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Examining the moderating role of adverse childhood experiences on the link between executive functioning and depressive/anger rumination among adolescents

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ABSTRACT

Introduction: Adverse childhood experiences (ACEs) are theorized to amplify the effects of poor executive functioning (EF) leading to rumination. Though, few studies test this hypothesis among adolescents. Rumination is a transdiagnostic risk factor linked to mental health problems. We tested the moderating effect of ACEs (across informants) on the association between EF (measured using neutral and negative stimuli) and depressive and anger rumination.

Method: Youth were initially recruited at 3–5 years-old for a longitudinal project examining the biopsychosocial consequences of child maltreatment. These analyses are based on a follow-up study that included adolescents ($n = 48$; ages 14–16; $M = 14.86$, SD = .50) who completed self-reports of lifetime ACEs, depressive and anger rumination, and the affective interference resolution task (a measure of EF). Additionally, a caregiver provided lifetime report of youth ACEs, and early childhood ACEs (3–5 years of age) were assessed using child protective records and caregiver interviews.

Results: Contrary to expectations, EF in the context of negative information was not associated with any form of rumination. Instead, poor EF in the context of neutral information was associated with more anger rumination for adolescents who experience two or more ACEs per adolescent report (b = .01, $p = .011$), or three or more ACEs per caregiver report (b = .01, $p = .046$) after controlling for gender and current mental health problems; however, these effects were no longer significant when mental health problems were removed as a covariate. Furthermore, the interaction utilizing early childhood ACEs was not significant. Lastly, the interactions between ACEs and EF assessed with neutral information on depressive rumination and brooding were null.

Conclusions: There is some support for the interactive relationship between EF and ACEs on rumination. However, statistical significance varies based on model specification and assessment of constructs. It is important to utilize multi-informants to assess ACEs, EF measured across valenced stimuli, and broad conceptualizations of rumination.

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Introduction

Rumination, or repetitive negative thinking, is a transdiagnostic risk factor implicated in the onset, persistence, and exacerbation of various mental health problems (Ehring & Watkins, 2008). It is associated with internalizing and externalizing syndromes (McLaughlin et al., 2014), as well as substance use (Ciesla et al., 2011), posttraumatic stress disorder (Szabo et al., 2017), eating disorders (K. E. Smith et al., 2018), and suicidality (Rogers & Joiner, 2017). Rumination is difficult to control or stop and disrupts goal pursuit (Nolen-Hoeksema et al., 2008; Watkins & Roberts, 2020). Thus, several researchers have posited that executive functioning (EF), also referred to as executive control or cognitive control (Diamond, 2013), underlies rumination (Joormann et al., 2006; Koster et al., 2011; Whitmer & Gotlib, 2013). EF encompasses higher order multifaceted cognitive processes essential for goal-directed

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behavior (Miyake et al., 2000). Meta-analyses in adult populations support a link between EF and rumination (Yang et al., 2017; Zetsche et al., 2018). However, findings in youth have been inconsistent (Mennies et al., 2021). These mixed findings are notable given that theoretical frameworks and longitudinal studies suggest that rumination emerges during adolescence (Hankin, 2008; Shaw et al., 2019; L. C. Stewart et al., 2022), marking this developmental phase as critical for identifying underlying mechanisms. Factors contributing to these inconsistencies in published literature include a narrow definition of rumination and collapsing assessment across childhood and adolescence (Mennies et al., 2021). Additionally, there is a lack of consensus on how to assess EF (Bunge, 2024). Furthermore, few studies have explored the moderating role of important contextual determinants, such as exposure to adverse childhood experiences (ACEs), in the EF-rumination relationship.

Most studies on the EF-rumination link have focused on depressive rumination, which involves repetitive negative thinking about the symptoms, causes, and consequences of one's sadness/distress (Nolen-Hoeksema, 1991). However, rumination can also take the form of anger rumination, which is repetitive negative thinking on past anger experiences, and the causes and consequences of anger (Sukhodolsky et al., 2001). Emerging evidence indicates that both depressive and anger rumination are similarly linked to EF deficits (du Pont et al., 2019). Importantly, recent research suggests that anger rumination may be especially relevant for youth exposed to ACEs (Zhu et al., 2020). Thus, examining both depressive and anger rumination may be an important advancement.

Developmental factors also play a crucial role in understanding the EF-rumination link. EF follows a developmental trajectory, with early, middle, and late adolescence representing distinct phases of EF development (Boelema et al., 2014; Laureys et al., 2022). There is significant variability in the development and consolidation of EF during the transition from childhood to adolescence, emphasizing the potential benefit of examining the impact of EF within discrete developmental periods. Yet, most youth studies on EF and rumination have utilized samples with a wide age range, potentially obscuring findings (Mennies et al., 2021). Research focusing on narrowly defined adolescent age groups has found poorer EF is associated with higher levels of rumination (Dickson et al., 2017). Thus, inconsistencies in the EF-rumination link may be due to the broad age ranges included in previous studies.

Contributing to inconsistent findings in the EF-rumination link may be that EF can be assessed in the context of affectively and non-affectively valenced information. It has been hypothesized that EF deficits may be particularly related to rumination when individuals are processing negative stimuli (Joormann & Gotlib, 2008; Whitmer & Gotlib, 2013). While some adolescent studies support this idea, demonstrating that tasks assessing EF in the context of negatively valenced information reveal a link between EF and rumination (Hilt et al., 2014; Kray et al., 2020; Romens & Pollak, 2012), other studies find no link between affectively assesed EF and rumination (T. M. Stewart et al., 2018) or show null effects between non-affectively assessed EF and rumination (Thomas et al., 2023).

Joormann et al. posit that the difficulty discarding no-longer-relevant negative information from working memory is the aspect of EF specific to rumination (Joormann & Gotlib, 2008). More precisely, once negative information becomes available in working memory presumably because it was "useful" for some goal, it becomes cognitively "stuck" despite receiving new input that it is no longer useful for the current goal. This premise is supported by meta-analytic findings in adults (Zetsche et al., 2018). Although similar hypotheses have been suggested for adolescents (Schweizer et al., 2020), few adolescent studies have utilized EF tasks that can parse out this specific EF deficit.

Given the mixed findings on the EF-rumination link, it may be that this association only arises under specific conditions. Rumination is conceptualized as a "style" of thinking (e.g., repetitive, uncontrollable), but the specific content of rumination is shaped by the environment (Nolen-Hoeksema & Watkins, 2011). Exposure to ACEs may influence the development of specific cognitive content. For example, ACEs are linked to negative views of the self (Gibb, 2002; Pilkington et al., 2021) and views of others as threatening (Richey et al., 2016). Indeed, a recent systematic review revealed that ACEs are associated with rumination in adults (Mansueto et al., 2021). Thus, ACEs may moderate the EF-rumination link, though there is a dearth of studies testing this hypothesis. Consistent with this hypothesis, a prior study showed poor EF in the context of negative information was linked to depressive rumination only among those who exhibited high levels of negative self-referential content; however, this study did not directly assess ACEs and was conducted with young adults (Vergara-Lopez et al., 2016). In contrast, another study showed no significant interaction between ACEs and EF predicting rumination across middle and late adolescence; though that study did not assess EF in the context of affectively valenced information (Thomas et al., 2023).

In the current study, we examined the link between EF and depressive and anger rumination among youth in middle adolescence. In line with Joormann & Gotlib (2008) and Joormann et al. (2010), we hypothesized that difficulty discarding or removing no-longer-relevant negatively valenced information from working memory would be associated with higher levels of depressive and anger rumination. Futhermore, we hypothesized that adolescents with more ACEs would display a stronger association between poor EF and both types of rumination. Our hypotheses focused on adolescents' self-report of lifetime ACEs. We posited that self-report may show a stronger connection to rumination (an internal process). However, there is growing research to suggest that a comprehensive assessment of ACEs includes reports from multiple sources (Lombardi et al., 2022; Ndjatou et al., 2024). Therefore, we also examined the moderating role of ACEs based on caregiver report of youth lifetime ACEs, as well as early childhood ACEs (3–5 years of age) based on a composite derived from child protective records and caregiver interviews.

Methods

Participants

Participants were recruited from a larger longitudinal parent project examining the biopsychosocial consequences of child maltreatment. In the parent study, a primary caregiver and youth were initially recruited when youth were 3–5 years-old from the state's child protection agency, a pediatric medical clinic, or from childcare centers. Approximately half of participants in the parent project had a history of moderate-severe childhood maltreatment in the 6-months prior to initial study enrollment. Excluded were youth with chronic illness, medication use, obesity, and/or failure-to-thrive. To be eligible for the current investigation, youth must have completed the early (ages 3–5) and middle (ages 9–11) childhood assessments of the parent study and be between ages of 14–16 years old. For this investigation, we recruited a subset of $n = 50$ caregivers and adolescents. Two families were unable to participate fully due to time constraints; thus, analyses are presented for $n = 48$.

Study measures

Depressive rumination

Adolescents completed the 8-item version of the rumination subscale (Armey et al., 2009) of the Response Styles Questionnaire (RSQ, Nolen-Hoeksema, 1991). This scale assesses the tendency to ruminate in response to sadness/distress using a Likert scale ranging from 1 (almost never) to 4 (almost always) with higher scores indicating higher levels of depressive rumination. To measure depressive rumination, a composite score across these 8-items is derived. Five items from this scale can also be used to index brooding, a subtype of depressive rumination. Possible scores for depressive rumination are 8–32 and 5–20 for brooding. Both depressive rumination and brooding displayed high internal consistency $\alpha = .86$ and $\alpha = .87$, respectively.

Anger rumination

Adolescents were administered the Children's Anger Rumination Scale, a 19-item questionnaire adapted from the Anger Rumination Scale (Sukhodolsky et al., 2001) to assess rumination in response to anger in youth (S. D. Smith et al., 2016; Spyropoulou & Giovazolias, 2023). The questionnaire uses a Likert scale ranging from 1 (almost never) to 4 (almost always) with higher composite scores indicating higher levels of anger rumination (range 19–79). The internal consistency in this sample was high $\alpha = .95$.

The affective interference resolution task (AIRT)

Adolescents completed an adapted computerized version of the AIRT (Levens & Phelps, 2008; Pe et al., 2013). This task consisted of eight practice trials and 96 trials across eight blocks. There were 48 neutral and 48 negative valence words. Word stimuli were sourced from the Affective Norms of English Words list (ANEW; Bradley & Lang, 1999). A trial consisted of participants being shown four target words on a computer screen accompanied by a fixation cross in the middle of the screen. This trial was presented for 1,200 ms. Next, there was a 3,000-ms delay where only the fixation cross was shown on the computer screen. This delay was followed by a probe word presented for 1,500 ms. Participants were instructed to determine as quickly and accurately as possible if the probe word was part of the four target words shown before the delay by responding "Yes" or "No" using a response box. "Interference," or difficulty discarding previously relevant but no longer useful information was measured by the reaction time difference between "recent no" and "non-recent no" trials. In "recent no" trials, the probe word did not match the current target set but rather matched one from the two previous sets, while in "non-recent" no trials, the probe word did not match the current nor previous target sets. Interference scores were calculated for each probe valence (negative and neutral), with higher reaction times indicating more difficulty

discarding no longer relevant information. Only correct trials with reaction times between 300 and 2,000 ms were included in the analysis (Friedman & Miyake, 2004; Pe et al., 2013). Spearman-Brown split-half reliabilities were calculated on the critical trials demonstrating adequate internal consistency ("*recent no" neutral trials* $r_{SB} = 0.71$, "*recent no" negative trials* $r_{SB} = 0.79$, "non *recent no" neutral trials* $r_{SB} = 0.79$, "non *recent no" negative trials* $r_{SB} = 0.80$). Furthermore, there were no scores below 3*SD*s; however, one score was above 3SDs and was winsorized to the 3SD value (Tabachnick & Fidell, 2021).

Early childhood assessment of adverse childhood experiences (ACEs)

A composite score of ACEs was created by adding the following three factors from reports when the youth were between the ages of 3–5 years old: (1) number of types of maltreatment experiences, (2) number of lifetime contextual stressors, and (3) number of other traumatic life events. To assess childhood maltreatment (e.g., abuse and neglect) child protection records were coded using the System for Coding Subtype and Severity of Maltreatment in Child Protective Records (Barnett et al., 1993). To determine contextual stressors, caregivers completed a semi-structured interview (Tyrka et al., 2015) that assessed the death of a caregiver, separation from a caregiver, housing instability, inadequate food or clothing, and witnessing neighborhood violence or parental arrest. Interviews were completed by PhD-level psychologists and scored by a trained rater (kappa was conducted on 10% of original sample with value of .89 indicating high reliability). Lastly, other traumatic events were assessed utilizing the Diagnostic Infant and Preschool Assessment (Scheeringa & Haslett, 2010) conducted by PhD-level psychologists or clinical social workers and scored via group consensus. The following trauma categories were assessed: experiencing an accident, animal attack, man-made disaster, natural disaster, witnessing violence, accidental burning, medical emergency/hospitalization/invasive medical procedure, kidnapping, and other events (e.g., near drowning).

Adolescent and caregiver assessment of lifetimes adverse childhood experiences (ACEs)

Caregivers and adolescents were administered the *Pediatric* ACEs *and Related Life Events Screener* (PEARLS) (Thakur et al., 2020) to assess 10 ACEs in the domains of abuse (physical, emotional, sexual), neglect (physical, emotional), and household dysfunction (caregiver separation/divorce, domestic violence, substance misuse, incarceration, mental illness) consistent with the original ACE study (Felitti et al., 1998). Participants indicate yes or no if the youth ever experienced any listed ACEs. This assessment was completed during the adolescent phase.

Mental health problems

The Youth Self-Report (YSR) was administered to assess mental health problems (Achenbach & Rescorla, 2001). The YSR contains 112 items, each rated on a 3-point scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true). For this investigation, we utilized the T-sores of the Total Problem Scale, which is a composite score of anxious/depressed symptoms, somatic complaints, attention problems, social problems, thought problems, rule-breaking behavior, and aggressive behavior. A T-score of 50 represents the mean with a standard deviation of 10. T-scores below 65 are in the normal range, while scores above 70 are in the clinical range.

Clinical diagnoses

The Kiddie Schedule for Affective Disorders and Schizophrenia in School-Age Children Present and Lifetime version (K-SADS-PL) (Kaufman et al., 1997) was administered to youth and their caregiver to assess for psychiatric disorders among the adolescent participants. Interviews were conducted by PhD level psychologists or a trained project director. Summary scores that considered both the report of the youth and the caregiver scored via group consensus were utilized to determine psychiatric diagnoses.

Study procedures

After informed consent procedures were completed, caregivers provided baseline assessments and child protection records were reviewed at the time of initial enrollment during the early childhood phase of the longitudinal study. During the adolescent phase of the study, a caregiver and adolescent attended one laboratory visit. Caregivers provided consent and adolescents provided assent for participation. The caregivers and adolescents reported on adolescent ACEs. Adolescents reported on their demographic characteristics and completed the computerized EF task. The protocol was approved by the Lifespan Institutional Review Board protocol #1774452.

Data analytic plan

Analyses were conducted using R version 4.4.1 (R CORE Team, 2024). Conceptually, our aim was to test

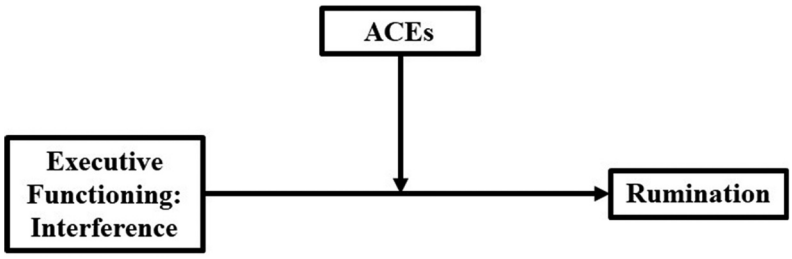

Figure 1. Conceptual moderation model. *Note*. This conceptual model was the framework utilized to conduct four focal interaction tests and additional eight tests to examine the robustness of effects. The four focal models examined youth self-reported Adverse Childhood Experiences (ACEs) as a moderator of the association between executive function in the context of neutral or negative information on depressive or anger rumination. Additional models utilizing the brooding component of depressive rumination and utilizing caregiver report of youth ACEs were also run.

Table 1. Description of analytic models conducted.

Dependent Variable	Youth Reported ACEs	Caregiver Reported ACEs	Early Childhood ACEs
Depressive Rumination	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs
Depressive Rumination	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs
Anger Rumination	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs
Anger Rumination	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs
Brooding	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs	EF:I$^{(neutral)}$ X ACEs
Brooding	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs	EF:I$^{(negative)}$ X ACEs

Note. Adverse Childhood Experiences is abbreviated as ACEs. Executive Function: Interference is abbreviated as EF:I. The four focal models examined youth self-reported ACEs as a moderator of the association between executive function in the context of neutral or negative words and depressive or anger rumination. Next, a set of models utilizing the brooding component of depressive rumination were conducted. A similar set of models were run utilizing caregiver report of youth ACEs and early childhood ACEs. The apriori models controlled for gender and current mental health symptoms. Alternative models that removed current mental health problems as a covariate were also conducted.

the interaction between ACEs and EF interference predicting rumination (see Figure 1). We conducted four focal interaction tests utilizing the number of adolescent reported ACEs as the moderator. To rigorously evaluate our conceptual model and examine the generalizability of findings, we also conducted interaction tests treating the number of caregiver reported youth ACEs as the moderator, as well as the number of early childhood assessed ACEs as the moderator (see Table 1). In all models, EF interference was specified as the independent variable. One set of models assessed the impact of EF interference in the context of neutrally valenced words, and another set of models assessed the impact of interference in the context of negatively valenced words. Depressive and anger rumination were treated as the dependent variables in separate models. Due to previous studies suggesting that the brooding component of depressive rumination is the most maladaptive (Cox et al., 2012; Joormann et al., 2006), we ran robustness check analyses treating brooding as the dependent variable. Furthermore, a substantial body of research has indicated gender differences in rumination and that mental health problems are linked to rumination (Vergara-Lopez et al., 2024). Thus, we included gender (i.e., a four-level variable reflecting identification as a girl, boy, non-binary, and preference to self-describe) and mental health problems (i.e., a continuous variable based on Total Problems on the YSR) as covariates. Alternative models removing mental health problems as a covariate were also conducted to ascertain their impact. A Bonferroni correction was applied to adjust the significance threshold for the focal analyses. Specifically, an original significance threshold of $p < .05$ was divided by 4 (the number of focal analyses; see Table 1) to yield an adjusted significance level of $p < .0125$ which was utilized to determine the significance of tested interactions. We used the Model 1 framework part of the PROCESS code script for R version 4.3.1 (Hayes, 2022) to test interactions. Lastly, we utilized the Johnson–Neyman technique for probing interactions (Hayes, 2022). This technique allows us to identify the range of values of the moderator for which the association of the independent variable and dependent variable is significant.

Results

Descriptive statistics

Adolescent participants were between 14 and 16 years old ($M = 14.86$; $SD = .50$), and 48% identified as girls, 44% identified as boys, and 8% identified as either non-

binary or preferred to self-describe their gender identity. In terms of sexual orientation, 68% of adolescents identified as heterosexual, 16% were not sure or figuring it out, 8% as bisexual, 4% as pansexual, 2% were gay or lesbian, and 2% as demisexual. This was an ethnoracially diverse sample, with 50% of youth identifying as Hispanic/Latino, and 42% identifying as multi-racial. Specifically, 22% were Hispanic race noted as other (not specified), 12% were Hispanic and multiracial (races not specified), 6% were Hispanic White, 4% were Hispanic Black and another non-specified race, 2% were Hispanic and American Indian/Alaska Native, 2% were Hispanic and Native Hawaiian/Pacific Islander, 18% were Non-Hispanic Black, 8% were Non-Hispanic Black and White, 4% were Non-Hispanic Black and Asian, 2% were Non-Hispanic Black-White-Native Hawaiian/Pacific Islander, 13% were Non-Hispanic White, 4% were Non-Hispanic White and other race (not specified), 2% were Non-Hispanic White and Asian. The annual household income ranged from $9,600–$280,000 (M= $54,208; SD=$43,780), and 60% of families had incomes that qualified them for public assistance programming. This sample consisted of 50% of youth who met diagnostic criteria for at least one psychiatric disorder (see Table 2). In terms of exposure to ACEs during early childhood, 31% of the current sample had a history of moderate-severe abuse and/or neglect at the time of the early childhood assessment as verified by child protection record review, and 69% of the sample had a score of 1 or higher on the early childhood adversity composite (*range* = 0–9). When lifetime ACEs were assessed during adolescence, caregivers reported that 77% of the adolescents experienced at least 1 ACE (range 0–9) and 68% of adolescent self-reported at least 1 ACE (range 0–7). Table 3 provides the counts of endorsed ACEs assessed in adolescence. Adolescents were exposed to ~2 ACEs on average, and associations among the ACE assessments were moderately to strongly positively correlated. Table 4 displays means, standard deviations, and correlations of key

Table 2. Clinical diagnoses from the kiddie schedule for affective disorders and schizophrenia.

Clinical Diagnosis	#n Current	#n Past
1. Post-Traumatic Stress Disorder	4	6
2. Major Depressive Disorder	6	11
3. Dysthymia	0	0
4. Generalized Anxiety Disorder	5	5
5. Social Anxiety Disorder	2	2
6. Panic Disorder with and without Agoraphobia	0	1
7. Obsessive Compulsive Disorder	0	0
8. Attention Deficit Hyperactivity Disorder	10	10
9. Oppositional Defiant Disorder	2	2
10. Conduct Disorder	1	1
11. Anorexia Nervosa Disorder	0	1
12. Bulimia Nervosa Disorder	0	1
13. Binge Eating Disorder	0	1

Note. Only assessed disorders reported based on DSM-IV. A participant may have presented with co-morbid diagnoses.

Table 3. Adverse childhood experiences of adolescent participants by Reporter.

Assessment Tool: *Pediatric* ACEs *and Related Life Events Screener* (PEARLS)	# of Endorsements	
	Adolescent Report	Caregiver Report
1. Ever lived with a parent/caregiver who went to jail/prison.	9	7
2. Ever felt unsupported, unloved, and/or unprotected.	9	11
3. Ever lived with a parent/caregiver who had a mental health issue.	19	22
4. Parent/caregiver that ever insulted, humiliated or put down the youth.	12	5
5. Biological parent or any caregiver ever had, or current has a problem with too much alcohol, street drugs or prescription medication use.	7	15
6. Ever lacked appropriate care by any caregiver.	0	1
7. Ever seen or heard a parent/caregiver being screamed at, sworn at, insulted or humiliated by another adult OR ever seen or heard a parent/caregiver being slapped, kicked, punched beaten up or hurt with a weapon.	13	19
8. Any adult in the household often or very often pushed, grabbed, slapped, or thrown something at the youth OR any adult in the household ever hit the youth so hard that the youth had marks or was injured OR any adult in the household ever threatened the youth in a way that made the youth afraid that they might be hurt.	4	5
9. Ever experienced sexual abuse.	5	7
10. Ever had significant changes in the relationship status of the youth's caregivers.	16	22

Note. In this table, items assessing Adverse Childhood Experiences (ACEs) were paraphrased from the PEARLS measure (Thakur et al., 2020). The PEARLS was completed during the adolescent phase of study and assessed lifetime exposure to ACEs.

Table 4. Means, standard deviations, and correlations.

Variable	Mean	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. E-ACEs	2.62	2.78	—-	.41*	.71**	.28†	.18	.16	.38*	.05	−.05
2. A-ACEs	1.88	2.19		—-	.53**	.63**	.35*	.34*	.49**	.16	.16
3. C-ACEs	2.32	2.38			—-	.41*	.27†	.23	.47**	.30*	.29*
4. Anger Rumination	35.08	12.05				—-	.69**	.67**	.70**	.26	.11
5. Depressive Rumination	16.41	5.02					—-	.95**	.54**	.07	.14
6. Brooding	10.52	3.64						—-	.58**	.05	.09
7. Mental Health Problems	56.59	11.94							—-	.22	.08
8. EF:I Neutral	72.01	168.54								—-	.44*
9. EF:I Negative	67.58	131.70									—-

Note. **$p < 0.001$,*$p < 0.05$,† = .06, E-ACEs = Early childhood Adverse Childhood Experiences, A-ACEs = Adolescent Reported Adverse Childhood Experiences, C-ACEs = Caregiver Reported Adverse Childhood Experiences, EF:I Neutral = Executive Functioning Interference in the context of neutral stimuli, and EF:I Negative = Executive Functioning Interference in the context of negative stimuli.

constructs. There was a wide range of rumination scores and mental health symptoms. Specifically, scores ranged from 8 to 29 for depressive rumination, 5–20 for brooding, 19–64 for anger rumination, and 32–80 for mental health problems. Adolescent-reported ACEs were significantly and positively correlated with all rumination constructs, as well as mental health problems, and did not display a significant association with executive functioning. In contrast, caregiver reported ACEs were only significantly positively correlated with adolescent reported anger rumination. Caregiver reported ACEs were also significantly and positively associated with adolescent mental health problems and worse EF (higher scores on the interference task are indicative of worse executive functioning). Early childhood assessed ACEs were only significantly and positively associated with adolescent mental health problems; though, the positive correlation with adolescent anger rumination approached significance ($p = .06$). All rumination constructs were significantly and positively correlated with each other and with mental health problems. Lastly, EF in the context of neutral and negative stimuli were moderately associated with each other.

Moderation models: adolescent reported ACEs

Adolescent reported ACEs moderated the link between EF (interference in the context of neutral stimuli) and anger rumination (interaction test $b = .01$, $p = .011$; see Table 5), but only when controlling for current mental health symptoms (see *Supplemental Table S1*). Next, we contextualize the significant interaction in the model that controls current mental health symptoms. The Cohen's $f^2 = .17$ for the interaction was a medium effect size (Cohen, 1988) and findings remained significant after applying the Bonferroni adjusted p-value ($p < .0125$). We probed the significant interaction using the Johnson-Neyman technique. Results showed that EF interference in the context of neutral stimuli became significantly related to anger rumination when adolescents had

Table 5. The interaction between ACEs and Adolescent executive functioning: interference on rumination.

Models Assessing Executive Functioning: Interference with Neutral Stimuli

	Anger Rumination			Depressive Rumination			Brooding		
	b	LB, UB	*p*-value	*b*	LB, UB	*p*-value	*b*	LB, UB	*p*-value
A-ACEs	.88	−.64–2.40	.251	.02	−.89–.93	.961	.01	−.62–.64	.978
EF:I^{Neutral}	−.00	−.02–.01	.639	−.00	−.012–.007	.583	−.00	−.01–.00	.40
Gender	−.23	−3.48–3.03	.889	−.35	−2.28–1.59	.719	.06	−1.29–1.40	.93
Mental Health Problems	.55	.32–.79	.000	.22	.09–.36	.002	.17	.08–.27	.001
A-ACEs ×EF:I^{Neutral}	.01	.00–.02	.011	.00	−.00–.01	.528	.00	−.00–.00	.521

Models Assessing Executive Functioning: Interference with Negative Stimuli

	Anger Rumination			Depressive Rumination			Brooding		
	b	LB, UB	*p*-value	*b*	LB, UB	*p*-value	*b*	LB, UB	*p*-value
A-ACEs	1.52	−.40–3.44	.116	.20	−.85–1.25	.705	.23	−.51–.96	.539
EF:I^{Negative}	−.00	−.02–.02	.689	.01	−.01–.02	.355	.00	−.01–.01	.629
Gender	.72	−2.80–4.23	.682	−.36	−2.26–1.53	.703	.06	−1.28–1.41	.924
Mental Health Problems	.54	.28–.80	.000	.22	.09–.36	.002	.16	.068–.258	.001
A-ACEs ×EF:I^{Negative}	.01	−.01–.02	.359	−.00	−.01–.01	.852	−.00	−.01–.00	.633

Note. b = beta coefficient, LB = lower bound of 95% confidence interval, UB = upper bound of 95% confidence interval, A-ACEs = Adolescent Reported Adverse Childhood Experiences, EF:I^{Neutral} = Executive Functioning Interference in the context of neutral stimuli. EF:I^{Negative} = Executive Functioning Interference in the context of negative stimuli.

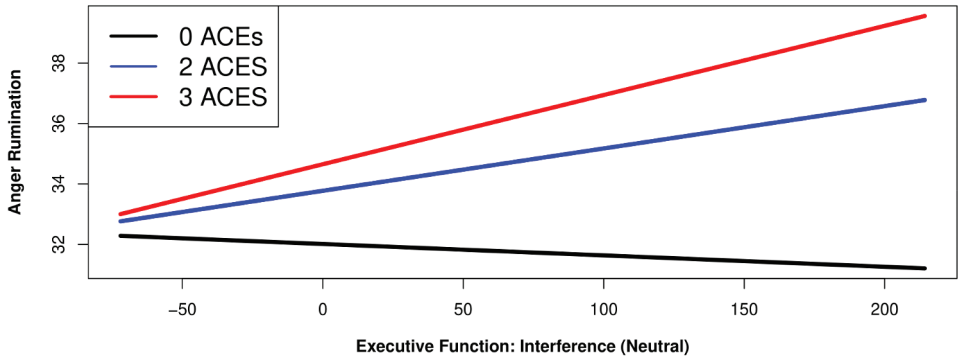

Figure 2. Interaction Plot. *Note*. Adverse Childhood Experiences is abbreviated as ACEs. In this plot, higher millisecond scores on executive functioning are indicative of more difficulty discarding previously relevant neutral information

experienced at least two ACEs ($b = .01$, $p = .048$) and this association became stronger with three or more ACEs ($b = .02$, $p = .011$). As shown in Figure 2, we plotted these conditional effects utilizing the data output for visualization produced by the Process R script (Hayes, 2022) which shows that among adolescents with at least two ACEs worse EF (higher interference scores with neutral stimuli) is associated with higher rumination. The interaction between ACEs and EF interference assessed with neutral stimuli on depressive rumination and brooding was null ($p > .05$; see Table 5). Similarly, no significant interactions were observed in models examining the interaction between ACEs and EF interference assessed using negative stimuli (all $ps > .05$; see Table 5).

Moderation models: caregiver reported ACEs

Caregiver reported ACEs moderated the link between EF (interference assessed using neutral stimuli) and anger rumination (interaction test $b = .01$, $p = .046$), but only when controlling for current mental health symptoms. Next, we contextualize the significant interaction in the model that controls current mental health symptoms. The p-value of this interaction did not survive correction for multiple testing (Bonferroni-adjusted the significance threshold of $p < .0125$). Nevertheless, the conditional effects of this interaction are similar to the results of the model utilizing adolescent reported ACEs such that the link between EF interference using neutral stimuli is significant and positively related to anger rumination when caregivers report that adolescents had experienced three or more ACEs ($b = .02$, $p = .048$). The interaction between caregiver reported ACEs and EF (interference assessed using neutral stimuli) on depressive rumination and brooding yielded p-values of .06; however, none of the conditional effects were significant. Lastly, no significant interactions were observed in models examining the interaction between ACEs and EF interference assessed using negative stimuli (all $ps > .05$).

Moderation models: early childhood ACEs

None of the models testing the interactive effect between early childhood ACEs and EF interference were significant (all $ps > .05$; see Table 1 for a summary of models examined).

Discussion

Our overarching aim was to examine the link between EF and rumination among adolescents. We built upon past research by investigating this association across both depressive and anger rumination. We utilized a sample of youth in middle adolescence to decrease the impact of potential developmental differences in EF. Furthermore, we administered an EF task that could parse out difficulty discarding previously relevant negative or neutral information. This specific type of EF has been theoretically and empirically linked to rumination in adult samples with few studies examining this type of EF among adolescents (Joormann et al., 2010; Zetsche et al., 2018). Lastly, we tested whether ACEs moderated the link between EF and rumination.

Contrary to our hypotheses, neither difficulty discarding previously relevant negative nor neutral information was correlated with depressive or anger rumination (Table 4). While our hypotheses were based on a theoretical framework developed for adults, the current null findings are in line with several studies among youth that do not support a direct association between EF and rumination (Thomas et al., 2023; Wilkinson & Goodyer, 2006). From a developmental perspective, both EF and rumination are being solidified during adolescence. Thus, it may be the case that this link is not yet robust, explaining the mixed findings in

the literature. Alternatively, it is possible that EF deficits do not underlie rumination, at least for youth, or that the effect size is too small to be detected with a modest sized sample.

Although not part of the formal hypotheses, the present finding that adolescent reported ACEs have a moderate positive association with depressive rumination is consistent with past research (Boyes et al., 2016). Expanding on past research, adolescent reported ACEs demonstrated a large positive association with anger rumination (Table 4). Regarding the caregiver report of ACEs, only anger rumination displayed a significant positive correlation; while the correlations with depressive rumination and brooding were positive, they did not reach statistically significant levels, $p = .06$ and $p = .10$, respectively. Similarly, the early childhood assessed ACEs displayed a marginally significant ($p = .06$) link with anger rumination, but not depressive rumination or brooding. Together, these findings related to the ACE-rumination link support the notion that early adverse experiences may influence tendencies to engage in repetitive negative thinking; however, the effect appears to be stronger for anger rumination and adolescent reported ACEs. Furthermore, while adolescent reported ACEs were not linked to EF, poorer EF was associated with more ACEs based on caregiver report.

In contrast to our predictions, we found that ACEs moderated the effect of neutrally valanced EF impairment on anger rumination in the model that controlled for mental health symptoms. Specifically, greater difficulty discarding previously relevant neutral but not negative information was associated with higher anger rumination, but only for adolescents who endorsed two or more ACEs (based on youth report). Although the model based on caregiver report did not meet our stringent Bonferroni correction threshold for significance, it did show a significant association based on the conventional p-value $< .05$ in the model that controlled for mental health symptoms. In line with the adolescent findings, we found that difficulty discarding previously relevant neutral, but not negative information, was associated with higher anger rumination, but only for adolescents who endorsed three or more ACEs (based on caregiver report). Moderation analyses involving early childhood assessed ACEs and rumination were null.

Consistent with burgeoning literature, the current findings suggest that anger rumination may be a particularly important sequela of ACEs (Weindl et al., 2020; Zhu et al., 2020). While speculative, it may be that ACEs only moderated the effect of EF on anger rumination when assessed with neutral information because neutral information was perceived to be more distracting. In other words, neutral information may be schema-inconsistent among adolescents exposed to ACEs, thus requiring more EF resources leading to worse EF performance. Relatedly, it may be that adolescents exposed to ACEs are able to discern and process negative information more quickly, leading to better performance in this EF task. This possibility is in line with a study in adults that showed enhanced cognitive processing of trauma related content among patients with Posttraumatic Stress Disorder versus healthy controls (Tudorache et al., 2019). Yet another possibility is that EF assessed in the context of neutral information may reflect "true" cognitive impairment, which makes it difficult to regulate rumination. In contrast, EF assessed in the context of negative information may reflect mood congruent bias, rather than a "trait-like" impairment in executive function, and would likely only be observed when negative mood is induced. Few studies have investigated the association between ACEs and executive function under both affectively valenced and non-affectively information with the utilization of mood inductions (Rahapsari & Levita, 2024). Furthermore, most studies utilize tasks with non-verbal stimuli (e.g., shapes) (Rahapsari & Levita, 2024). Rumination is an internal verbal process, and it is possible that tasks that utilize words may have increased ecological validity. Lastly, the moderation by ACEs emerged only when controlling for current mental symptoms, suggesting that current mental health symptoms may be a suppressor variable increasing the predictive validity of the interaction term (Smith et al., 1992). However, current mental health symptoms displayed a strong positive association with the anger rumination, the dependent variable ($r = 0.70$, $p < .001$), and only weakly correlated with EF (interference in the context of neutral stimuli), the independent variable ($r = 0.22$, $p = .12$), violating requirements for suppressor variables. Furthermore, current mental health symptoms were moderately correlated with adolescent reported ACEs, the moderator ($r = 0.49$, $p < .001$), thus, it is most likely a confound in this model (see *Supplemental Table S2;* MacKinnon et al., 2000; Sharpe & Roberts, 1997). It appears that the EF-rumination link is only detectable under very specific circumstances such as in models that account for the substantial influence of current mental health symptoms and when contextual determinants (e.g., ACEs), are considered. These specific conditions may explain mixed findings on EF-rumination relationship and underscore the need for larger studies that are powered to test complex models, including three-way interactions.

Important limitations of this investigation are noted. The main findings were based on cross-sectional results. Furthermore, this study utilized a modest sample size and limited sampling of gender identities, which may have precluded detection of effects. Research shows that

girls tend to report higher levels of rumination compared to boys (Jose & Brown, 2008); however, we were not powered to detect conditional effects by gender. We tested our hypotheses with the Bonferroni correction. This was a stringent statistical test to address possible Type 1 error, however, this approach may have also increased Type 2 error. While we assessed both depressive and anger rumination, other conceptualizations of repetitive thought were not included (e.g., worry). Furthermore, the assessment of EF deficits was narrow. Though we were guided by past research in selecting difficulty discarding previously relevant information as the specific EF to assess, there are other types of EF that have also been proposed to be linked to rumination such as set-shifting (Koster et al., 2011). Another limitation of the current assessment and the broader EF literature is that no EF task is "process pure" and likely assesses various facets of EF, thus making parsing out specific types of EF is difficult. Lastly, our conceptualization of ACEs is consistent with past research allowing for comparability with other studies. However, a cumulative approach to ACEs has been critiqued as insufficiently capturing ACE exposure across a continuum (McLaughlin & Sheridan, 2016) or in breadth of experiences such as the impact of racism (Bernard et al., 2021).

In conclusion, while our hypotheses were not supported, these findings highlight the importance of utilizing multi-informant approaches to assess ACEs, measuring EF across affectively and non-affectively valenced stimuli, and examining a broader conceptualization of rumination (to include anger) when examining the impact of ACEs on cognition. A great deal of research has suggested that ACEs impact deficits in EF (Lund et al., 2020). This study supported this view as evidenced by the link between caregiver reported ACEs and EF. Furthermore, in this study focused on youth in middle adolescence, we found that the association between poor EF (specifically in the context of neutral information) and anger rumination (but not depressive rumination) was moderated by the number of ACEs (in the model that controlled for mental health symptom). This suggests that anger rumination may be the product of diminished EF development and negative memory experiences from ACEs. However, an alternative possibility is that adolescents with more negative memory associations due to ACEs are more likely to ruminate (as supported by the bivariate associations in this study) which taxes EF leading to EF deficits. Future longitudinal and experimental studies are needed to identify the directionality of effects, as well as qualify the specific contexts in which associations may exist. While this cross-sectional study cannot disentangle these important questions, it contributes to the accumulating evidence that rumination is a transdiagnostic factor and that adolescents exposed to ACEs, regardless of clinical diagnosis, may benefit from interventions that target ruminative thinking.

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