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Attentional biases for sad faces in offspring of mothers with a history of major depression: trajectories of change from childhood to adolescence

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Background: Theorists have proposed that the way children process social–emotional information may serve as a mechanism of risk for the intergenerational transmission of depression. There is growing evidence that infants and children of mothers with a history of major depressive disorder (MDD) during the child's life exhibit attentional avoidance of sad faces, which has been proposed as an early emerging emotion regulation strategy. In contrast, there is clear evidence that at-risk and depressed adolescents and adults exhibit difficulty disengaging attention from sad faces. **Methods:** Seeking to link these two literatures, the current U.S.-based study used eye tracking within the context of an accelerated longitudinal design to assess attentional biases in 8–14-year-old offspring of mothers with a history MDD during the child's life ($n = 123$) or no history of MDD ($n = 119$) every six months for two years, allowing us to map trajectories of attention from age 8 to 16. **Results:** Mother MDD history moderated age-based changes in children's gaze duration to sad ($t[240] = 2.44$, $p = .02$), but not happy ($t[240] = 0.11$, $p = .91$) or angry ($t[240] = 0.67$, $p = .50$), faces. Consistent our hypotheses, offspring of mothers with MDD exhibited significantly less attention to sad faces than offspring of never depressed mothers before age 8.5 but significantly more attention to sad faces after age 14.5, which was due to an increase in gaze duration to sad faces from childhood to adolescence among offspring of mothers with MDD ($t[122] = 5.44$, $p < .001$) but not among offspring of never depressed mothers ($t[118] = 1.49$, $p = .14$). **Conclusions:** It appears that the form, and perhaps function, of attentional bias may shift across development in at-risk youth. To the extent that this is true, it has significant implications not only for theories of the intergenerational transmission of depression risk but also for prevention and early intervention efforts designed to reduce this risk. **Keywords:** Depression; attentional bias; intergenerational transmission; eye tracking.

Introduction

According to cognitive models of depression (Clark, Beck, & Alford, 1999; Disner, Beevers, Haigh, & Beck, 2011), individuals' characteristic ways of attending to, interpreting, and remembering stimuli may contribute to the development and maintenance of the disorder. These information-processing biases are hypothesized to develop during childhood, stabilize in adolescence, and contribute vulnerability to depression across the lifespan. With regard to attentional biases, depressed and at-risk individuals are hypothesized to exhibit preferential attention toward, or difficulty disengaging their attention from, depression-relevant stimuli (e.g., sad faces) but not other stimuli. This hypothesis has received considerable support in adult and adolescent samples (Armstrong & Olatunji, 2012; Hankin, Gibb, Abela, & Flory, 2010; Joormann & Arditte, 2014; Peckham, McHugh, & Otto, 2010). Importantly, there is evidence that this attentional bias predicts prospective increases in depression (Beevers & Carver, 2003; Beevers, Lee, Wells, Ellis, & Telch, 2011), suggesting that it represents a true vulnerability factor rather than merely being a correlate of current depression.

Based on this, researchers have begun to examine whether attentional biases may represent an early-emerging risk factor for the development of depression, including as a mechanism of risk for the intergenerational transmission of depression. Consistent with studies in depressed adults, these studies have documented the presence of attentional biases for sad faces among school-aged children with a current depression diagnosis (Harrison & Gibb, 2015) as well as nondepressed children of mothers with major depressive disorder (MDD; Gibb, Benas, Grassia, & McGeary, 2009; Gibb, Pollak, Hajcak, & Owens, 2016; Joormann, Talbot, & Gotlib, 2007; Kujawa et al., 2011). In contrast to what has been observed among adults and adolescents, however, the majority of these studies found that depressed and at-risk children exhibit reduced attention toward sad faces compared to their low-risk peers (Gibb, Benas, et al., 2009; Gibb, Pollak, et al., 2016; Harrison & Gibb, 2015; but see also Joormann et al., 2007; Kujawa et al., 2011).

This pattern of attentional bias is consistent with what has been observed in the infant literature. Specifically, there is clear evidence from gaze data that infants of mothers with depression spend less time looking at their mothers' faces (Boyd, Zayas, & McKee, 2006; Field, 1984), and sad faces more

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generally (Diego et al., 2004; Field, Pickens, Fox, Gonzalez, & Nawrocki, 1998), than do infants of nondepressed mothers. This attentional avoidance of sad facial expressions has been proposed to serve as an emotion regulation strategy. Specifically, theorists have suggested that infants become upset following exposure to sad facial stimuli and then avert their gaze in an effort to regulate their negative affect (Bistricky, Ingram, & Atchley, 2011; Termine & Izard, 1988). This is consistent with Gross's (1998, 2014) process model of emotion regulation in which attentional deployment is viewed as a key emotion regulation strategy that, while not necessarily the product of conscious effort, first develops during infancy and can be used to reduce negative affect. Although this may be adaptive in the short term, attentional avoidance of sad stimuli is associated with children's concurrent symptoms and diagnoses of depression and predicts risk for future increases in depressive symptoms (Gibb, Benas, et al., 2009; Harrison & Gibb, 2015), demonstrating that it is not adaptive in the long run.

Despite the strengths of prior research, there are two key limitations that the current study sought to address. First, no prior studies have examined change in attentional biases in children or adolescents. In the current study, therefore, we utilized a multiwave longitudinal design in which 8–14-year-old offspring of mothers with either a history of MDD during their child's life or no lifetime history of any depressive disorder were assessed at baseline and then every six months for two years (5 assessments total). A second limitation is that most previous studies have relied on reaction times to index attentional allocation rather than assessing it directly. In these studies, preferential attention for emotional faces (e.g., sad vs. neutral) is inferred when participants' reaction times to a probe are faster when the probe appears in the location of an emotional face than in the location of a neutral face (MacLeod, Mathews, & Tata, 1986). However, there is growing concern with the low reliability of these indices, which affects their potential validity (Brown et al., 2014; Gibb, McGeary, & Beevers, 2016; Gibb, Pollak, et al., 2016; Kappenman, Farrens, Luck, & Proudfit, 2014; Kappenman, MacNamara, & Proudfit, 2015; Price et al., 2015; Rodebaugh et al., 2016; Staugaard, 2009; Waechter et al., 2014). In the current study, therefore, we used eye-tracking indices of attentional allocation, which have demonstrated stronger psychometric properties (Gibb, McGeary, & Beevers, 2016; Price et al., 2015).

Our accelerated longitudinal design, in which 8–14-year-olds were assessed at baseline and then every six months for two years, allowed us to map trajectories of change in attentional biases between age 8 and 16. Consistent with what has been observed in infants and young children, we predicted that, at the youngest ages, offspring of mothers with a history of MDD would exhibit less attention to sad faces than offspring of never depressed mothers. In contrast, consistent with what has been observed in adolescent and adult samples, we predicted that, at the oldest ages, offspring of mothers with a history of MDD would exhibit more attention to sad faces than offspring of never depressed mothers. To determine whether any observed significant relations were at least partially independent of offspring's concurrent levels of depressive symptoms, follow-up analyses were conducted to determine whether any observed significant relations would be maintained when statistically controlling for offspring's concurrent levels of depressive symptoms.

Methods

Participants

Participants in this study were 242 mothers and their children recruited from the community. To qualify for the study, mothers were required to either meet criteria for MDD during the child's lifetime (n = 123) according to the *DSM–IV* (American Psychiatric Association, 1994) or have no lifetime history of any *DSM-IV* mood disorder and no current Axis I diagnosis (n = 119). Exclusion criteria for both groups included symptoms of schizophrenia, alcohol or substance abuse within the last 6 months, or history of bipolar disorder. Children's participation was limited such that no more than one child per family could participate and all children were 8–14 years old at the initial assessment. If more than one child was available within this age range, one child was chosen at random for participation. The average age of mothers in our sample was 40.34 years (SD = 6.83) and the median family income was $50,000–55,000 per year. In terms of race/ethnicity, 85.95% of the mothers were non-Hispanic White, 4.55% were Black, 3.31% were multiracial, and the remaining 6.19% were from other racial/ethnic groups. For the children in our sample, the average age was 11.35 years (SD = 1.91) at the baseline assessment and 51.65% were girls. In terms of race/ethnicity, 81.40% were non-Hispanic White, 11.16% were multiracial, 4.55% were Black, and the remaining 2.89% were from other racial/ethnic groups.

Measures

The Structured Clinical Interview for *DSM-IV* Axis I Disorders (SCID-I), a widely used diagnostic interview with strong psychometric properties (First, Spitzer, & Gibbon, 1995), was administered at the initial assessment to determine mothers' lifetime histories of MDD. As noted above, 129 mothers met criteria for at least one episode of MDD during the child's life. A subset of 20 SCID-I interviews from this project was coded by a second interviewer, and inter-rater reliability for diagnoses of MDD was excellent (κs = 1.00).

Children's attentional biases for facial displays of emotion were assessed using a Tobii T60XL eye-tracking monitor (60 Hz data rate; 1,920 × 1,200 pixels) while they completed a modified dot probe task (cf. MacLeod et al., 1986). Before the dot-probe task, participants completed a 5-point calibration of the eye tracker where they were asked to look at specific points at the center and corners of the monitor. Accuracy of the calibration was confirmed by visual inspection of fixations recorded during the calibration procedure. Fixations during the task were defined as gaze allocation in a predefined area of interest lasting at least 100 ms. Stimuli for the dot probe task consisted of pairs of facial expressions that contained one emotional (angry, happy, or sad) and one neutral photograph from the same actor taken from a standardized stimulus set (Tottenham et al., 2009). Photographs from each actor (16 males and 16 females) were used to create angry-neutral, happy-neutral, and sad-neutral stimulus pairs (96 pairs total). Children sat 65 cm away from the computer monitor, and each of the two facial stimuli was 15.50 cm tall × 12.75 cm wide. Each stimulus pair was presented in random order in each of the two blocks, with a rest in between blocks (192 trials total). Each trial began with the presentation of a central fixation cross, and participants were required to make a central fixation before stimuli were presented. Stimuli were presented for 1,000 ms, followed by a probe (one or two asterisks) replacing one of the pictures. Following presentation of the dot probe on the screen, participants were asked to indicate whether the probe consisted of one or two asterisks as quickly as possible using a response box. The probe was presented with equal frequency in the location of the emotional and neutral faces. The intertrial interval varied randomly between 750 and 1,250 ms. Collapsing across the five waves of data, the Spearman-Brown split-half reliabilities for gaze duration to angry, happy, and sad faces were .78, .71, and .63, respectively. The split-half reliabilities for gaze duration to neutral faces when paired with angry, happy, and sad faces were .71, .67, and .67, respectively. For our analyses, we focused on the proportion of attention to the emotional versus neutral face for each emotion-neutral pairing.

Children's levels of depressive symptoms were assessed at each time point with the Children's Depression Inventory (CDI; Kovacs, 1981). The CDI has demonstrated strong reliability and validity in previous studies using community samples (Smucker, Craighead, Craighead, & Green, 1986) and exhibited good internal consistency across all five assessment points in this study (CDI: αs = .85–.89).

Procedure

Potential participants were recruited from the community through a variety of means (e.g., newspaper and bus advertisements, flyers). Mothers responding to the recruitment advertisements were initially screened over the phone to determine potential eligibility. Those reporting significant depressive symptoms during the child's lifetime or no significant lifetime symptoms of depression were invited to participate in the study. Upon arrival at the laboratory, mothers were asked to provide informed consent and children were asked to provide assent to be in the study. Next, the mother was administered the SCID-I by a research assistant. During this time, the child completed the dot probe task and the CDI. Follow-up assessments occurred 6, 12, 18, and 24 months after the initial assessment, during which children again completed the dot probe task and the CDI. Families were compensated monetarily for their participation. All study procedures were approved by the University's Institutional Review Board.

Analysis plan

We used hierarchical linear modeling (HLM 7; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2016; Raudenbush & Bryk, 2002) to examine trajectories of offspring's attention to facial displays of emotion across the study and to determine whether these trajectories were moderated by mothers' histories of MDD. The Level 1 (within subject) model was

$$\text{Gaze Duration}_{ti} = \pi_{0i} + \pi_{1i}(\text{Age}_{ti}) + e_{ti},$$

where Gaze Duration$_{ti}$ represents the proportion of gaze duration to the emotional (versus neutral) face for a given emotion type (angry, happy, sad) at age t for offspring i, π_{0i} is the gaze duration intercept, π_{1i} is the slope of linear change in gaze duration across the 2-year follow-up, and e_{ti} represents the error term. In these analyses, age was centered so that the intercept reflected gaze duration at age 8. Because youth were 8–14 years old at the baseline assessment and followed for 2 years, this allowed us to construct trajectories of change in attention to facial displays of emotion from age 8 to 16 years. Each emotion type was examined in a separate analysis.

The Level 2 (between subject) model was

$$\pi_{0i} = \beta_{00} + \beta_{01}\,(\text{Mother MDD}) + r_{0i}$$

$$\pi_{1i} = \beta_{10} + \beta_{11}\,(\text{Mother MDD}) + r_{1i},$$

where the key effects of interest are β_{01} and β_{11} reflecting the cross-level interaction effects of Mother MDD on the gaze duration intercept (level of attention bias at age 8) and on linear change in gaze duration between age 8 and 16. Mother MDD was grand centered so that intercepts for the Age slope equation reflects average levels of age-related change in gaze duration to each emotion across the full sample.

Two sets of follow-up tests were used to examine any significant Mother MDD × Age interactions. First, we examined age-based trajectories of attention separately in offspring of mothers with a history of MDD during their child's life versus offspring of never depressed mothers to determine the pattern of age-related change in each group separately. Then, a second set of analyses was conducted to determine regions of significance, or age ranges within which there were significant Mother MDD group differences in gaze duration to a specific emotion type. These analyses take advantage of the fact that the intercept of the Level 1 model reflects the value of the outcome variable (gaze duration) when the value of the predictor in the model (child age) equals zero. In our initial analyses, offspring age was centered at age 8 so that the intercept reflected the proportion of gaze duration to a given emotion type at age 8. By systematically adjusting the value at which offspring age was centered, we could determine the ages at which there were significant differences in gaze duration based on mothers' histories of MDD. Finally, for any significant effects observed, we examined if they would be maintained after entering concurrent CDI scores as a time-varying covariate to determine whether the result was at least partially independent of children's current depressive symptoms.

Results

Preliminary analyses

Descriptive statistics for the study variables are presented in Table 1. Of the 242 mother–offspring pairs participating in the initial assessment, 205, 193, 166, and 171 participated in the 6-, 12-, 18-, and 24-month follow-ups, respectively, and 81.40% of participants completed at least three of the five assessments. Given the presence of missing data, we then examined whether the data were missing at random, thereby justifying the use of data imputation methods for estimating missing values (Schafer & Graham, 2002). Little's missing completely at random test, for which the null hypothesis is that the data are missing completely at random (Little &

Rubin, 1987), was nonsignificant, $\chi^2(4470) = 4{,}519.87$, $p = .30$, supporting the imputation of missing values. Therefore, maximum likelihood estimates of missing data were created and used in all subsequent analyses (see Schafer & Graham, 2002).

Trajectories of change in children's attention biases

Next, we used HLM to test our hypothesis that mothers' MDD history would moderate trajectories of change in offspring's attention to sad faces such that offspring of mothers with a history of MDD during their lives, compared to offspring of never depressed mothers, would exhibit less attention to sad faces during childhood but greater attention to sad faces during adolescence. The results of the HLM analyses are summarized in Table 2. Focusing first on attention to sad faces, we found that mother MDD history moderated the attention bias intercept, $t(240) = -2.03$, $p = .04$, $r_{\text{effect size}} = -.13$, as well as the slope of age-based change over time, $t(240) = 2.44$, $p = .02$, $r_{\text{effect size}} = .16$. Follow-up analyses revealed that attentional biases toward sad faces increased significantly between age 8 and 16 among offspring of mothers with a history of MDD, $t(122) = 5.44$, $p < .001$, $r_{\text{effect size}} = .44$, but not among offspring of never depressed mothers, $t(118) = 1.49$, $p = .14$, $r_{\text{effect size}} = .14$. In contrast to what was observed for attention to sad faces, mothers' history of MDD was not related to intercept (attention at age 8) or slope (change in attention between age 8 and 16) for happy (Intercept: $t[240] = -0.59$, $p = .55$, $r_{\text{effect size}} = -.04$; slope: $t[240] = 0.11$, $p = .91$, $r_{\text{effect size}} = .01$) or angry (Intercept: $t[240] = -0.83$, $p = .41$, $r_{\text{effect size}} = -.05$; Slope: $t[240] = 0.67$, $p = .50$, $r_{\text{effect size}} = .04$) faces.[1]

Consistent with our hypothesis, the direction of attention bias to sad faces exhibited among children of mothers with a history of MDD during their child's life, compared to offspring of never depressed mothers, flipped as children aged into adolescence (see Figure 1). Evaluating regions of significance as described above, we found that offspring of mothers with a history of MDD during their child's life exhibited significantly *less* attention to sad faces than offspring of never depressed mothers before approximately age 8.5 and significantly *more* attention to sad faces after approximately age 14.5.[2] Finally, the mother MDD × age interaction, $t(240) = 2.45$, $p = .02$, $r_{\text{effect size}} = .16$, as well as the follow-up test demonstrating significant increases in attention to sad faces between age 8 and 16 among offspring of mothers with a history of MDD, $t(122) = 5.27$, $p < .001$, $r_{\text{effect size}} = .43$, remained significant even after statistically controlling for the influence of CDI scores at each assessment as a time varying covariate, suggesting that the results were not due simply to the concurrent influence of offspring's depressive symptoms.

Exploratory analyses

Finally, we conducted exploratory analyses to determine (a) whether any of the effects of maternal MDD

Table 1 Descriptive statistics for study variables

	Mothers with MDD during child's lifetime ($n = 123$)	Never depressed mothers ($n = 119$)
Offspring Age (at baseline)	11.37 (2.01)	11.34 (1.82)
Offspring Gender (% girls)	49.59%	53.78%
Offspring Race (% Non-Hispanic White)	71.54%	91.60%
T1 Attention to Angry	.70 (.09)	.70 (.09)
T2 Attention to Angry	.71 (.10)	.72 (.09)
T3 Attention to Angry	.71 (.10)	.74 (.09)
T4 Attention to Angry	.76 (.11)	.74 (.09)
T5 Attention to Angry	.76 (.11)	.76 (.11)
T1 Attention to Happy	.66 (.09)	.67 (.10)
T2 Attention to Happy	.68 (.09)	.67 (.09)
T3 Attention to Happy	.68 (.10)	.72 (.11)
T4 Attention to Happy	.73 (.11)	.72 (.10)
T5 Attention to Happy	.73 (.12)	.74 (.11)
T1 Attention to Sad	.68 (.09)	.69 (.10)
T2 Attention to Sad	.69 (.10)	.70 (.10)
T3 Attention to Sad	.69 (.10)	.71 (.11)
T4 Attention to Sad	.74 (.11)	.73 (.10)
T5 Attention to Sad	.74 (.11)	.71 (.10)
T1 CDI	7.62 (5.94)	4.81 (5.28)
T2 CDI	6.77 (6.67)	3.65 (4.24)
T3 CDI	5.87 (5.10)	3.58 (4.10)
T4 CDI	5.79 (5.41)	2.99 (4.01)
T5 CDI	6.24 (5.84)	3.47 (4.83)

MDD, Major Depressive Disorder. Attention variables reflect the proportion of attention to emotional versus neutral faces. CDI, Children's Depression Inventory. To facilitate comparisons with other studies, statistics for the CDI are based on untransformed variables.

Table 2 Summary of hierarchical linear models examining trajectories of attention to emotional stimuli across the follow up

	Sad			Happy			Angry		
	beta	*t*	$r_{\text{effect size}}$	*beta*	*t*	$r_{\text{effect size}}$	*beta*	*t*	$r_{\text{effect size}}$
Gaze duration intercept (π_{01})									
Intercept (β_{00})	0.65	49.68**	0.95	0.62	54.55**	0.96	0.76	62.79**	0.97
Mother MDD (β_{01})	−0.05	−2.03*	−0.13	−0.01	−0.59	−0.04	−0.02	−0.83	−0.05
Age slope (π_{1i})									
Intercept (β_{10})	0.01	4.82**	0.30	0.02	7.63**	0.44	0.01	6.68**	0.40
Mother MDD (β_{11})	0.01	2.44*	0.16	0.00	0.11	0.01	0.00	0.67	0.04

MDD, Major Depressive Disorder (coded as 1 for mothers with MDD during the offspring's life and 0 for mothers with no lifetime history of MDD).
*$p < .05$. **$p < .001$.

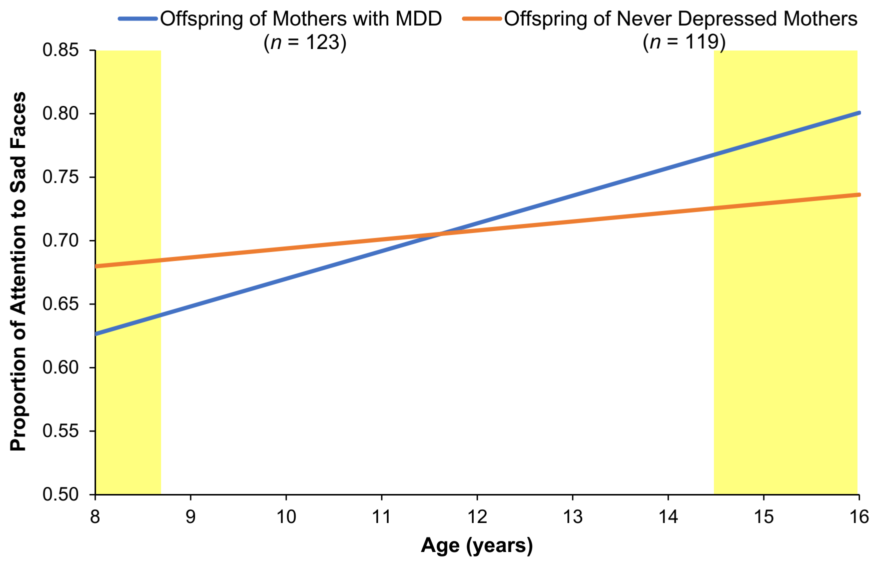

Figure 1 Trajectories of Attention to Sad Faces Among Offspring of Mothers with and without a History of MDD. MDD, Major Depressive Disorder during the child's lifetime. Offspring were 8–14 years old at the baseline assessment and assessed every six months for two years. Using this accelerated longitudinal design, we were able to map trajectories of attention between age 8 and 16. Highlighted areas indicate regions of significant group differences

history on attentional biases for any of the three emotion types were moderated by child gender or race/ethnicity, or (b) whether, within the MDD group, characteristics of mothers' MDD histories predicted attentional bias trajectories (i.e., recurrent MDD during the child's life, child age at first exposure to their mother's MDD, and overall proportion of the child's life that their mother was in an episode of MDD). None of these analyses was significant (lowest $p = .16$).

Discussion

The goal of the current study was to link two lines of research that have, thus far, remained relatively independent. The first, based on school-aged children and infants of mothers with depression, has suggested that these youth exhibit attentional avoidance of sad facial stimuli (Boyd et al., 2006; Diego et al., 2004; Field, 1984; Field et al., 1998; Gibb, Pollak, et al., 2016; Harrison & Gibb, 2015), which may reflect an emotion regulation strategy (Bistricky et al., 2011; Gross, 2014; Termine & Izard, 1988). The second, based on adolescent and adult samples, has shown that currently depressed and at-risk individuals exhibit increased sustained attention to, or difficulty disengaging attention from, sad faces (Armstrong & Olatunji, 2012; Hankin et al., 2010; Joormann & Arditte, 2014; Peckham et al., 2010). The current study is the first to prospectively assess attention biases in offspring of mothers with and without a history of MDD across the transition from childhood to adolescence. In doing so, we were able to examine trajectories of change in attention to facial displays of emotion across an age range spanning 8–16 years old.

Consistent with hypotheses, we found that, among younger children in our sample (prior to approximately age 8.5) offspring of mothers with a history of MDD during their lives exhibited significantly *less* attention to sad faces than offspring of never depressed mothers. In contrast, at older ages (after approximately age 14.5) offspring of mothers with a history of MDD during their lives exhibited significantly *more* attention to sad faces than offspring of never depressed mothers. This change was due specifically to increasing levels of attention to sad faces among offspring of mothers with MDD during this developmental period rather than any significant change in attention to sad faces among offspring of never depressed mothers. These results were maintained when we statistically controlled for the influence of offspring depressive symptoms at each assessment, suggesting that they are at least partially independent of the influence of offspring depression. The results were also specific to attention to sad faces and were not observed for attention to happy or angry faces.

These findings suggest that the form, and perhaps function, of attention to sad faces in offspring of mothers with MDD may change across the transition from childhood to adolescence. Clarifying this change is essential not only for theories of the intergenerational transmission of depression but also for prevention and intervention efforts. For example, attention bias modification programs are increasingly being developed for the treatment of psychopathology including "gamified" versions (e.g., Dennis & O'Toole, 2014; Linke et al., 2019; Sardi, Idri, & Fernández-Alemán, 2017) that may be more user-friendly and feasible with youth. To the extent that the form and function of attentional biases change across development, it would suggest that attention bias modification interventions, or interventions more generally, need to be tailored for the child's specific developmental stage, since they could backfire if they only reinforce a bias that is already present. For example, programs developed for adolescents and adults that train attention away from sad stimuli may further enhance attentional avoidance of sad faces in at-risk children thereby further increasing rather than decreasing risk. Similarly, the results could suggest ways that family-based interventions (see Goodman & Garber, 2017) could be modified to target maladaptive interaction styles to reduce the development and expression of attentional biases as a mechanism of risk for the intergenerational transmission of depression.

Although the current results provide the first direct test of age-based shifts in the direction of attentional biases for sad faces, showing that it occurs during the transition from childhood to adolescence, it leaves unanswered the key question of *why* it may occur. We can think of at least three plausible explanations. First, this period is characterized by normative developmental changes in neural activity within, and functional and structural connectivity between, brain regions implicated in attentional biases such as amygdala, anterior cingulate cortex, and dorsolateral and ventrolateral prefrontal cortex (Casey, Heller, Gee, & Cohen, 2019; Disner et al., 2011; Gee et al., 2013; Goddings, Roalf, Lebel, & Tamnes, 2021; Morales, Fu, & Pérez-Edgar, 2016; Todd, Evans, Morris, Lewis, & Taylor, 2011), which may be associated with a reduced ability to inhibit attention to emotionally-salient stimuli. The transition to adolescence is also notable for normative age-related increases in two other factors that have been linked to attention biases: rumination and interpersonal stress. There is evidence that rumination is associated specifically with difficulty disengaging attention from depression-relevant stimuli (e.g., sad faces), even in nondepressed samples (Donaldson, Lam, & Mathews, 2007; Duque, Sanchez, & Vazquez, 2014; Grafton, Southworth, Watkins, & MacLeod, 2016; Owens & Gibb, 2016; Southworth, Grafton, MacLeod, & Watkins, 2017). It is possible, therefore, that reductions in offspring's ability to disengage their attention from depression-relevant stimuli (shifting, over time, from a pattern of attentional avoidance to difficulty disengaging attention) are due to age-related increases in rumination among these youth. In addition, although research has supported the link between interpersonal stress and attentional biases, this research has focused primarily on the role of childhood abuse (Gibb, Schofield, & Coles, 2009; Johnson, Gibb, & McGeary, 2010; Pine et al., 2005; Pollak & Tolley-Schell, 2003) and less is known about more developmentally typical interpersonal stressors that occur during childhood and adolescence. This type of research is important because there are clear increases in interpersonal stress that occur during the transition to adolescence, particularly for girls (Rose & Rudolph, 2006).

Strengths and limitations

This study exhibited a number of strengths including the use of eye tracking to assess attentional biases and the multiwave accelerated longitudinal design, which allowed us to examine changes in attentional biases during the transition from childhood to adolescence. There were also limitations that highlight important areas for future research. First, although significant effects were observed for trajectories of change in attention to sad faces, the overall proportion of variance accounted for by children's exposure to MDD in their mothers was small (2.42%). Though substantially higher than that observed for trajectories of change in attention to happy (0.01%) or angry (0.19%) faces, there is clearly room for improvement. There are at least three potential avenues for this. The first is better characterization of children's attentional biases. For example, future research could use tasks specifically designed to assess one's ability to disengage or inhibit attention (cf. Sanchez, Vazquez, Marker, LeMoult, & Joormann, 2013; Woody et al., 2017), which is the key component of attention thought to be most strongly linked to depression risk. Another avenue would be to better characterize children's exposure to depression in their mothers. Although characteristics of mothers' MDD history (e.g., single vs. recurrent MDD during the child's life, child's age at first MDD onset, proportion of the child's life that their mother was in an episode of MDD) did not predict attention biases in this study, it is possible that a more direct measure of children's exposure to their mothers' depression would be a stronger predictor. Finally, it is clear that having a mother with MDD not only affects relations with one's mother but also with peers (e.g., Feurer, Hammen, & Gibb, 2016). Therefore, future research could also examine the impact of peer relations, which become more salient during the transition into adolescence and likely impact the development of attentional biases during this developmental period. A second limitation of the current study is that, despite the relatively large sample size, we were not powered to detect smaller effects (e.g., moderation by offspring gender or race), which may be relevant for understanding the development of attention biases. Third, the sample was relatively homogeneous with regard to race/ethnicity and future research is needed to determine the generalizability to more diverse samples.

Conclusions

In summary, the current study offers the first concrete evidence that the form of attentional biases exhibited by offspring of mothers with MDD, relative to offspring of never depressed mothers, changes from a pattern of reduced attention to sad faces during childhood to a pattern of increased attention to sad faces in adolescence. As such, it brings together an extensive body of research that has, thus far, progressed independently. Although additional research is needed to replicate these findings and to more clearly define the core features of attention that are implicated and the mechanisms underlying this shift in direction, the current results suggest a need for developmentally sensitive revisions to our current understanding of how attentional biases may serve as a mechanism of risk for the intergenerational transmission of depression.

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Key points

- Previous research in school-aged children and infants of mothers with depression indicate that they exhibit attentional avoidance of sad facial stimuli.
- Among adolescents and adults, however, depressed and at-risk individuals exhibit increased sustained attention to sad stimuli.
- We show, for the first time, this flip in the direction of attentional biases, which appears to occur during the transition from childhood to adolescence.
- These findings suggest that the form, and perhaps function, of attentional biases may shift across development.

Endnotes

1. Although we were primarily focused on linear age-related change in attentional biases, we also conducted exploratory analyses to test for possible nonlinear (quadratic) change. There was no evidence of quadratic change in any of the attentional biases (lowest $p = .34$) nor did mother MDD group moderate any of the quadratic trends (lowest $p = .51$).
2. Additional details of these analyses are available from the first author.

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