- Zahn-Waxler, C., Shirtcliff, E. a., & Marceau, K. (2008). Disorders of childhood and adolescence: gender and psychopathology. *Annual Review of Clinical Psychology*, *4*, 275–303. <https://doi.org/10.1146/annurev.clinpsy.3.022806.091358>.