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Research paper

# Attention, rumination and depression in youth with negative inferential styles: A prospective study

Lara S. Rifkin [a,*], Naoise Mac Giollabhui [a], Philip C. Kendall [a], Lyn Y. Abramson [b], Lauren B. Alloy [a,*]

[a] Department of Psychology, Temple University, 1701 N. 13th Street, Philadelphia, PA 19122, USA
[b] University of Wisconsin-Madison, Madison, WI, USA

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ABSTRACT

*Background:* Negative inferential style, rumination and attention are cognitive vulnerabilities implicated in depression that first emerge in childhood and adolescence.
*Methods:* The current study used a prospective longitudinal design to examine whether rumination mediates the relationship between attention (selective attention, sustained attention, attentional switching, and divided attention) and depression (depressive symptoms and depressive episode onset) conditional on negative inferential style. A diverse community sample of adolescents (n = 364) completed semi-structured diagnostic interviews, behavioral measures of attention, and self-report measures of rumination, negative inferential style, and depression annually for three consecutive years.
*Results:* Rumination mediated the relationship between strong sustained attention and both depressive symptoms and disorder onset conditional on negative inferential style. Specifically, adolescents high in negative inferential style with strong sustained attention were more likely to experience increased subsequent rumination that, in turn, led to increased depressive symptoms and episode onset. In contrast to study hypotheses, there were no significant effects for models that included selective attention, attentional switching, or divided attention.
*Limitations:* Significant effects were relatively small, and therefore, should be interpreted with caution and require replication. We were unable to control for intelligence, and as a result, stronger sustained attention may be indicative of higher intelligence.
*Conclusions:* Stronger sustained attention in early adolescence compared to peers may facilitate rumination on negative self-evaluation and subsequent depression. Use of non-emotion-relevant stimuli to assess attention may account for the lack of findings for selective attention, attentional switching, or divided attention. Implications and directions for future research are discussed.

Depression is prevalent in the United States and an estimated 16.2% of individuals will experience clinical depression in their lifetime (Kessler et al., 2007). Depression is associated with numerous negative sequelae including disorder recurrence, poor self-reported physical health and additional health conditions (e.g., obesity, cardiovascular disease), low social support, and suicide attempts (e.g., Naicker et al., 2013; Roberts and Duong, 2013; Weissman et al., 1999). Depression frequently onsets in adolescence with an estimated 15.4% of adolescents experiencing clinical depression by the age of 17–18 years (Merikangas et al., 2010). Therefore, it is crucial to identify vulnerabilities that contribute to the onset and course of depressive disorders in adolescents in order to inform prevention and intervention efforts.

One leading cognitive model of depression, the hopelessness theory of depression, hypothesizes that the ways an individual typically interprets negative life events are crucial to the development of depression (Abramson et al., 1989). The hopelessness theory of depression specifies that three negative inferential styles confer risk for depression: (1) attributing a negative life event to a stable rather than unstable and global rather than specific cause, (2) believing that negative consequences will result from the negative event, and (3) inferring that the

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* Corresponding authors.
*E-mail addresses:* lara.rifkin@temple.edu (L.S. Rifkin), lalloy@temple.edu (L.B. Alloy).

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negative event's occurrence implies negative traits about the self. To date, extensive support has been found for the relationship between negative inferential styles and depression, including prospective first onset of major depression (e.g., Alloy et al., 2000, 2006; Mac Giollabhui et al., 2018), as well as for the interaction between negative inferential styles and negative life events in predicting subsequent depression in youth and adult samples (see Liu et al., 2015 for a review). These negative inferential styles are present in individuals who have experienced a previous episode of depression but no longer meet criteria in comparison to individuals with no history of depression, indicating that they are not merely a concomitant of current depression (Haeffel et al., 2005). Negative inferential styles also appear to be stable in adolescents (Hankin, 2008), indicating that this important cognitive vulnerability previously shown to confer risk for depression can be studied in adolescents. However, it is unclear how such cognitive vulnerabilities interact with the development of cognitive functioning in adolescence to confer risk for depression. In addition, little is known about how negative inferential styles interact with other cognitive vulnerabilities that confer risk for depression (e.g., rumination) during cognitive development.

Research examining the relationship between cognitive vulnerabilities in adults indicates that negative cognitive styles are associated with rumination or repetitive negative thinking about one's distress or past negative events, and that rumination both mediates and moderates the relationship between negative inferential styles and future major depressive episodes (Spasojević and Alloy, 2001; Robinson and Alloy, 2003). The response styles theory of depression (Nolen-Hoeksema, 1991) suggests that individuals have different trait ways of coping with the experience of negative affect and that rumination is one such response. Specifically, individuals ruminate because they believe this will provide them with insight into their negative mood and symptoms. However, rumination does not actually lead to insight, and instead, is associated with later increases in negative affect (Thomsen et al., 2004) and associated thinking patterns. Rumination predicts both symptoms (Nolen-Hoeksema et al., 2008; Roelofs et al., 2009) and episodes of depression in youth (Abela and Hankin, 2011; Stange et al., 2016). Research indicates that rumination is not necessarily maladaptive because of its prolonged focus on negative affect, but rather because of its prolonged focus on negative evaluations about the self (Rude et al., 2007). This suggests that rumination may be particularly harmful for those with negative inferential styles who tend to attribute negative events to internal and negative traits of the self, as shown by Robinson and Alloy (2003).

Researchers have theorized that rumination on negative evaluations of the self may be related to executive function abilities, specifically attention. The 'impaired disengagement' hypothesis suggests that deficits in attentional control and difficulties disengaging attention from negative repetitive thoughts results in prolonged rumination (De Raedt and Koster, 2010; Koster et al., 2011). This idea has received support from research with adults that indicates that stress predicts subsequent rumination for those with deficits in cognitive control compared to those without deficits in cognitive control (De Lissnyder et al., 2012). Deficits in inhibiting attention from emotional stimuli also may be important and have been shown to predict continuity of symptoms of depression and rumination measured six months later (Zetsche and Joormann, 2011). Finally, high levels of sustained attention to emotional stimuli may facilitate prolonged attention to negative thought content produced by individuals with negative inferential styles. In line with this, research indicates that increased sustained attention to unhappy faces is associated with rumination on negative self-evaluation in non-depressed individuals (Owens and Gibb, 2017). Two recent meta-analyses also have examined the relationship between rumination and attention, with one indicating that rumination is associated with deficits in inhibiting attention and set-shifting (Yang et al., 2017) and the other indicating repetitive negative thinking is associated with deficits in cognitive control (Zetsche et al., 2018). Of note, effect sizes were small in both meta-analyses. Overall, it appears that deficits inhibiting attention selectively, deficits disengaging attention, and high sustained attention to negatively valenced stimuli may be important in facilitating rumination on negative thought content conferring risk for subsequent depression among those with negative inferential styles. Given that rates of depression begin to increase in youth aged 12-14 and rise starkly in youth aged 15 (Hankin et al., 1998; Weissman et al., 1997), early adolescence is the ideal time in which to examine how the development of attentional executive functioning capacities interact with negative inferential style to confer risk for rumination and depression.

However, few studies have examined attention, rumination, and depression in adolescents and findings are mixed. Overall, it appears that there is a significant association between concurrent depression and cognitive deficits in youth, including on measures of inhibition capacity, attentional switching, sustained attention, and planning (see Wagner et al., 2015 for a meta-analysis); however, this work does not inform whether and how attention may confer risk for the subsequent onset of depression over the course of development. One prospective study found that measures of selective attention, sustained attention, attentional switching, and divided attention as measured by a behavioral task with neutral stimuli (i.e., The Test of Everyday Attention for Children; TEA-Ch; Manly et al., 1999) did not predict self-reported rumination or self-reported depression symptoms in adolescents a year later (Connolly et al., 2014). Another prospective study using the TEA-Ch with neutral stimuli found that deficits in attentional switching, but not selective, sustained, or divided attention predicted self-reported depression symptoms over the course of adolescence (measured yearly for six years; Mac Giollabhui et al., 2019). These discrepancies may reflect differences in the relationship between attention and depression over the course of adolescence, given that Connolly et al. (2014) examined change at a single time point one year later, whereas Mac Giollabhui et al. (2019) examined change over a six-year period using a model that assumes that the association between depression and attention is constant over time when this relationship may, in fact, differ over the course of development. Given that rumination involves sustained and repetitive focus on self-referent content, additional research is needed to examine whether attention may facilitate rumination to confer risk for depression in early adolescence as substantial attentional executive functioning in general, whether for neutral or emotionally-valenced stimuli, may be a prerequisite to engage in full-scale rumination. In addition, research has yet to examine the role of negative inferential style in this relationship. Specifically, attentional executive functioning development and associated prefrontal cortex development should increase the capacity for self-regulation in adolescents low in negative inferential style, but may facilitate rumination in adolescents high in negative inferential style by improving their ability to sustain attention on negative, self-referential material for extended periods of time. Thus, high general sustained attention abilities along with difficulties disengaging and inhibiting attention relative to peers may be particularly costly for youth high in negative inferential style by facilitating subsequent rumination and depression.

The current study examined whether deficits in selective attention, deficits in attentional switching, deficits in divided attention and strong sustained attention relative to peers may facilitate subsequent rumination and depression for youth high in negative inferential style. Specifically, we examined whether baseline attention and baseline inferential style interact to predict subsequent rumination and later depression in a moderated mediation model in a sample of young adolescents. We hypothesized that for adolescents high in negative inferential style, rumination would mediate the relationship between attention measures, specifically poor selective attention, strong sustained attention, poor attentional switching, and poor divided attention, and symptoms and episodes of depression.

## 1. Method

### 1.1. Participants

Participants were drawn from the Adolescent Cognition and Emotion (ACE) Project, a prospective longitudinal study of the onset of depression in adolescence. Beginning in May of 2009, 642 adolescents and their primary female caregivers were recruited and assessed at baseline. Participants came in for further brief assessments at 6-month intervals and comprehensive assessments at 12-month intervals, which included a semi-structured diagnostic interview, behavioral measures of attentional functioning, and self-report measures. Participants were recruited from middle schools in Philadelphia and the surrounding area (68% of participants) and from advertisements in local newspapers (32% of participants). Youth were eligible for participation if they were aged 12-13, identified as White, African American / Black, or biracial and had primary female caregivers who agreed to participate. Exclusion criteria included being unable to read or speak English sufficiently to complete all assessments or having a psychotic, developmental, medical or learning disorder (for additional information about recruitment and sample characteristics, see Alloy et al., 2012).

The current study included 364 participants who had complete data on measures of depressive symptoms and negative inferential style at baseline (Time 1; T1) and provided data at either the following yearly assessment (Time 2; T2) or the yearly assessment after (Time 3; T3). From the 364 selected participants, 267 were present at the second assessment and 291 at the third assessment. Available data varied according to the measure administered due to missing data or invalidated assessments of cognitive functioning (see Table 1).

Participants in this sample were 52.7% female, 54.4% Black or Biracial, and entered the study at a mean age of 13.15 ($SD$ = 0.99). Around half qualified for free lunch (45.9%), a measure of low socioeconomic status (SES) that accounts for income and number of dependents supported on that income. Independent sample t-tests indicated that the analytic sample did not differ from the complete sample of 642 adolescents at baseline on measures of depressive symptoms ($p$ =.75) or negative inferential style ($p$ =.42), although the age of the analytic sample (mean age = 13.12) was significantly (but not substantially) older than the excluded sample (mean age = 12.94). Chi-squared analyses indicated no difference between the analytic and the excluded sample based on sex ($p$ =.87), race ($p$ =.26) or SES ($p$ =.16).

### 1.2. Measures

The Adolescent Cognitive Style Questionnaire - Modified (ACSQ-M; Alloy et al., 2012) assesses negative inferential styles, and specifically, the tendency to make negative inferences regarding the causes and consequences of events, and implications of events for the self. The ACSQ-M presents adolescents with 12 scenarios containing typical negative events, with four each related to the interpersonal, achievement, and physical appearance domains. Participants generate one potential cause for each event and rate the extent to which each cause is internal, stable, and global to assess negative inferences for causal attributions. Participants also rate the degree to which they believe additional negative consequences will follow from each event and the extent to which they attribute the event to personal flaws. Ratings are made on a 7-point Likert scale and total scores, used for the purpose of the current study, are determined by averaging all scores. Research indicates the ACSQ-M demonstrates adequate psychometric properties including internal consistency and test-retest reliability (Alloy et al., 2012). The ACSQ-M demonstrated internal consistency in the current sample of α = .95.

**Table 1**
Missing data (% of participants missing data on each variable).

| Variable | % Missing |
|---|---|
| Sustained attention (T1) | 10.99 |
| Selective attention (T1) | 12.36 |
| Switching attention timing (T1) | 17.86 |
| Switching attention accuracy (T1) | 11.81 |
| Divided attention (T1) | 12.64 |
| Rumination (T1) | 2.20 |
| Rumination (T2) | 36.26 |
| Negative inferential style (T1) | 0.00 |
| Depressive symptoms (T1) | 0.00 |
| Depressive symptoms (T3) | 22.53 |
| Depressive episode onset (T3) | 15.93 |
| Gender | 0.00 |
| Length of time in study | 0.00 |

The Children's Depression Inventory (Kovacs, 1985, 1992) is a 27-item self-report measure that assesses symptoms of depression in youth. For each item, youth are presented with three response options depicting different levels of a particular symptom and asked to indicate which sentence best describes how they have felt over the past two weeks. Each response option has a corresponding score ranging from 0-2, which are added together for a total score, with higher scores indicating greater severity. Previous research indicates that the CDI demonstrates good internal consistency, discriminant validity, test-retest reliability and sensitivity to change. The CDI had internal consistency in the current sample of α = .86.

The Children's Response Styles Questionnaire (CRSQ; Abela et al., 2000) is a 25-item self-report questionnaire that evaluates how youth respond to depressed mood. The CRSQ has three subscales, including the Ruminative Response Subscale (RRS), the Distracting Response Subscale, and the Problem-Solving Subscale. The RRS was used in the current study and contains 13 items evaluating repetitive, self-focused thought as a reaction to sad mood. Youth indicate their response on a 4-point Likert-type scale ranging from 0, *almost never* to 3, *almost always*. Responses are summed for a final score on the RRS ranging from 0-39. Research on the CRSQ has provided support for a two-factor model with the RRS loading on its own factor and the distraction and problem solving subscales loading onto a single factor (Abela et al., 2007). The RRS has evidenced adequate psychometric properties including internal consistency, convergent validity, retest reliability and stability over time (Abela et al., 2002, 2004; Hankin, 2008). The RRS demonstrated internal consistency in the current sample of α = .88.

The Test of Everyday Attention for Children (TEA-Ch; Manly et al., 1999) is a behavioral assessment for youth aged 6-16 that assesses the attentional component of executive functioning. Youth complete four subtests measuring selective attention, sustained attention, attentional switching, and divided attention. Research indicates that the TEA-Ch evidences convergent and discriminant validity (Manly et al., 2001). The Sky Search subtest is a timed task that measures selective attention in which participants are instructed to search for 20 pairs of identical spaceships amid 108 pairs of distractor spaceships. Participants also complete the task a second time without the distractor spaceships so psychomotor speed can be measured and controlled. Selective attention scores are determined by adolescents' ability to identify matching pairs of spaceships and the time they take to do this controlling for psychomotor speed. Score! is an auditory task measuring sustained attention that consists of ten trials. Participants are played recordings of identical tones at irregular intervals and count the number of tones they hear. Sustained attention is the number of tones accurately identified. Sky Search Dual Task measures divided attention. Youth perform Sky Search and Score subtests simultaneously by identifying matching spaceships among distractor spaceships while listening to and counting tones. Divided attention is the number of tones correctly identified, the number of spaceship pairs correctly identified, and the length of time a participant takes to complete the task. Creature Counting assesses attentional switching with seven trials measuring adolescents' ability to switch from one response set to another. Youth count pictures of creatures that appear on a path and alternate between counting forward and backward based on the direction of arrows interspersed throughout the path.

Attentional switching is measured by switching accuracy and time taken to complete the task. All four subscales of the TEA-Ch evidence adequate retest reliability (Mac Giollabhui et al., 2019).

The Schedule for Affective Disorders and Schizophrenia for School-Age Children-Epidemiologic Version (K-SADS-E; Orvaschel, 1995) is a semi-structured diagnostic interview that assesses psychopathology in youth in accordance with the DSM-IV-TR and RDC. The same interviewer administered the K-SADS-E to youth and their mothers at baseline to assess current and lifetime psychopathology. Overall ratings were determined by combining information gathered from mother and youth report. Youth and their mothers were reassessed at yearly follow-up visits to assess subsequent psychopathology. The ACE Study evidenced interrater reliability of K = .85 for 120 pairs of ratings (five raters for each of 24 diagnoses from 10 K-SADS–E interviews). The outcome variable in the current study was onset of a depressive episode as defined by DSM-IV-TR criteria.

### 1.3. Procedures

Adolescents completed the TEA-Ch, the K-SADS-E interview, and self-report measures at baseline and at their yearly study visits. Adolescents' primary female caregivers also provided demographic information at baseline. For the purposes of the current study, measures of attention, negative inferential style, and depressive symptoms were gathered from the baseline assessment (Time 1; T1). Ruminative response style was obtained from the subsequent assessment one year later (Time 2; T2). Depressive symptoms and onset of a depressive episode used for outcome measures were obtained from the third assessment (Time 3; T3) or beyond in the case of depression diagnosis, where participants were followed for the entire duration of the study, 5.04 years (*SD* = 2.31).

### 1.4. Analyses

All analyses were performed using Mplus (Version 7.4). Full Information Maximum Likelihood Estimation was used to estimate missing data in the analytic sample. Moderated mediation models were estimated to examine whether rumination at T2 mediated the relationship between components of attention at T1 (selective, sustained, switching timing, switching accuracy, and divided) and depressive symptoms at T3, conditional on negative inferential style at T1. Negative inferential style was set to moderate the path of attention at T1 to rumination at T2. Five separate models were estimated for each of the five measures of attention. These analyses were repeated to examine whether these models predicted to onset of a depressive episode instead of depressive symptoms. In all models, when predicting to T3 depression, we included pathways from T2 rumination, T1 depression, T1 attention, T1 negative inferential style, and gender (see Fig. 1). In addition, when predicting to depression diagnosis that occurred at T3 or beyond and varied by participant, we controlled for the length of time participants were followed in the study (a longer period of follow-up by itself increases the likelihood of being diagnosed with depression). When predicting to T2 rumination, we included pathways from T1 rumination, T1 attention, T1 negative inferential style, gender, and the interaction of T1 attention by T1 negative inferential style. We also included pathways of T1 depression and T1 rumination regressed on T1 attention and T1 negative inferential style. Given that five moderated mediation models were estimated when predicting to depression symptoms and five moderated mediation models were estimated when predicting to depression diagnosis, a Bonferroni family-wise error rate correction is reported (significance set at $p < .01$) for all model pathways.

To estimate conditional indirect effects, variables were mean centered and 10,000 bootstrapped samples were specified. Model fit was assessed by examining the $\chi 2$ estimate of goodness of fit, the comparative fit index (CFI), and the root-mean-square error of approximation (RMSEA). A significant $\chi 2$ test of model fit indicates that there is a significant amount of error left unexplained by the model, although this metric is of limited utility in large samples (Chen, 2007; Cheung and Rensvold, 2002). The CFI indicates adequate fit with a value $> 0.90$ and excellent fit with a value $> 0.95$. Finally, a RMSEA indicates good fit with a value $< 0.05$ and the upper limit of the 90% confidence interval $< .10$.

## 2. Results

Descriptive statistics and bivariate correlations for main study variables are presented in Table 2 for the 364 participants who completed the baseline assessment (T1) and provided data at either the following yearly assessment (T2) or the yearly assessment after (T3). Of note, means of self-report depressive symptoms and incidence of depressive

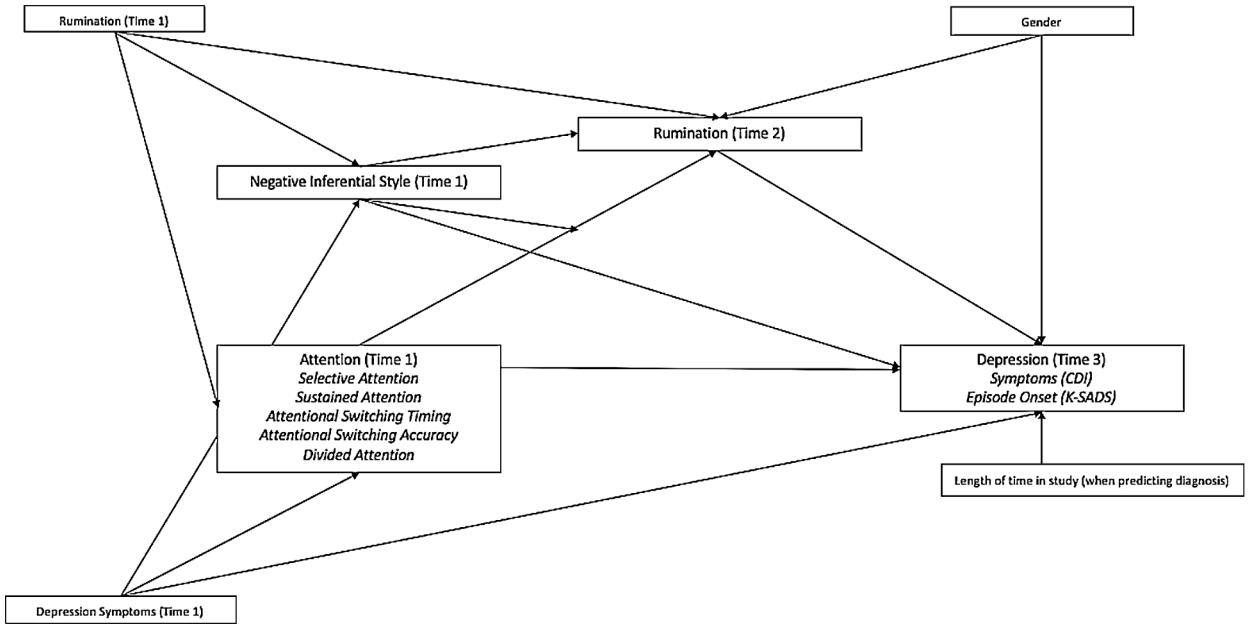


**Fig. 1.** Longitudinal moderated mediation model.

**Table 2**
Descriptive statistics and bivariate correlations for main study variables.

| Variable | ACSQ-M T1 | RRS T1 | RRS T2 | CDI T1 | CDI T3 | Depressive episode | Sustained attention | Selective attention | Attentional switching | Attentional switching accuracy | Divided attention |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ACSQ-M T1 | | .40** | .21** | .30** | .30** | .03 | .05 | -.01 | -.01 | .01 | .14* |
| RRS T1 | | | .49** | .51** | .41** | .13* | .07 | -.03 | -.00 | .04 | .05 |
| RRS T2 | | | | .34** | .44** | .21** | .11 | -.01 | .07 | .01 | .06 |
| CDI T1 | | | | | .38** | .12* | -.06 | -.02 | .04 | -.03 | .01 |
| CDI T3 | | | | | | .25** | .04 | -.05 | .06 | .10 | .21** |
| Depressive episode | | | | | | | .00 | .06 | -.00 | .01 | .07 |
| Sustained attention | | | | | | | | .17** | .21** | .16** | .24** |
| Selective attention | | | | | | | | | .19** | -.03 | -.03 |
| Attentional switching | | | | | | | | | | .16** | .14* |
| Attentional switching accuracy | | | | | | | | | | | .16** |
| Divided attention | | | | | | | | | | | |
| Mean | 2.47 | 25.10 | 23.72 | 7.24 | 6.72 | .26 | 9.54 | 10.05 | 8.24 | 9.67 | 7.43 |
| SD | 0.83 | 7.91 | 7.68 | 6.10 | 5.92 | .44 | 3.07 | 2.49 | 2.60 | 3.04 | 2.26 |

Note. ACSQ-M = Adolescent Cognitive Style Questionnaire-Modified; RRS = Ruminative Response Style; CDI = Children's Depression Inventory.
* $p > .05$.
** $p > .01$.

episode onset were somewhat lower than those previously observed in community samples of similarly aged youth (Costello et al., 2003; 3-month prevalence rate in youth aged 12 = .4%; McLaughlin and Nolen-Hoeksema, 2011; CDI T1 $M = 9.67$, $SD = 6.44$; CDI T3 $M = 10.63$, $SD = 8.15$ in youth enrolled in grades 6-8). First, we examined whether demographic variables including baseline age, gender, baseline pubertal development, socioeconomic status, and child race predicted outcome measures. Results indicated that only gender significantly predicted symptoms of depression, $F$ (1, 280) = 6.15, $p < .02$, and depressive episode onset, $F$ (1, 304) = 6.35, $p < .02$. Gender was controlled for in subsequent hypothesis-testing analyses.

Five moderated mediation models were estimated with each of the five measures of attention at T1 entered as predictors, negative inferential style at T1 as the moderator, rumination at T2 as the mediator, and depressive symptoms at T3 as the outcome variable (see Analyses and Fig. 1 for all model pathways). Results indicated that there was a significant indirect effect of sustained attention on depressive symptoms via rumination, conditional on negative inferential style (Table 3) and that this model fit the data well (Table 4). Specifically, rumination significantly mediated the relationship between sustained attention and depressive symptoms for adolescents high in negative inferential styles (Table 5) such that adolescents high in negative inferential style at T1 with strong sustained attention at T1 were more likely to experience higher levels of rumination at T2 that, in turn, led to higher depressive symptoms at T3. There were no significant effects for individuals with moderate or low negative inferential styles (Table 5). There were no other significant indirect effects for selective attention, attentional switching, or divided attention with depressive symptoms as the outcome measure (i.e., all other confidence intervals estimating conditional indirect effects contained 0; Table 3).

**Table 3**
Indices of moderated mediation.

| Index of moderated mediation | *B* | 95% CI |
|---|---|---|
| Sustained attention, outcome: CDI | .126 | (.023-.293) |
| Sustained attention, outcome: K-SADS | .016 | (.001-.039) |
| Selective attention, outcome: CDI | .140 | (-.037-.372) |
| Selective attention, outcome: K-SADS | .016 | (-.006-.052) |
| Attentional switching, outcome: CDI | -.079 | (-.327-.080) |
| Attentional switching, outcome: K-SADS | -.009 | (-.055-.012) |
| Attentional switching accuracy, outcome: CDI | -.072 | (-.258-.066) |
| Attentional switching accuracy, outcome: K-SADS | -.011 | (-.042-.005) |
| Divided attention, outcome: CDI | .036 | (-.228-.240) |
| Divided attention, outcome: K-SADS | .006 | (-.022-.036) |

Note. CDI = Children's Depression Inventory; K-SADS = Schedule for Affective Disorders and Schizophrenia for School-Age Children-Epidemiologic Version.

These analyses were repeated with depressive episode onset at T3 or subsequent assessments entered as the outcome variable. Results indicated that there was a significant indirect effect of sustained attention on depressive episode onset via rumination, conditional on negative inferential style (Table 3) and that this model fit the data well (Table 4). Specifically, rumination mediated the relationship between sustained attention and depressive episode onset for adolescents high in negative inferential styles (Table 5) such that adolescents high in negative inferential style at T1 with strong sustained attention at T1 were more likely to experience increased rumination at T2 that, in turn, led to higher likelihood of depressive episode onset at T3. There were no significant effects for individuals with moderate or low levels of negative inferential style (Table 5). There were no other significant indirect effects for selective attention, attentional switching, or divided attention with depressive episodes as the outcome measure (i.e., confidence intervals contained 0; Table 3). The conditional indirect effects of the models testing whether adolescents high in negative inferential style at T1 with strong sustained attention at T1 were more likely to become depressed (higher symptoms and diagnosis) via rumination at T2 are presented both visually and in a table format (Supplementary Figs. 1–2; Supplementary Tables 1–2) to help readers identify the point when the confidence interval of the conditional indirect effects no longer include zero.

## 3. Discussion

Using a prospective longitudinal design, we found that rumination mediated the relationship between strong sustained attention and both depressive symptoms and depressive episode onset conditional on negative inferential style. Specifically, adolescents with higher levels of negative inferential style and higher levels of sustained attention at T1 were more likely to experience higher levels of rumination at T2 that, in turn, led to higher depressive symptoms at T3 and an increased likelihood of experiencing a depressive episode at or after T3. There were no significant effects for individuals with moderate or low levels of negative

**Table 4**
Indices of model fit.

| | Sustained attention CDI | Sustained attention K-SADS | Selective attention CDI | Selective attention K-SADS | Attentional switching CDI | Attentional switching K-SADS | Attentional switching accuracy CDI | Attentional switching accuracy K-SADS | Divided attention CDI | Divided attention K-SADS |
|---|---|---|---|---|---|---|---|---|---|---|
| $X^2$ | 25.09, $p$ = .07 | 19.09, $p$ = .06 | 26.26, $p$ = .051 | 22.52, $p$ = .02 | 19.80, $p$ = .23 | 21.44, $p$ = .03 | 23.74, $p$ = .10 | 27.86, $p$ < .01 | 34.48, $p$ < .01 | 30.15, $p$ < .01 |
| CFI | 0.96 | 0.92 | 0.95 | 0.89 | 0.98 | 0.90 | .96 | 0.85 | 0.91 | 0.81 |
| RMSEA (90% CI) | .04 (.00-.07) | .05 (.00-.08) | .05 (.00-.08) | .06 (.02-.09) | .03 (.00-.06) | .06 (.02-.09) | .04 (.00-.07) | .07 (.04-.10) | .06 (.03-.09) | .08 (.04-.12) |

Note: CDI = Children's Depression Inventory; K-SADS = Schedule for Affective Disorders and Schizophrenia for School-Age Children-Epidemiologic Version.

inferential styles. In contrast to study hypotheses, there were no significant effects for models that included selective attention, attentional switching timing or accuracy, or divided attention as predictors of depressive symptoms or episode onset.

Results suggest that stronger sustained attention in early adolescence may facilitate rumination and subsequent depression. This makes sense in that in order to ruminate, one needs to be able to maintain focus on negative self-referent thoughts. Importantly, stronger sustained attention in early adolescence may be reflective of more advanced development compared to peers. Adolescence is a particularly important period for the development of attention to emotionally and motivationally salient tasks, which peaks in youth aged 14 to 15 (Poon, 2018). Superior attentional executive functioning at this period therefore may play an important role in conferring risk for rumination and subsequent depression in youth high in negative inferential style while slower maturation may be protective.

The finding that stronger sustained attention in early adolescence relative to peers may facilitate rumination and subsequent depression is in contrast to previous research that has indicated an inverse relationship between sustained attention and depression in youth (see Wagner et al., 2015 for a meta-analysis). However, these studies examined concurrent depression and attentional impairment and did not measure negative inferential style. It is possible that higher levels of sustained attention may facilitate rumination and lead to subsequent depression, but that once an individual is actively experiencing an episode of depression, their attentional capacity is altered (e.g., a symptom of depression is difficulty concentrating; one could experience difficulty sustaining attention on other topics because attention is sustained on negative evaluations of the self). This idea is in line with the resource allocation hypothesis, which suggests that individuals have finite cognitive resources and that depression utilizes these resources resulting in impaired engagement in other tasks (Gotlib and Joormann, 2010; Levens et al., 2009; Watkins and Brown, 2002). There is some research to support this in youth, with findings indicating that rumination predicts strong sustained attention in youth with low levels of depression and weak sustained attention in youth with high levels of depression (Wagner, et al., 2015).

The relationship between sustained attention and depression was mediated by rumination only for individuals with high levels of negative inferential styles. Although not tested in the current study, it is possible that individuals high in negative inferential style engage in a qualitatively different form of rumination compared to those low in negative inferential style, which then differentially predicts depression. Previous research indicates that the construct of rumination is composed of two factors: self-reflection, which is defined as "purposeful turning inward to engage in cognitive problem-solving to alleviate one's depressive symptoms," and brooding, which is defined as "a passive comparison of one's current situation with some unachieved standard" (Treynor et al., 2003, p. 256; Verstraeten et al., 2010). Research has found that brooding prospectively predicts higher symptoms of depression (Burwell and Shirk, 2007) and self-reflection prospectively predicts lower symptoms of depression (Treynor et al., 2003). In addition, brooding but not reflection mediates the relationship between negative cognitive styles and symptoms of depression (Lo et al., 2008). Results of the current study do not indicate that low negative inferential style and strong sustained attention interact to predict lower subsequent rumination and depression. Therefore, it is possible that individuals low in negative inferential style with strong sustained attention are more like to engage in self-reflection, which may be protective against depression, whereas individuals high in negative inferential style with strong sustained attention are more likely to engage in brooding, which confers risk. However, this was not tested directly in the current study and future work is needed to examine this.

The current study hypothesized that in addition to strong sustained attention, difficulty disengaging and inhibiting attention in individuals prone to negative self-evaluation would predict subsequent rumination and depression, as suggested by the attentional disengagement hypothesis. However, results of the current study do not offer support for the attentional disengagement hypothesis as no significant effects emerged for models that included selective attention, attentional switching timing or accuracy, or divided attention. This is in contrast to previous research in adult and youth samples that has found that deficits in attentional shifting and inhibition predicted symptoms of depression and anxiety (e.g., De Lissnyder et al., 2012; Demeyer et al., 2012; Kertz et al., 2016; Koster et al., 2011; Zetsche and Joormann, 2011). However, these studies measured attention using emotion-relevant stimuli (Demeyer et al., 2012; Zetsche and Joormann, 2011) or with self-report measures (Hsu et al., 2015; Kertz et al., 2016), whereas the current study employed behavioral tasks using non-emotion-relevant, neutral stimuli. Therefore, it is possible that individuals only experience difficulty inhibiting and disengaging attention from emotionally valenced material prior to the onset of depression.

Strengths of the current study include use of a prospective, longitudinal study design that provides temporal precedence for mediation analyses and use of a behavioral measure to assess attention. In addition, the current study included a semi-structured diagnostic interview that allowed examination of depressive episode onset in addition to depressive symptoms. Further, the racially and socioeconomically diverse community sample increases generalizability of findings to adolescents at risk for developing depression.

Important limitations also merit consideration. The authors did not preregister the data analysis plan for the current study. In addition, significant effects were relatively small, and therefore, should be interpreted with caution and require replication. The reader should keep in mind that the number of models we examined and parameters we estimated in the current study increase the risk of type I error and should be considered when evaluating questions of replicability. We also were unable to control for intelligence, and as a result, stronger sustained attention may be indicative of higher intelligence rather than more advanced development of executive function capacities. Previous research examining the association between sustained attention and intelligence has been mixed, with some work indicating that sustained attention is not associated with fluid intelligence and working memory in children (Voelke and Roebers, 2016) and other studies reporting a

**Table 5**
Rumination at T2 mediates the relationship between attention at T1 and depression at T3 for different values of the moderator, negative inferential style at T1.

| Symptoms (CDI) | | | | | | Diagnosis (K-SADS) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| a' path: predicting to T2 rumination | | | | | | | | | | |
| | Sustained attention | Selective attention | Attentional switching, timing | Attentional switching, accuracy | Divided attention | Sustained attention | Selective attention | Attentional switching, timing | Attentional switching, accuracy | Divided attention |
| *B* (SE) | | | | | | | | | | |
| T1 Negative Inferential style | .085 (.063) | .092 (.065) | .068 (.068) | .073 (.065) | .081 (.069) | .105 (.063) | .102 (.066) | .088 (.069) | .082 (.065) | .093 (.068) |
| T1 Attention | .036 (.053) | -.069 (.067) | .079 (.054) | -.001 (.058) | -.014 (.059) | .043 (.055) | -.059 (.071) | .078 (.054) | -.004 (.057) | .002 (.057) |
| Gender | .257 (.053)*** | .258 (.054)*** | .276 (.054)*** | .247 (.056)*** | .258 (.054)*** | .258 (.055)*** | .244 (.056)*** | .279 (.056)*** | .244 (.058)*** | .255 (.055)*** |
| T1 Rumination | .401 (.063)*** | .388 (.067)*** | .429 (064)*** | .414 (.065)*** | .399 (.066)*** | .337 (.074)*** | .342 (.076)*** | .376 (.074)*** | .358 (.075)*** | .345 (.075)*** |
| T1 Attention * T1 Negative Inferential Style | .110 (.051)* | .096 (.067) | -.054 (.062) | -.056 (.056) | .022 (.067) | .113 (.061) | .087 (.067) | -.045 (.067) | -.072 (.062) | .028 (.063) |
| b' path: predicting to T3 depression | | | | | | | | | | |
| T1 Negative Inferential style | .177 (.058)** | .185 (.058)** | .153 (.061)* | .176 (.057)** | .168 (.063)** | -.027 (.098) | -.020 (.091) | -.018 (.095) | -.019 (.090) | -.018 (.092) |
| T1 Depression Symptoms | .180 (.07)* | .185 (.071)** | .226 (.072)** | .185 (.068)** | .178 (.071)** | .091 (.092) | .101 (.094) | .147 (.098) | .094 (.094) | .101 (.092) |
| T2 Rumination | .341 (.099)** | .331 (.097)** | .334 (.099)** | .348 (.096)*** | .346 (.098)*** | .214 (.106)* | .217 (.101)* | .231 (.100)* | .217 (.097)* | .215 (.099) |
| T1 Attention | .010 (.064) | -.031 (.056) | .025 (.055) | .057 (.054) | .160 (.056)** | .011 (.079) | .090 (.076) | -.012 (.079) | .012 (.079) | .075 (.079)* |
| Gender | .064 (.059) | .064 (.060) | .058 (.063) | .063 (.058) | .034 (.060) | .109 (.083) | .090 (.085) | .081 (.088) | .118 (.083) | .110 (.084) |
| TimeIn | | | | | | .322 (.092)*** | .314 (.094)** | .317 (.098)** | .331 (.091)*** | .304 (.092)** |
| T1 Depression predicting to T1 Attention and T1 Negative Inferential Style | | | | | | | | | | |
| T1 Attention | -.111 (.073) | -0.007 (0.063) | .089 (.066) | -.063 (.063) | -.032 (.068) | -.108 (.075) | -.026 (.064) | .093 (.067) | -.057 (.065) | -.040 (.070) |
| T1 Negative Inferential style | .130 (071) | .125 (.070) | .142 (.074) | .120 (.071) | .133 (.071) | .138 (.070)* | .130 (.070) | .143 (.073) | .132 (.069) | .142 (.070)* |
| T1 Rumination predicting to T1 Attention and T1 Negative Inferential Style | | | | | | | | | | |
| T1 Attention | .125 (.064) | -.022 (.069) | -.047 (.071) | .070 (.065) | .068 (.073) | .114 (.066) | -.035 (.070) | -.064 (.070) | .069 (.067) | .055 (.076) |
| T1 Negative Inferential style | .349 (.059)*** | .348 (.060)*** | .341 (.062)*** | .350 (.060)*** | .344 (.060)*** | .365 (.060)*** | .370 (.061)*** | .362 (.062)*** | .374 (.061)*** | .360 (.060)*** |
| ab' path: T2 Rumination as a mediator of the relationship between T1 attention and T3 depression at values of the moderator, negative inferential style | | | | | | | | | | |
| | Sustained Attention | Selective Attention | Attentional Switching, Timing | Attentional Switching, Accuracy | Divided Attention | Sustained Attention | Selective Attention | Attentional Switching, Timing | Attentional Switching, Accuracy | Divided Attention |
| Effect (Boot CI LL - Boot CI UL) | | | | | | | | | | |
| 1 SD below mean | -.041 (-.146-.048) | -.121 (-.304-.010) | .098 (-.007-.267) | .035 (-.067-.164) | .030 (-.185-.120) | -.005 (-.020-.005) | -.014 (-.045-.001) | .012 (-.001-.042) | 0.005 (-0.006-0.025) | -.003 (-.025-.014) |
| At mean | .022 (-.039-.113) | -.051 (-.181-.038) | .058 (-.011, .179) | -.001 (-.078-.078) | -.012 (-.118-.078) | .003 (-.004-.017)) | -.006 (-029-.006) | .008 (-.001-.028) | .000 (-.011-.009) | .000 (-.014-.014) |
| 1 SD above mean | **.086 (.010-.218)** | .019 (-.141-.171) | .019 (-.109-.182) | -.037 (-.156-.061)-. | .006 (-.179-.157) | **.011 (.001-.033)** | 0.002 (-.019-.026) | .003 (-.015-.029) | -.006 (-.026-.006) | .003 (-.016-.027) |

*$p$ <.05, **$p$ < .01, ***$p$<.001. Only effects with $p$ < .01 remain significant after applying a Bonferroni correction for family-wise error rate. All coefficients reported are standardized.

significant relationship between sustained attention and fluid intelligence in adults (Burns et al., 2009) and children (Tillman et al., 2009). In addition, around 20% of our sample was at the celling for our measure of sustained attention, which limited our capacity to explore individual differences at the upper end of sustained attention. We also performed analyses on secondary data and did not conduct a priori power analyses; thus, the current analyses may have been underpowered. Further, means of self-report depressive symptoms and incidence of depressive episode onset were somewhat lower than those previously observed in community samples of similarly aged youth (Costello et al., 2003; McLaughlin and Nolen-Hoeksema, 2011), which may limit the generalizability of findings. Finally, the behavioral tasks used to assess attention were comprised of non-emotion-relevant, neutral stimuli and observed results may not generalize to executive attention abilities in the context of emotionally salient stimuli.

Future research should investigate how attention and negative inferential style interact to confer risk for subsequent rumination and depression in youth using attention tasks with both emotion-relevant and non-emotion-relevant stimuli. Specifically, researchers should examine whether results for sustained attention replicate using emotion-

relevant stimuli and whether difficulties with attentional inhibition and disengagement are specific to emotion-relevant stimuli. Future work also should examine whether the relationship between attention and depression differs over the course of adolescence. This line of work holds important implications for prevention efforts, which may ultimately target youth based on attentional executive functioning and inferential style.

## Author statement

LBA and LYA designed, secured grant funding for, and conducted the Adolescent Cognition and Emotion (ACE) Project from which current study participants were drawn. LSR, LBA and NMG designed the current study. NMG and LSR conducted the analyses. LSR wrote the initial draft of the manuscript and LBA, NMG, and PCK provided comments on the initial drafts. All authors have contributed to and approved the final manuscript.

## Declarations of Competing Interest

None.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2021.04.095.

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