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RESEARCH ARTICLE

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Do markers of daily affect mediate associations between interpretation bias and depressive symptoms? A longitudinal study of early adolescents

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Abstract

Introduction: Early adolescence represents a time of heightened vulnerability for depression. Negative interpretation biases have been associated with increases in depressive symptoms during this developmental period; however, the mechanisms underlying the association between interpretation biases and depression remain poorly understood. Cognitive theories posit that interpretation biases give rise to depression by modulating daily affect, particularly in the context of stress. However, this has not yet been directly examined. The present study tested affect intensity and instability as mechanisms linking negative interpretation biases with change in adolescent depressive symptoms.

Methods: Ninety-four adolescents (aged 11–13 years; 51% boys) from Vancouver, Canada, were recruited for this longitudinal study. At baseline (Time 1), participants self-reported depressive symptoms and completed the Scrambled Sentences Task to assess negative interpretation biases. Next, participants completed daily diaries to assess positive affect (PA) and negative affect (NA) during a naturalistic stressor—the first 2 weeks of high school (Time 2). Finally, participants self-reported depressive symptoms 3 months later (Time 3). Path models were conducted to test whether PA and NA intensity and instability mediated prospective associations between negative interpretation biases and depressive symptom changes.

Results: Although NA intensity, NA instability, and PA instability predicted increases in depressive symptoms, only NA intensity mediated associations between interpretation biases and symptom changes. Neither PA intensity nor instability mediated these associations.

Conclusions: Elevated daily NA represents a specific mechanism through which stronger negative interpretation biases predict increases in depressive symptoms in adolescence.

KEYWORDS

adolescence, affect dynamics, depression, interpretation bias, longitudinal

1 | INTRODUCTION

Depression is among the most prevalent mental health conditions in the world, affecting an estimated 280 million individuals each year (World Health Organization, 2021). This condition is not only common but costly; a recent study estimated that internalizing disorders cost the global economy US $1 trillion each year in lost productivity (Chisolm et al., 2016). Underlying these costs are significant effects of depression on quality of life and overall well-being, particularly when the

onset occurs early in life (i.e., in adolescence; Zisook et al., 2007). This is especially concerning given that approximately one-quarter of individuals with depression first experience symptoms in adolescence (Solmi et al., 2021). While the early onset of depressive symptoms has been linked to stressors common during this developmental period, only a subset of adolescents experience changes in mental health following stress exposure (Evans et al., 2018). This underscores the importance of identifying factors implicated in vulnerability for depression during times of stress in adolescence.

Negative interpretation bias, or the tendency to negatively interpret ambiguous information, has emerged as an important predictor of depressive symptoms in adolescence (Everaert, Podina, et al., 2017; Platt et al., 2017). Empirical work using various interpretation bias paradigms with different types of ambiguous stimuli (e.g., words, scenarios, faces; Orchard et al., 2016; Platt et al., 2017; Sfärlea et al., 2020; Würtz & Sanchez-Lopez, 2023) largely supports this hypothesized pathway. Indeed, one meta-analysis described a medium effect of interpretation bias on depressive symptoms (Everaert, Podina, et al., 2017). Yet, the mechanisms underlying associations between negative interpretation biases and depression are poorly understood. Beck (1967) initially proposed that these biases influence depressive symptoms by modulating experiences of positive and negative affect in daily life. While this conceptualization has persisted in current cognitive models (Joormann & Quinn, 2014), researchers have not yet examined whether interpretation biases influence daily emotions in ways that give rise to adolescent depression.

Several studies have described associations between markers of daily affect and depressive symptoms (Houben et al., 2015). Disturbances in the average intensity of daily affect are particularly well-established in depression. For example, greater depressive symptoms are consistently associated with lower positive affect and greater negative affect (Barge-Schaapveld et al., 1999; Watson, Clark, & Carey, 1988). However, those with similar average emotions may vary in how their affect fluctuates over time (Reitsema et al., 2022). Thus, subsequent studies have also examined more complex affective dynamics (i.e., patterns of affective change) in relation to well-being (Bos et al., 2019). These include affect instability, or the degree of variability (i.e., the within-person SD) and temporal dependency (i.e., moment-to-moment consistency) in affect. This metric is often quantified as the root mean square of successive differences (rMSSD) in levels of positive and negative affect across several timepoints (Jahng et al., 2008; Reitsema et al., 2022). Similar to affect intensity, more extreme and inconsistent fluctuations in affect have been concurrently associated with greater depressive symptoms in adolescents and adults (Houben et al., 2015; Thompson et al., 2012; van Roekel et al., 2016).

An intriguing possibility is that maladaptive markers of daily affect may arise from inflexible negative interpretations of ambiguous events in daily life (i.e., negative interpretation biases). This possibility is supported by related work on emotion regulation. Negative interpretations of ambiguity have been linked to the use of maladaptive emotion regulation strategies (e.g., brooding; Everaert, Grahek, et al., 2017; Wilson et al., 2006), which has been shown to mediate associations between more negative interpretation biases and greater depressive symptoms (Blanco et al., 2021; Sfärlea et al., 2021). Automatic and inflexible interpretations may also facilitate further mood-congruent cognitions, thereby impairing the efficacy of more adaptive strategies such as cognitive reappraisal. Thus, interpretation biases may give rise to adolescents' depression by modulating the capacity to regulate daily emotions, possibly resulting in more frequent or extreme fluctuations in affect (Joormann & Quinn, 2014). Initial evidence for this proposition comes from one preliminary study in adults (Puccetti et al., 2020) where positive and negative affect instability, though not intensity, mediated associations between negative interpretations of surprise and adults' depressive symptoms. However, the mediating role of positive and negative affect intensity and instability in associations between interpretation biases and adolescents' depressive symptoms remains unexplored.

To our knowledge, the present study is the first to examine whether prospective associations between negative interpretation biases and change in adolescents' depressive symptoms are mediated by positive and negative affect intensity and instability. Adolescents completed an interpretation bias task at baseline, followed by daily diary assessments of positive and negative affect during a naturalistic stressor: the first 2 weeks of high school (Evans et al., 2018; Zeedyk et al., 2003). Examining markers of daily affect during this naturalistic stressor was of particular interest, as affective responses to environmental stressors may be especially consequential for depression (Joormann & D'Avanzato, 2010). Participants self-reported depressive symptoms at baseline and approximately 3 months later. In keeping with our dimensional approach and with studies indicating that depression is best conceptualized as a continuous construct (e.g., Hankin et al., 2005; Liu, 2016), depressive symptoms were examined along a continuum. Based on cognitive theories of depression (Beck, 1967; Joormann & Quinn, 2014) and work on trait emotion regulation (e.g., Sfärlea et al., 2021), we hypothesized that positive and negative affect intensity and instability would mediate prospective associations between negative interpretation biases at baseline and changes in depressive symptoms.

2 | MATERIALS AND METHODS

2.1 | Participants

Participants were recruited as part of a larger study examining mental health risk and resilience across the transition to high school. The sample was composed of early adolescents who were between 11 and 13 years of age at the outset

of the study. Eligible participants were fluent in English and were to begin high school the following September. Participants were excluded if they had a history of serious head trauma, had a current substance use disorder, or endorsed a significant learning or psychiatric problem likely to interfere with completing the extensive laboratory protocol (e.g., mania, psychosis). Given the aims of the larger study, participants were also excluded if they had a medical condition or were taking medications known to affect the autonomic nervous system or neuroendocrine system (i.e., corticosteroids, depot neuroleptics, or oral/inhaled steroids; McKay & Cidlowski, 2003; Subramaniam et al., 2019). Participants were recruited from the Vancouver metropolitan area using online ads and flyers posted in diverse neighborhoods, as well as by leveraging connections with community organizations. Recruitment took place between spring 2018 and winter 2019. The final sample included 94 early adolescents from the larger study who provided data for at least one timepoint ($n_{t1} = 91$, $n_{t2} = 76$, $n_{t3} = 69$). Participants were between 11.88 and 13.89 years of age ($M = 12.87$; SD = 0.39) at baseline (additional participant characteristics presented in Table 1). This sample size is in line with the suggested 10:1 ratio of cases (participants) to free parameters for adequately powered path models (Kline, 2005).

2.2 | Procedure

After obtaining approval from the institutional ethics board, data were collected in a multisession procedure. At baseline (Time 1), participants' parents provided informed consent, and adolescents were asked for their assent upon attending a laboratory session. Participants then self-reported current depressive symptoms and completed interviews (described elsewhere; Jopling et al., 2021) to determine eligibility for the broader study. Given that cognitive biases can remain latent before being triggered by a negative mood state (Teasdale, 1988), participants next watched a randomly assigned 6-min negative movie clip immediately before completing the Scrambled Sentences Task (SST; Sanchez-Lopez et al., 2019 [described below]).[1] They also self-reported positive and negative affect before and after the movie clip to confirm that changes in affect occurred. Approximately 4 months later, daily diary data were collected across the first 2 weeks of high school (Time 2; M [SD] = 123.65 [84.74] days between Time 1 and 2). Finally, participants self-reported depressive symptoms approximately 3 months after beginning high school (Time 3; M [SD] = 109.67 [7.83] days between Time 2 and 3). All participants were compensated $30 for completing the Time 1 session and $40 for completing the at-home survey components for Time 2 and 3.

3 | MEASURES

3.1 | Interpretation bias

A computerized version of the SST (Wenzlaff & Bates, 1998) measured individual differences in the tendency to derive positive or negative meanings from ambiguous information (Everaert et al., 2014; Sanchez-Lopez et al., 2019). Specifically, for each trial, participants were instructed to form a grammatically correct and meaningful sentence using five of the six words provided. Each sentence contained one positive (e.g., "include") and one negative (e.g., "exclude") target word, and could only be unscrambled with either a positive (e.g., "people like to include me") or negative (e.g., "people like to exclude me") meaning. Positive and negative words were displayed in the second or fifth position in a counterbalanced manner to control for effects of word position. Word stimuli were adapted from the original stimulus list which was created for use in adults by Wenzlaff and Bates (1998). However, synonyms for positive and negative words were substituted where necessary, to ensure that all words used were age-appropriate for adolescents. Substitutions were made based on Flesch reading ease and grade level scores. Positive and negative words were then matched on word length, arousal, frequency, Flesch reading ease, and grade level. Arousal and valence ratings were taken from the Affective Norms for English Words data set (Bradley & Lang, 1999). Paired samples t tests showed no significant differences between positive and negative words on these lexical variables (all $ps > .05$).

Each trial started with a fixation cross at the left side of the computer screen to elicit natural left-to-right reading patterns. Participants used the mouse to click the cross and start the reading portion of the trial. During this portion, words were only visible when participants placed the mouse cursor over them. Thus, words could only be read one at a time. Participants had maximum of 14 s to read the words and mentally form a five-word sentence. Once a sentence had been formed, participants clicked a "Ready" button that was continuously visible at the bottom of the screen to begin the response portion of the trial. During the response portion, participants selected five words as quickly as

[1]Participants completed additional cognitive tasks as part of the larger study (see Jopling et al., 2021).

TABLE 1 Participant characteristics.

Variable	*N* (%) unless otherwise specified
Age, *M* (SD)	12.87 (0.39)
Gender	
Boy	48 (51)
Girl	45 (48)
Nonbinary	1 (1)
Sex	
Male	48 (51)
Female	46 (49)
Household income[a]	
$20,000–79,000	13 (13.9)
$80,000–139,000	35 (37.3)
$140,000–199,000	22 (23.4)
≥$200,000	13 (13.8)
Don't know	1 (1.1)
Prefer not to say	4 (4.3)
Racial identity[b]	
European–Canadian	58 (61.70)
Chinese	14 (14.89)
Latinx	4 (4.26)
Canadian–Indigenous	2 (2.13)
Japanese–Canadian[c]	2 (2.13)
Additional identities	6 (6.38)
Unsure/prefer not to answer	8 (8.51)
Negative interpretation bias, *M (SD)*	0.18 (0.18)
PA intensity, *M* (SD)	2.64 (0.66)
PA instability, *M* (SD)	0.55 (0.22)
NA intensity, *M* (SD)	1.59 (0.52)
NA instability, *M* (SD)	0.43 (0.23)
T1 depressive symptoms, *M* (SD)	12.80 (7.86)
T3 depressive symptoms, *M* (SD)	16.39 (11.53)

Note: $n = 94$.

Abbreviations: NA, negative affect; PA, positive affect; T1, Time 1; T3, Time 3.

[a]Income data were missing for six participants.

[b]Additional racial identities included South Asian, Southeast Asian, West Asian, Korean–Canadian, Korean–European, and European–Jewish. Race-related data were missing for eight participants.

[c]Racial identity was written in by participants.

possible to form their chosen grammatically correct sentence. The trial finished when participants clicked on the "Ready" button at the bottom of the screen or when the 7 s time limit to provide a response was over. Participants completed 30 trials based on previous extensive piloting, from which researchers determined the number of trials required to obtain reliable cognitive bias indices related to stress vulnerability and depression status (Martin-Romero & Sanchez-Lopez, 2022). The task was programmed using E-prime Professional software (Psychology Software Tools).

Negative interpretation bias was computed by dividing the number of grammatically correct, negatively resolved sentences by the total number of sentences unscrambled. Values above 0.5 indicate a negative interpretation bias, while values below 0.5 indicate a positive interpretation bias. Internal consistency for this metric was strong ($\alpha = .86$).

3.2 | Markers of daily affect

Participants self-reported positive and negative affect across the first 14 days of high school. Items from the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen et al., 1988) were used to measure participants' self-reported positive and negative affect. Specifically, participants indicated the extent to which they currently felt happy, proud, calm, excited, upset, nervous, ashamed, and stressed on a 5-point scale from 1 (*very slight or not at all*) to 5 (*extremely*). Positive affect scores were calculated by averaging scores for the happy, proud, calm, and excited items. The between-person reliability was $R_{kf} = 0.99$ and the within-person reliability was $R_c = 0.59$ (Cranford et al., 2006). Negative affect mean scores were calculated by averaging scores for the upset, nervous, ashamed, and stressed items. The between-person reliability was $R_{kf} = 0.99$ and the within-person reliability was $R_c = 0.59$. On Days 1 and 2, participants self-reported affect immediately upon waking, 30 min after waking, at 3 p.m., and before going to bed. On Days 3–14, participants completed these surveys at 3 p.m. and before bed. Data were collected more frequently on the first 2 days of high school due to the needs of the larger study. Surveys were distributed via text and email, which contained a link to an online survey administered via REDCap. Participants' personal information was stored separately from their survey responses throughout this process. If participants did not complete the survey, they received two reminders one and 2 h after receiving the initial email. Mean affect and instability were calculated for participants who completed at least 10 surveys (consistent with Puccetti et al., 2020). After exclusion of daily diary data for $n = 4$ participants who completed less than 10 surveys, the average number of surveys completed was 26 out of 32 across the first 2-weeks of high school (Total $n = 1975$, SD = 4.71, range = 12–32). No significant differences were observed between participants who did versus did not provide daily diary data on any demographic or other variables of interest (e.g., interpretation bias, depressive symptoms), all $ps > .05$. Positive and negative affect intensity were calculated by averaging scores for each participant across all surveys. Positive and negative affect instability were calculated as the rMSSD between observations within subjects (Jahng et al., 2008):

$$\text{rMSSD} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N-1}(x_{i+1} - x_i)^2}\,. \tag{1}$$

3.3 | Depressive symptoms

The Centre for Epidemiological Studies Depression Scale for Children (CES-DC; Weissman et al., 1980) was used to measure self-reported depressive symptoms at baseline and 3 months after the high school transition (Time 3). This 20-item self-report questionnaire measures the past-week frequency and severity of depressive symptoms on a 4-point Likert scale, from 0 (*not at all*) to 3 (*a lot*). This scale demonstrates strong psychometric properties in both clinical and community settings. There was strong reliability for this measure at both timepoints in the present study ($\alpha = .87$ at Time 1; $\alpha = .92$ at Time 3).

3.4 | Statistical analyses

Paired samples t tests were first conducted to test whether the pre-SST mood induction was successful. An additional paired samples t test tested whether participants' stress levels were significantly higher during the first 2 weeks of high school compared to during the Time 1 baseline assessment. Bivariate correlations were also examined across variables of interest, including negative interpretation bias, positive and negative affect mean and instability, and depressive symptoms at Times 1 and 3, as well as potential covariates (days between Time 1 and 2, days between Time 2 and 3, number of daily diary assessments completed, age, and sex). Finally, Little's MCAR test was run using the *naniar* package in R to determine whether auxiliary covariates were needed to address missingness in the data set (Tierney & Cook, 2023). This test was significant, $\chi^2 = 85.2$, $p < .001$, suggesting that data were not missing completely at random. As such, we next examined associations among missingness at T2 and T3 and observed variables in the data set. Only age was significantly associated with missingness at either timepoint, such that younger participants were more likely to be missing T2 affect or T3 depressive symptom data, $t(92) = -2.84$, $p < .01$. Consistent with recommendations of Collins et al. (2001), we, therefore, ran additional models with age as an auxiliary covariate to ensure that omitting this variable did not change our primary results.

Next, we adopted a theoretically driven approach in specifying indirect path models to examine whether positive and negative affect dynamics across the first 2 weeks of high school (Time 2) mediated associations between negative

interpretation biases (Time 1) and change in depressive symptoms (Time 1–Time 3). To mitigate concerns about multicollinearity, positive and negative affect dynamics were examined in two separate models. Consistent with Preacher and Hayes' (2008) recommendations for multiple mediation, affect intensity and instability were allowed to covary in both models. Each model initially contained all covariates, but nonsignificant covariates were subsequently removed for model parsimony (as recommended by Murtaugh, 1998). Change in depressive symptoms was indexed as the standardized residual score of depression at Time 3 after accounting for Time 1 symptoms, rather than a difference score. Specifically, residualized changes scores were created by regressing Time 3 depressive symptoms onto Time 1 symptoms, with standardized residuals saved and used in subsequent analyses. In contrast to simple difference scores, residualized change scores represent a reliable method of controlling for variability in baseline scores (Cohen et al., 2003; Segal et al., 2006) as variability among residuals can be considered independent of previous score variability. Moreover, our use of residualized change scores allowed us to prioritize model parsimony and analytic power by minimizing the number of variables included in the model. Bootstrapping procedures were used to evaluate statistical significance of indirect effects and to obtain bootstrapped confidence intervals and standard errors. Indirect effects were computed using bias-corrected bootstrapping with 5000 iterations. Missing endogenous and exogenous variables were handled using full information maximum likelihood estimation. Path analyses were conducted using the *lavaan* package in R (Rosseel, 2012).

4 | RESULTS

4.1 | Preliminary analyses

Paired samples *t* tests confirmed that the pre-SST mood induction was successful. Negative affect postinduction ($M = 7.74$, SD = 2.88) was significantly greater than negative affect preinduction ($M = 7.18$, SD = 2.85), $t(89) = -2.07$, $p = .041$, $d = -0.22$, 95% CI [−0.43, −0.01]. Similarly, positive affect postinduction ($M = 8.09$, SD = 3.30) was significantly lower than positive affect preinduction ($M = 9.31$, SD = 3.71), $t(89) = 4.38$, $p < .001$, $d = 0.46$, 95% confidence interval, CI [0.24, 0.68]. A paired samples *t* test further confirmed that there was an increase in stress levels from Time 1 to Time 2, consistent with research documenting the stressful nature of the high school transition (Evans et al., 2018; Zeedyk et al., 2003). Specifically, average stress ratings (taken from the PANAS) across the first 2-weeks of high school ($M = 2.0$, SD = 0.81) were significantly greater than self-reported stress at Time 1 ($M = 1.55$, SD = 0.75), $t(70) = -4.16$, $p < .001$, $d = -0.49$, 95% CI [−0.62, −0.22]. Bivariate correlations among study variables of interest are presented in Supporting Information: Table 1.

4.2 | Main analyses

We next tested whether the intensity and instability of negative and positive affect across the first 2 weeks of high school mediated the association between negative interpretation biases and changes in depressive symptoms (unstandardized estimates presented in Table 2; standardized estimates presented in Figure 1). In the first model, negative affect intensity, $b = 0.68$, 95% CI [0.09, 1.54], but not instability, $b = 0.19$, 95% CI [−0.11, 0.70], significantly mediated the association between negative interpretation bias and changes in depressive symptoms. Although both negative affect intensity, $b = 0.60$, 95% CI [0.17, 1.03], and instability, $b = 1.03$, 95% CI [0.05, 2.19], predicted increases in depressive symptoms from Time 1 to Time 3, negative interpretation biases significantly predicted greater negative affect intensity, $b = 1.13$, 95% CI [0.34, 1.95], not instability, $b = 0.18$, 95% CI [−0.11, 0.48]. All covariates were removed from the final model as none achieved significance.[2] Relative fit indices (i.e., Akaike's information criterion [AIC], Bayesian information criterion [BIC]) were smallest for this final model, indicating superior model fit (see Supporting Information: Table 3; Kline, 2016).

In the second model, neither positive affect intensity, $b = -0.22$, 95% CI [−0.96, 0.55], nor instability, $b = -0.03$, 95% CI [−0.29, 0.26], significantly mediated the association between negative interpretation biases and change in depressive symptoms (unstandardized estimates shown in Table 2; standardized estimates shown in Figure 2). Although greater negative interpretation biases at Time 1 predicted lower positive affect intensity at Time 2, $b = -1.20$, 95% CI [−1.79, −0.51], positive affect intensity did not predict changes in depressive symptoms from Time 1 to Time 3, $b = 0.19$, 95% CI [−0.43, 0.78]. Conversely, whereas negative interpretation biases at Time 1 did not significantly predict positive affect instability at Time 2, $b = -0.03$, 95% CI [−0.24, 0.25], greater positive affect

[2]Although we also ran an additional model with age as an auxiliary covariate, adding this variable had little effect on our primary findings. As such, we include this intermediary model in Supporting Information: Table 2.

TABLE 2 Indirect path estimates from negative interpretation biases to Time 3 depression via affect intensity and instability during the first 2 weeks of high school.

Outcome	Predictor	*b*	SE	95% CI
Model 1 (negative affect)				
NA intensity				
	Interpretation bias (*a*)	1.13	0.42	**[0.34, 1.95]**
NA instability				
	Interpretation bias (*d*)	0.18	0.15	[−0.11, 0.48]
T3 depression change				
	Interpretation bias (*c*)	−0.70	0.71	[−2.0, 0.81]
	NA intensity (*b*)	0.60	0.22	**[0.17, 1.03]**
	NA instability (*e*)	1.03	0.53	**[0.05, 2.19]**
Covariance	NA intensity and instability	0.05	0.01	**[0.02, 0.07]**
Indirect effect ($a \times b$)		0.68	0.38	**[0.09, 1.54]**
Indirect effect ($d \times e$)		0.19	0.21	[−0.11, 0.70]
Total effect		0.86	0.45	**[0.12, 1.86]**
Model 2 (positive affect)				
PA intensity				
	Interpretation bias (*a*)	−1.20	0.32	**[−1.79, −0.51]**
	Days between T1 and T2	0.002	0.001	**[0.001, 0.004]**
PA instability				
	Interpretation bias (*d*)	−0.03	0.12	[−0.24, 0.25]
	Days between T1 and T2	0.00	0.00	[−0.001, 0.001]
T3 depression change				
	Interpretation bias (*c*)	0.41	0.77	[−1.06, 2.02]
	PA intensity (*b*)	0.19	0.31	[−0.43, 0.78]
	PA instability (*e*)	0.97	0.51	**[0.12, 2.13]**
	Days between T1 and T2	−0.003	0.002	[−0.01, 0.00]
Covariance	PA intensity and instability	0.02	0.01	[−0.003, 0.04]
Indirect effect ($a \times b$)		−0.22	0.37	[−0.96, 0.55]
Indirect effect ($d \times e$)		−0.03	0.13	[−0.29, 0.26]
Total effect		−0.26	0.40	[−1.02, 0.58]

Note: $n = 94$; Unstandardized coefficients are presented. Change in depressive symptoms was indexed as the standardized residual score of depression at Time 3 after accounting for Time 1 symptoms. Indirect effect test statistics, standard errors, and confidence intervals were estimated using bias-corrected bootstrapping procedures. Bold values are statistically significant.

Abbreviations: CI, confidence interval; NA, negative affect; PA, positive affect; T1, Time 1; T2, Time 2; T3, Time 3.

instability significantly predicted increases in depressive symptoms from Time 1 to Time 3, $b = 0.97$, 95% CI [0.12, 2.13]. Greater number of days between Time 1 and 2 significantly predicted more positive affect intensity and was therefore retained in the final model; no other covariates were significant.[3] Again, smaller AIC and BIC values indicated superior fit for this final simplified model (see Supporting Information: Table 3).

[3]As before, we ran an additional model controlling for the number of days between T1 and T2 as well as age as an auxiliary covariate. However, this model is also included in Supporting Information: Table 2 as including age in this manner did not change interpretation of our findings.

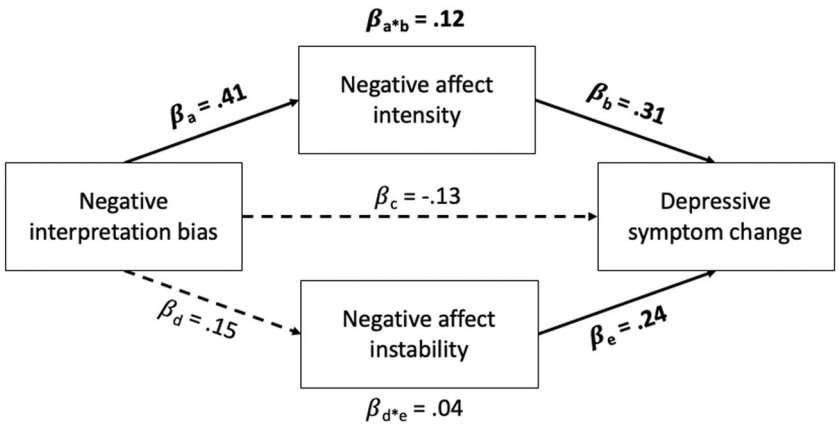

FIGURE 1 Negative affect intensity and instability as mediators of the association between negative interpretation biases and change in depressive symptoms. Standardized coefficients are presented, with significant effects shown in bold. The *a* and *d* paths illustrate the effects of the predictor on the mediators, *b* and *e* paths show the effects of the mediators on the outcome, and the $a \times b$ and $d \times e$ paths reflect the indirect effects of the predictor on the outcome via each respective mediator. Negative affect intensity and instability were allowed to covary (not pictured here).

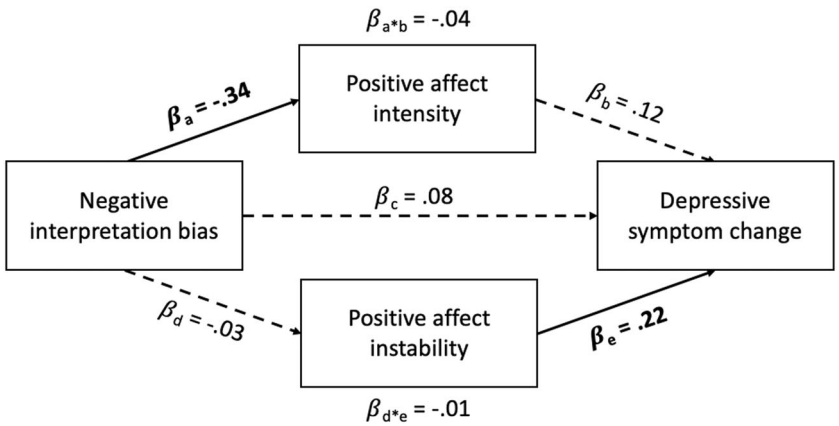

FIGURE 2 Positive affect intensity and instability as mediators of the association between negative interpretation biases and change in depressive symptoms. Standardized coefficients are presented, with significant effects shown in bold. The *a* and *d* paths illustrate effects of the predictor on the mediators, *b* and *e* paths show the effects of the mediators on the outcome, and $a \times b$ and $d \times e$ paths reflect the indirect effects of the predictor on the outcome via each respective mediator. The number of days between Time 1 and 2 were included as a covariate, and positive affect intensity and instability were allowed to covary (not shown here).

5 | DISCUSSION

Negative interpretations of ambiguity are theorized to foster depressive symptoms by modulating everyday emotional experiences (Beck, 1967; Joormann & Quinn, 2014). However, this has not been directly tested in adolescence. The present study, to our knowledge, is the first to examine whether daily markers of affect (i.e., negative and positive affect intensity and instability) mediate associations between negative interpretation biases and changes in depressive symptoms in early adolescence. Specifically, we examined how negative interpretation biases modulate affective responding across the transition to high school, a naturalistic stressor (Evans et al., 2018; Zeedyk et al., 2003). Interestingly, negative affect intensity, negative affect instability, and positive affect instability during the first 2 weeks of high school predicted greater increases in depressive symptoms. However, only negative affect intensity, not instability, significantly mediated prospective associations between more negative interpretation biases and increases in depressive symptoms, evincing specificity in the mechanisms through which such bias predicts symptom change.

Findings regarding the role of negative affect intensity in the interpretation bias-depression association are largely consistent with prior research. Specifically, the interpretation bias-negative affect link is supported by work suggesting that modifying interpretation biases influences negative mood in the laboratory (Al-Moghrabi et al., 2018; Lothmann et al., 2011; Mackintosh et al., 2006; Wilson et al., 2006; Yiend et al., 2005). Prior work has also demonstrated concurrent (Silk et al., 2003) and prospective (Neumann et al., 2011) associations between negative affect and depressive symptoms in

adolescence. We extend these findings by demonstrating that more negative interpretation biases also predict greater daily negative affect during a naturalistic stressor. This association between negative interpretation biases and adolescents' negative affect may reflect a tendency to experience greater affective reactivity and/or slower recovery in response to both explicitly stressful and otherwise ambiguous events. Supporting this assertion, negative interpretation biases have been associated with maladaptive emotion regulation strategies (e.g., rumination), which have been linked to both prolonged stress-induced negative affect and depression (Broderick & Korteland, 2004; Vrshek-Schallhorn et al., 2019). Although previous findings have been somewhat inconsistent (Fodor et al., 2020; LeMoult et al., 2018; Lothmann et al., 2011), it is possible that modifying negative interpretation biases may help to mitigate heightened levels of negative affect during times of stress and, thus, vulnerability for depression. However, rigorous, well-designed studies that combine experimental and experience sampling approaches are needed to establish whether this is the case.

In contrast to negative affect intensity, our nonsignificant findings for negative affect instability are somewhat unexpected based on work in adults (Puccetti et al., 2020) and prior research demonstrating associations between interpretation biases and trait emotion regulation (e.g., Sfärlea et al., 2021). First, discrepancies with Puccetti and colleagues (2020) may reflect developmental differences in the mechanisms underlying markers of daily affect in adults compared to early adolescents. For example, researchers have documented decreasing levels of affect instability from early adolescence to adulthood (Maciejewski et al., 2015; Reitsema et al., 2022). However, differences in the interpretation bias task used (i.e., negative ratings of ambiguous faces vs. sentences) as well as the depressive symptom outcome measure (i.e., cross-sectional means vs. changes) in Puccetti et al. (2020) relative to the present study are also notable. Clearly, further work is needed to elucidate whether these discrepant findings can be attributed to differences in the population, task, or outcome measure used.

Second, discrepant findings with work on trait emotion regulation could also reflect important differences between trait and daily affect regulation, consistent with recent findings that trait emotion regulation measures often fail to account for actual levels of momentary affective states (Maxwell et al., 2019). In contrast with trait emotion regulation, daily affect instability may be better explained by other facets of cognition associated with emotional responding, such as attention. Indeed, the orienting response to a stimulus has been theoretically implicated in extreme and frequent emotional shifts characteristic of affective instability (Koenigsberg, 2010). Despite this, significant pathways from greater negative affect instability to adolescents' depressive symptoms both support and extend previous findings in this population. Previous research demonstrated concurrent and prospective associations between daily negative affect variability, a specific facet of affect instability, and adolescent depression (Neumann et al., 2011; Silk et al., 2003). However, our findings suggest that both the overall variability and moment-to-moment consistency of daily negative affect (captured by rMSSD) constitute a marker of risk for adolescent depression. Though interpretation biases did not underlie negative affective instability, future research should examine whether other facets of cognitive processing also implicated in depression (e.g., attention bias; Baert et al., 2010) contribute to instability of daily negative affect.

In contrast to findings for negative affect, neither the intensity nor instability of positive affect significantly mediated associations between interpretation biases and depression. Though negative interpretation biases predicted lower levels of positive affect, levels of positive affect did not predict changes in depressive symptoms. These differential associations are consistent with contemporary views of positive and negative affect as distinct entities (Reitsema et al., 2022), but inconsistent with previously demonstrated relations of both positive and negative affect with adolescent depression (Kansky et al., 2016; Neumann et al., 2011; van Roekel et al., 2016). Explaining this finding may require consideration of the context in which affect was measured. Specifically, lowered positive affect may be normative across the stressful high school transition and, thus, less predictive of longer-term increases in internalizing symptoms (Larson et al., 2002; Meyer & Schlesier, 2022). Positive affect instability, on the other hand, may be less normative, possibly reflecting overreliance on positive events to experience positive affect (Rueschkamp et al., 2020). Moreover, greater positive *and* negative affect instability were associated with increased depressive symptoms. Both were also strongly correlated with each other, highlighting instability as a generalized affective marker of depression risk, irrespective of valence. Future research might examine whether these similar effects persist across different timescales and contexts (e.g., measuring affect instability across a laboratory stressor). This work might also consider how findings vary across dimensions of depression, such as anhedonia. Indeed, prior work has established a particular association of anhedonia with both higher instability and lower intensity of positive affect in adolescence (Murray et al., 2022). Although this factor has not been specifically identified within the CES-DC (as used in our study; Barkmann et al., 2008), future investigations might use other measures to examine this possibility.

By identifying specific affective mechanisms in associations between negative interpretation biases and internalizing symptoms, this study has implications for understanding and mitigating depression risk in early adolescence. Heightened risk for depression throughout this time has been linked with normative life events, including the transition to high school. Indeed, this transition has been referred to as one of the greatest stressors associated with adolescence (Evans et al., 2018; Zeedyk et al., 2003). During this time, individuals must adapt to a novel environment, characterized by higher social and academic expectations and less individual support (Bailen et al., 2019). Consequently, early adolescents often report concerns related to fear of victimization, peer relationships, and their ability to cope with the increased workload (Zeedyk et al., 2003). While some distress is to be expected, our findings suggest that adolescents with a tendency to interpret ambiguity as negative

may experience especially elevated negative affect during this transition, which in turn, increases their risk for depressive symptoms by the end of their first semester of high school. Though not examined in the present study, such increases in depressive symptoms may be consequential for mental health trajectories long into adulthood (Yaroslavsky et al., 2013). Modifying negative interpretation biases early might facilitate more adaptive emotional responding in relation to stressors in early adolescence, thereby mitigating vulnerability for depression associated with this important developmental period. These interventions may be especially relevant during the transition to high school, but likely have further importance relative to other myriad stressors during this time. Future work might examine whether associations among negative interpretation bias, daily negative affect, and depressive symptoms are stronger during the transition to high school compared to other major life transitions.

6 | LIMITATIONS

The present study was not without limitations. First, the relatively small number of assessments per day may have impacted the reliability of our results. Although the frequency of assessments has not been shown to impact estimates of emotional variability (Reitsema et al., 2022), future research might collect more data either within or across a greater number of days. It may be especially important to measure morning affect more consistently as we only did so on Days 1 and 2. This omission may have reduced estimates of affect instability and should be addressed in future work. Given that affect intensity and instability were calculated across all daily diary responses, variable numbers of responses and times between observations may have further influenced estimates. In addition, the daily diary assessments provided information about momentary positive and negative affect, but not the sources of these emotions. While the timing of the assessments (i.e., across the first 2 weeks of high school) helps to contextualize participants' experiences, future research should collect further information about events or stressors underlying patterns of affect. Although we highlight the consequential nature of the high school transition for adolescents' mental health, our lack of a comparison period precludes assertions regarding its relative importance compared to other major life transitions. Finally, we recruited a community sample with relatively low levels of depressive symptoms, thereby limiting variability. Our sample was also somewhat restricted in size which may have influenced the extent to which our analyses were adequately powered. Although our sample closely approximates the minimum $n = 100$ recommended for path analysis, as well as the suggested 10:1 ratio of cases to free parameters (Kline, 2005), we recognize that more recent work (e.g., Kline, 2016) has questioned the adequacy of this approach. We partially address this concern by replicating our analyses using a simpler approach (i.e., single vs. multiple mediation; see Supporting Information: Tables 4 and 5). Yet, we also emphasize the importance of replicating our findings in a larger sample, especially one comprised of both clinical and nonclinical populations.

7 | CONCLUSIONS

This longitudinal study was the first to examine associations of negative interpretation biases with daily markers of affect, and the extent to which these affective markers mediate interpretation bias-depression associations in early adolescence. Findings highlight greater negative affect intensity, but not instability, as a mechanism through which negative interpretation biases lead to increases in internalizing symptoms. Positive affect markers did not mediate interpretation bias-depression associations. Though further study is needed to replicate these findings, we identify specific affective phenotypes which may facilitate early identification of at-risk populations. Identifying those at risk can inform the implementation of interventions aimed at facilitating adaptive emotional responding during times of stress, as in the transition to high school. As suggested by our findings, targeting cognitive processes underlying patterns of affect dynamics may help to mitigate well-documented increases in depressive symptoms across this important developmental period.

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Research data are not shared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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