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Moderating effects of environmental stressors on the development of attention to threat in infancy

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Abstract

An attention bias to threat has been linked to psychosocial outcomes across development, including anxiety (Pérez-Edgar, K., Bar-Haim, Y., McDermott, J. M., Chronis-Tuscano, A., Pine, D. S., & Fox, N. A. (2010). Attention biases to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion (Washington, D.C.)*, 10(3), 349). Although some attention biases to threat are normative, it remains unclear how these biases diverge into maladaptive patterns of emotion processing for some infants. Here, we examined the relation between household stress, maternal anxiety, and attention bias to threat in a longitudinal sample of infants tested at 4, 8, and 12 months. Infants were presented with a passive viewing eye-tracking task in which angry, happy, or neutral facial configurations appeared in one of the four corners of a screen. We measured infants' latency to fixate each target image and collected measures of parental anxiety and daily hassles at each timepoint. Intensity of daily parenting hassles moderated patterns of attention bias to threat in infants over time. Infants exposed to heightened levels of parental hassles became *slower* to detect angry (but not happy) facial configurations compared with neutral faces between 4 and 12 months of age, regardless of parental anxiety. Our findings highlight the potential impact of the environment on the development of infants' early threat processing and the need to further investigate how early environmental factors shape the development of infant emotion processing.

Keywords

anxiety; biased attention; infant attention; parenting hassles; threat detection

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CONFLICT OF INTEREST
The authors declare no conflicts of interests.

1 | INTRODUCTION

Given its adaptive nature, biased attention to threat—defined as rapid or prolonged attentional responses to threatening stimuli—has been hypothesized to emerge early in development and show stability over time (e.g., Öhman & Mineka, 2001). Consistent with this view, adults, children, and even young infants have exhibited rapid allocation of attention to threatening stimuli in a number of studies. These studies use diverse response metrics and threatening exemplars ranging from angry facial configurations to snakes and spiders and less evolutionarily relevant threats like needles, knives, and guns (see LoBue & Rakison, 2013, and Öhman & Mineka, 2001 for reviews).

While a robust literature suggests that biased attention to threat is normative, a parallel literature suggests that biased attention to threat constitutes a risk factor for psychopathology, and as a result, attention biases for threat have been implicated in the development and maintenance of anxiety disorders (Burris et al., 2019a,b; Morales et al., 2016). Indeed, anxious individuals tend to detect angry facial configurations more quickly than nonanxious individuals (see Von Bockstaele et al., 2014 for a review). Further, children with a behaviorally inhibited temperament, who are at a heightened risk for the development of anxiety, detect threatening facial configurations even faster than non-inhibited children as early as 5 years of age (LoBue & Pérez–Edgar, 2014).

There is some suggestion that the early association between attention biases to threat and anxiety points to a causal mechanism. As such, developmental studies are important for examining the underlying factors that contribute to both normative and divergent trajectories of attention bias over time. A small but growing literature on the development of attention biases to threat in infancy has recently emerged using a variety of passive looking paradigms with eye tracking (for review, see Burris et al., 2019a,b). For example, in a large sample of infants and young children ranging from 9 to 48 months, researchers have reported evidence of a normative attention bias towards emotional facial configurations over neutral ones (Burris et al., 2017). Further, several studies have shown that infants as young as 5 months of age do not differentially attend to happy versus fearful facial configurations, but by 7 months, infants look longer at fearful than happy configurations (Peltola et al., 2013; Peltola et al., 2009). Follow-up longitudinal work shows that this bias for stereotypical fear configurations decreases over time and is not correlated with attention bias patterns at the age of 2 years, demonstrating a great deal of variability and potential instability in infants' biased attention patterns over time (Peltola et al., 2018).

Such variability could suggest that attention biases for threat are only normative in the first few months of life, and that individual factors, such as a behaviorally inhibited temperament, begin shaping trajectories of attention bias shortly thereafter. Other factors associated with socioemotional functioning and anxiety risk, such as maternal anxiety, may also play a role in shaping these trajectories. Indeed, maternal anxiety has been associated with less infant engagement with emotional facial configurations (Vallorani et al., 2021a), and with infants' greater engagement with threatening facial configurations specifically in both prospective (Morales et al., 2017) and longitudinal studies (Vallorani et al., 2021b). Although biological factors may drive this relation as well, it is possible that anxious or stressed caregivers project different kinds of emotional input to their infants, affecting how infants perceive emotional information. If this is the case, broader environmental factors might also shape the development of infants' attention biases for threat over time.

Evidence from previous literature suggests that environmental factors impact attention biases for threat. For example, physically abused children allocate more attention to threat-relevant stimuli than do nonabused children (Shackman et al., 2007), as do adults who have experienced trauma (Lakshman et al., 2020). Attention biases also interact with other experiential factors to increase risk for psychopathology. For example, attention bias to threat moderates the link between violence exposure and anxiety symptoms in young children (Briggs-Gowan et al., 2015). Further, in one study, researchers reported that both attention bias to threat and experiencing a recent traumatic event were related to future trauma-related symptoms in a large sample of young children, with experience of abuse moderating the link between attention bias and future trauma symptoms (Briggs-Gowan et al., 2016). This work suggests that acute negative environmental events—such as physical abuse, trauma, or exposure to violence—are all related to attention biases to threat and might interact with attention biases to elevate a child's risk for psychopathology.

While there is evidence that acute negative environments can impact attentional patterns toward threat, less research exists to explore the impact of normative levels of negative factors in the environment. One commonly experienced feature of a normative environment that has received little attention in the literature is everyday parenting stress, or what can be operationalized as "parenting hassles" (Crnic & Greenberg, 1990). Perceptions of daily parenting hassles are a core tenet of parents' subjective daily experience, and high levels of parenting hassles can be considered a proxy for parenting stress, carrying implications for parental health and parenting efficacy (Crnic et al., 2005). Research suggests that even minor parenting hassles can translate to meaningful differences in the way parents interact with their infants and young children. For example, heightened levels of parenting hassles have been linked to more authoritarian parenting behaviors and less positive and less responsive interactions with children (Belsky et al., 1995; Crnic & Greenberg, 1990; Deater-Deckard & Scarr, 1996). Mechanistically, such negative parenting behaviors may lead to increased exposure to negative emotional information in the infant's immediate environment, which in turn may increase vigilance, or rapid attention to identifying threatening facial expressions over the course of development.

The current study investigates the potential impact of parenting stress, as measured by the self-reported intensity of daily parenting hassles, on the development of biased attention to threat in early infancy. Infants were tested at 4, 8, and 12 months of age. During testing, infants underwent an attentional vigilance task (Fu et al., 2020), where they were presented with a single emotional facial configuration (angry, happy, or neutral) on one of the four corners of a screen. Biased attention to threat was operationalized as visual latency to fixate angry emotional facial configurations compared with happy or neutral configurations. We obtained this metric using eye tracking, allowing us to study *when* in development attention biases to threat first develop, and as well as *how* the environment of a young infant is associated with threat perception.

We hypothesized that, over time, infants from households with high levels of daily parenting hassles would exhibit faster latencies or increased attentional vigilance to angry faces compared with happy or neutral faces. Given the association between anxiety and attention biases to threat in previous literature, we also hypothesized that parental anxiety may play a mediating role in the relation between biased attention to threat and parental stress.

2 | METHOD

These data were collected as part of the Longitudinal Anxiety and Temperament Study (see Pérez-Edgar et al., 2021, for a description of the full method). Eye-tracking data for the current analyses were collected from infants longitudinally at their 4-, 8-, and 12- month assessments, and caregivers self-reported measures of daily parenting hassles and anxiety at each time point. Most caregivers completed the questionnaires online at home prior to the visit, but in some cases, they were completed in the laboratory or over the phone.

2.1 | Participants

Participants were recruited through local baby registries (40% families) and university-sponsored participant databases (13% families). In addition, we used a variety of community-level recruitment strategies, such as visiting local lactation/parenting classes, communicating with families at local community events, and talking to parents at local hospitals, health care centers, and Women's and Infant Centers. Community recruiting identified 38% of our families. The remaining 10% of families were recruited by word-of-mouth. Prospective families were contacted by letter, email, or phone explaining the motivations and methods of the study. The Institutional Review Boards at the Pennsylvania State University and Rutgers University approved all procedures and parents provided written consent and were compensated for their participation.

Infants and their caregivers were enrolled when the infants were 4 months of age ($N = 298$; 151 males, 147 females; $M_{age} = 4.80$ months; $SD_{age} = .80$, $Range_{age} = 3.27–7.60$ months), with an additional 46 participants enrolled at 8 months ($N = 46$; 19 males, 27 females; $M_{age} = 8.83$ months; $SD_{age} = .73$, $Range_{age} = 7.53–10.20$ months), and 13 participants at 12 months ($N = 13$; 6 males, 7 females; $M_{age} = 12.73$ months; $SD_{age} = 1.12$, $Range_{age} = 10.63–14.90$ months), for a total enrollment of 357 infants in the full sample (176 males, 181 females). Participants were recruited from areas surrounding three sites: State College, PA ($N = 167$), Harrisburg, PA ($N = 81$), and Newark, NJ ($N = 109$).

Caregivers identified 58 of the infants (16%) as African American/Black, nine (3%) as Asian, 78 (22%) as Latinx, 180 (50%) as white, and 27 (8%) as mixed race. Five (1%) additional caregivers declined to provide this information. Across the sample, 49 families (14%) reported a household income of $15,000 or less, 20 (6%) reported $16,000–$20,000, 22 (6%) reported $21,000–$30,000, 16 (5%) reported $31,000-$40,000, 22 (6%) reported $41,000–$50,000, 29 (8%) reported $51,000–$60,000, and 140 (39%) reported an income above $60,000. Fifty-nine (17%) additional caregivers declined to provide this information. For mother's education, 11 (3%) completed grade school only, 17 (5%) had some high school, 36 (10%) graduated from high school, 57 (16%) had some college or trade/technical degree, 73 (20%) were college graduates, 58 (16%) had graduate training, and 66 (19%)

had a graduate degree; 39 (11%) additional caregivers declined to provide this information. For fathers, 11 (3%) completed grade school only, 15 (4%) had some high school, 50 (14%) graduated from high school, 60 (17%) had some college or trade/technical degree, 70 (20%) were college graduates, 42 (12%) had graduate training, and 56 (16%) had a graduate degree; 53 (15%) additional caregivers declined to provide this information.

2.2 | Measures

2.2.1 | Eye-tracking—Eye-tracking data were collected during an infant vigilance task to assess infants' ability to detect emotional facial configurations (Fu et al., 2020; Burris et al., 2019b). The task included 90 trials, with each trial beginning with a randomly presented fixation-dependent attention getting "Baby Sensory" animated video with a black background and classical music dubbed in. Each trial was initiated when the infant's attention was on the video clip presented centrally on the screen, which was triggered either when the infant fixated for at least 100 ms or when the experimenter determined that the infant was looking at the video clip. If the participant did not attend to the center of the screen, the slide advanced after 10,000 ms. Each trial continued with a random presentation of a face stimulus in one of the four corners of the screen. Faces were sampled from the NimStim face set and appeared for up to 4000 ms or until the participant fixated it for 100 ms (Tottenham et al., 2009). Ten actors (five male) provided neutral, happy, or angry, closed mouth images. Facial stimuli were approximately 9.50 cm × 6.50 cm and the visual angle of each face was 9.05° (H) × 6.20° (W). Faces were approximately 16.59° visual angle from center. No face stimuli appeared in the same location consecutively, and the order of face stimuli were randomized across participants. Location of the faces was counterbalanced across the four corners of the screen. There were 4000 ms white screens that were shown after every 7th trail to minimize habituation and predictive looking. Task design and recording were completed by Experiment Center and data were collected on SMI eye trackers, either a RED or REDm system, which offered comparable specifications (SensoMotoric Instruments, Teltow, Germany).

The raw (X, Y) position of fixations was exported from BeGaze (SensoMotoric Instruments). An area of interest (AOI) encircling and including the entire face stimulus was created and exported from BeGaze. A 2 cm "error margin" was added to each ellipse, to account for deviation permitted in the calibration procedure. Data processing was restricted to gaze data within the face AOI. An in-house processing script was written in R (R Development Core Team, 2020) to measure latency to fixate upon the face AOI on each trial.

Metrics were cleaned on a trial-by-trial level. If a fixation was not detected to the face AOI during a trial, that trial was not included in latency calculations. To calculate a threshold for the minimum number of trials infants should have to be included in the analyses, we adapted a method from Goldsworthy (2016) where we calculated the percent difference between the average latency for each individual trial, and the average mean latency for all trials for each participant. Using a threshold of 10%, we determined that infants needed to provide usable data on at least 10 trials of each emotion category to be included in our analyses. This is the point where average mean latencies per trial deviated by more than 10% of the mean latency for all trials. After data cleaning, average latencies were calculated for each emotion (the number of total valid cases can be found in Table 2 for each emotion).

2.2.2 | Parenting hassles—Parenting stress was measured at the 4-, 8-, and 12-month time points using the Parenting Daily Hassles Scale-Revised (PDHS-R). The PDHS-R is a 20-item survey designed to assess both the frequency and intensity of daily hassles experienced by parents (Crnic & Booth, 1991). Each item describes an event that may routinely occur in families with young children (e.g., being nagged, whined at, complained to) and parents note how frequent (rarely, sometimes, a lot, or constantly) and intense the “hassle” from these events have been for them within the past 6 months using a 1–5 scale. Responses are not child specific, and the survey is not designed to capture relational difficulties with any particular child or a certain sized family. The current study used the sum of the intensity scale. Internal consistency for this scale for the total sample was strong across time points: $\alpha_{\text{4-months}} = .89$, $\alpha_{\text{8-months}} = .89$, $\alpha_{\text{12-months}} = .88$).

2.2.3 | Parent anxiety—Parental anxiety was measured at the 4-, 8-, and 12-month time points using the Beck Anxiety Inventory (BAI). The BAI is a 21-item self-report questionnaire for evaluating the severity of anxiety in healthy and psychiatric populations (Beck et al., 1988). The BAI was specifically designed to distinguish cognitive and somatic symptoms of anxiety from symptoms of depression. Parents rated individual symptoms of anxiety (e.g., fear of losing control) in the past month using a 4-point Likert scale (0 = not at all, 1 = mildly, 2 = moderately, 3 = severely). The BAI is scored by adding the ratings for all 21 items, for a score range from 0 to 63. Higher scores indicate greater symptom severity. The BAI has very good psychometric properties among multiple outpatient samples (Morin et al., 1999; Steer et al., 1994; Wetherell & Areán, 1997). Internal consistency of the measure for the total sample was strong across time points ($\alpha_{\text{4-months}} = .91$, $\alpha_{\text{8-months}} = .89$, $\alpha_{\text{12-months}} = .93$) and adequate test–retest reliability has been demonstrated for anxiety patients ($r = .75$ to .83; Beck, Steer & Garbin, 1988; de Beurs et al., 1997). The measure is also moderately correlated with anxiety ($r = .36$ to .69) and depression measures ($r = .25$ to .56) completed by psychiatric (Beck et al., 1988) and normative samples (Osman et al., 1997).

2.3 | Data analysis plan

Models were fit using R 4.0.2. (R Core Team, 2020) and the following packages: emmeans (Lenth, 2020), lme4 (Bates et al., 2015), mice (van Buuren & Groothuis-Oudshoorn, 2011), papaja (Aust & Barth, 2020), and tidyverse (Wickham, 2017).

2.3.1 | Model estimation—Multiple imputation using chained equations was used to handle missing values. Multiple imputation consists of three-phases: an imputation phase, a fitting phase and a pooling phase. First, m versions of the raw data are created in which missing values are imputed by predicting them from a set of auxiliary variables. The statistical model to test the hypothesis of interest is then fitted to each of the imputed data sets in turn (the fitting stage). Finally, these models are combined to yield parameter estimates and standard errors that are pooled across the m models fitted to the imputed datasets (Rubin, 1987).

Using multiple imputation, model parameters will be unbiased when missing values on a variable X are unrelated to X itself. Provided this condition is met, it is acceptable for missing values on a variable X to be related to other variables in the data (so called missing at random, MAR) or not (so called missing completely at random, MCAR). Both MAR and MCAR conditions rely on missing values on a variable X being unrelated to X itself, which makes these conditions untestable, because to test them one would need to know the values of the missing variables (Enders, 2010; Field, 2021; Raykov, 2011). The practical issue is whether MAR (the less restrictive assumption) is a reasonable assumption, and it can be made more reasonable by using an inclusive strategy during imputation (Collins et al., 2001; White et al., 2011). That is, predict missing values on a given variable from a model that includes measured variables that might reasonably predict their missingness (so called auxiliary variables).

In keeping with best practice, imputation was done at the item-level rather than on scale totals (Enders, 2010) and the imputation model included all variables in the final model as well as scale totals for BAI and PDHS-R. Specifically, items on each measure (BAI, PDHS-R, and vigilance task) were predicted from (1) other items on the same measure at the same time point (but not other time points), (2) scale totals of other measures (but not the individual items) at the same time point, (3) test site, household income, and highest parent education level if they predicted items with a correlation greater than 0.2. For PDHS-R, the frequency and intensity subscales were treated as separate measures (i.e., PDHS-R hassles items were predicted from other hassles items at the same time point and the scale total for frequency and vice versa). So that scale totals could be imputed using item-level imputations, passive imputation was used (van Buuren, 2018; van Buuren & Groothuis-Oudshoorn, 2011).

Even with moderate missingness, estimates are unbiased with 5–20 imputations (Enders, 2010; van Buuren, 2018). More than 20 imputations are necessary only with missingness greater than 50% (Enders, 2010). We used 50 imputation samples to err on the side of caution.

Imputations were performed using the mice package (van Buuren & Groothuis-Oudshoorn, 2011) with all values imputed using predictive mean matching (PMM). Using PMM ensures that missing values are always replaced with values observed in the data and so tends to keep the distributional properties of the observed scores (Field, 2021; van Buuren, 2018). Having imputed 50 data sets, the lme4 package (Bates et al., 2015) was used to fit the model to each sample and model estimates were then pooled using mice (van Buuren & Groothuis-Oudshoorn, 2011). BAI and PDHS-R were standardized to z-scores prior to analysis (to make their scales comparable).

Interaction terms were followed up by estimating the rate of change of attentional biases when PDHS-R hassles was at −1.5, 0, and 1.5, which represents low, average, and high levels, and BAI was set at average levels. These analyses were conducted using the emmeans package (Lenth, 2020).

2.3.2 Model selection—A growth model was fitted in which time (j) is nested within participant (i). The effect of anxiety and hassles occur at level 1 (they vary over time). This situation is described by the following model:

$$\begin{aligned} \text{Bias}_{ij} = & [\gamma_{00} + \gamma_{10}\,\text{Time}_{ij} + \gamma_{20}\text{BAI}_{\,ij} + \gamma_{30}\text{PDHS} - \text{R}_{ij} \\ & + \gamma_{40}\text{Time}_{ij} \times \text{BAI}_{ij} + \gamma_{50}\text{Time}_{ij} \times \text{ PDHS} - \text{ R}_{ij} \\ & + \gamma_{60}\text{BAI}_{ij} \times \text{ PDHS} - \text{R}_{ij} + \gamma_{70}\text{Time}_{ij} \times \text{ BAI}_{ij} \times \text{PDHS} - \text{R}_{ij}] \\ & + [\zeta_{0i} + \zeta_{1i}\text{Time}_{ij} + \epsilon_{ij}] \end{aligned}$$

This model includes a random slope and intercept for time, but no other predictors. Most of the 50 models had zero estimates for the variance in the slope for time, so that parameter was removed leaving only a random intercept (which also resulted in many zero estimates for the variance in intercepts across imputation samples).

Therefore, the final model fitted in each imputation sample was:

$$\begin{aligned} \text{Bias}_{ij} = & [\gamma_{00} + \gamma_{10}\text{Time}_{ij} + \gamma_{20}\text{BAI}_{\,ij} + \gamma_{30}\text{ PDHS-R}_{ij} \\ & + \gamma_{40}\text{ Time}_{ij} \times \text{ BAI}_{\,ij} + \gamma_{50}\text{Time}_{ij} \times \text{ PDHS} - \text{ R}_{ij} \\ & + \gamma_{60}\text{ BAI}_{ij} \times \text{ PDHS-R}_{ij} + \gamma_{70}\text{Time}_{ij} \times \text{ BAI}_{\,ij} \times \text{ PDHS} - \text{ R}_{ij}] \\ & + [\zeta_{0i} + \epsilon_{ij}] \end{aligned}$$

2.3.3 | Missing values—Table 1 shows the pattern of missing data for items on the BAI and PDHS-R (hassles). Typically, participants responded to all items or no items at each time point with a small number partially completing the questionnaires. Table 2 shows the number of complete cases on vigilance trials at each time point.

Of the 357 families enrolled, there were 182 IDs that had missing data at every time point on at least one of BAI, PDHS-R, or the vigilance task. In the absence of any information at all about the change over time of variables, the missing information could not be imputed for these cases. The 182 cases that were excluded from the imputation process due to fully missing data consisted of the following number of cases: 20 (missing BAI, PDHS-R, and the vigilance task), 67 (missing both BAI and PDHS-R), 22 (missing both BAI and vigilance tasks), and 36 (missing both PDHS-R and vigilance task). The remaining 175 participants were included in all imputed samples.

2.3.4 | RESULTS—Table 3 shows the summary information for all measures. Tables 4 and 5 show the parameters for the unconditional growth models (without PDHS-R or BAI included) for the latency to respond to threat compared with the neutral stimuli (Table 4) and happy compared with the neutral stimuli (Table 5). In both cases, there is not a significant change over time in the relative attention to emotional stimuli compared with the neutral ones. Table 6 shows the parameter estimates for the model predicting bias for angry faces (relative to neutral). There was a significant main effect of PDHS-R intensity of hassles, suggesting that attention bias to threat, overall, was affected by parental perception of intensity of hassles. More importantly, PDHS-R hassles intensity significantly moderated the rate of change of attentional bias to threat over time.

A simple slopes analysis revealed that at low levels of hassles intensity (1.5 standard deviations below the mean), $\gamma = -9.64\ [-22.64,\ 3.36]$, and average levels,

$\gamma = 4.67\ [-2.94,\ 12.29]$, attentional biases showed little change over time with confidence intervals for the change over time crossing zero. However, at high levels of hassles intensity (1.5 standard deviations above the mean) attentional bias to threat significantly changed over time, $\gamma = 18.99\ [2.08,\ 35.90]$. The parameter estimate indicates that for every month elapsed, the difference between visual latency to angry and visual latency to neutral faces increased by 18.99 ms, or approximately 160 ms over the 8 months elapsed during this study.

So, at 12 months, infants with caregivers who are high on intensity of hassles are predicted to take 160 ms longer to react to angry faces than to neutral faces than they were at 4 months of age. Interestingly, this effect was not further moderated by BAI and BAI did not significantly predict attentional bias to angry faces or change over time. Figure 1 shows this relationship. As can be seen from the figure, infants who have caregivers who are high on intensity of hassles are faster to detect angry faces than other infants at 4 months, but get slower over time.

Table 7 shows the parameter estimates for the model predicting bias for happy faces (relative to neutral). No variables significantly predicted attention bias to happy faces or its rate of change over time. Figure 2 visually depicts the results for happy trials.

3 | GENERAL DISCUSSION

The current study investigated the impact of parenting stress and anxiety on the development of attention biases to threat in a longitudinal sample of infants across the first year of life. Biased attention to threat was measured using a vigilance task in which infants passively viewed emotional facial configurations appearing on a screen, and relative latency to visually fixate each face category (angry, happy, neutral) was the outcome of interest. Parenting stress was measured using the PDHS-R, a self-report measure of daily parenting hassles, while anxiety was measured using the BAI.

Results showed that perceived intensity of daily parenting hassles, a proxy of parenting stress, moderated the development of attention bias to threat in young infants over time. When parenting stress was at low or average levels, infants' attention to threat did not significantly change from 4 to 12 months. However, high levels of parenting stress were related to change in infants' attention bias to threat over time. At 4 months of age, infants exposed to heightened levels of parental stress were faster to detect angry facial configurations compared with the infants exposed to average or low levels of parental stress. Additionally, they became *slower* to detect angry (but not happy) facial configurations compared with the neutral faces over the course of the first year of life. Interestingly, these results were not impacted by parental anxiety levels.

The data suggest that infants of parents who experience high levels of parenting stress are more vigilant to threat as early as 4-months of age and are becoming *less* vigilant to threatening facial configurations as they age during the first year. While exposure to negative affect in the environment was not directly examined in this study, these findings could indicate that prolonged exposure to heightened levels of parenting stress in early infancy could be related to increased exposure to negative affect in the home. Our data suggest that increased exposure to parenting stress is initially related to heightened attentional responses, with infants' attentional systems prioritizing detection of threat early in development, and then a slowing of attentional responsivity to negative affect over time in the first year of life. Consistent with previous literature, an alternative, though not mutually exclusive possibility, is that infants are becoming less responsive to the presence of a threatening face. While additional longitudinal data are needed to speak to this trajectory, a dampened or avoidant response to negative emotions could be viewed as adaptive in a stressful environment (e.g., Pollak & Kistler, 2002).

Altogether, these results are some of the first to demonstrate that parents' perception of a stressful home environment is related to changes in attention biases to threat in infants. Importantly, these patterns are evident *very* early in life, as early as 4 months of age, and are changing in response to the environment within the first year of life. This is consistent with previous research demonstrating significant developmental change in infants' perception of emotional facial configurations around the same time (e.g., Grossmann, 2010). In other words, during this critical time in the first year of life when there are significant changes in infants' understanding of emotional facial expressions, presumed emotional input from the environment is already associated with that learning, beginning as early as 4–12 months. Importantly, this also raises the possibility that further and more significant developmental changes could occur well past the first year. These results have important implications for the direction of future research, as well as the design of potential interventions to mitigate the negative long-term associations between attention biases to threat and the development of anxiety. Most specifically, we find evidence that the environment begins to shape emotion perception by 4 months of age, suggesting that interventions at the earliest time points might be necessary to mitigate any long-term consequences. However, understanding the potential long-term consequences of these divergent trajectories also requires future research.

Despite the multimodal and longitudinal approach of the current study, there are several limitations that warrant discussion. While accounted for statistically, we have patterns of missing data in both the eye tracking data and the questionnaires, which are typical of large longitudinal samples, particularly with infants. Further, we were not able to provide data on how these early biases predict anxiety-related behaviors, as our infants were only 12 months of age at their final testing session. Data collection at later time points is still ongoing, so that such relations can be investigated in future research. Additionally, we did not have a direct measure of parenting stress. However, results on the PDHS-R have been highly correlated with stress in the literature (Crnic & Greenberg, 1990; Crnic et al., 2005). While the PDHS-R is an acceptable measure of parenting stress with children of all ages, using the PDHS-R in a sample of parents with young infants could be considered a limitation given that some items on the measure will not apply if a parent only has one young child (e.g., sibling arguments). Further, we did not examine several factors that could directly or indirectly lead to the reported levels of daily parenting hassles, including number of children in the household, child temperament, parental psychopathology, and factors related to socioeconomic status. These are all important factors to investigate in future research. However, the current study's focus on stress associated with parenting hassles in general is an important starting point for future research aimed at identifying how environmental stress impacts infants' emotional behavior over time.

Although this study presents some of the first evidence of the environmental impact on biased attention to threat very early in life, again, it is only a first step. Indeed, parenting hassles can be a relatively minor stressor compared with other environmental factors that might pose a greater risk to infants' developing attention to emotional information. For example, there is little research to date on the impact of extreme stressors—such as violence exposure—on the development and change of attention biases patterns to threat over time. Previous research has shown that children who have been physically maltreated show altered abilities for discriminating and categorizing threatening facial expressions (Pollak & Kistler, 2002). Further, Gulley et al. (2014) found that the link between family violence and adolescents' anxiety levels was strongest in participants who showed the largest attention bias to threat. However, participants in these previous studies were already at or near adolescence.

Parallel work in younger populations is sparse but has shown evidence of extreme stressors in the environment impacting attention patterns in younger children (Pine et al., 2005; Shackman et al., 2005). Children exposed to violence in the home who had posttraumatic stress disorder showed a greater attention bias to angry faces than those who were exposed to violence but did not have a diagnosis of posttraumatic stress disorder (Swartz et al., 2011). Additional work with young children showed that attention to threat may amplify the impacts of exposure to violence in the family, with greater family violence predicting heightened anxiety and trauma symptoms in young children, and attention bias moderating the link between that anxiety and violence exposure (Briggs-Gowan et al., 2015).

The current findings corroborate these studies, suggesting that the development of negative aspects of the environment are associated with emotion perception significantly earlier than mid to late childhood. More specifically, our results indicate that normative environmental factors related to stress can impact and interact with attentional patterns by 4 months of age. However, there is still very little research in this domain, particularly on the impact of infants' exposure to heightened levels of stress, negative emotionality, violence, and instability in the home on emotion perception and understanding over time (Conger et al., 2010; Fitzpatrick & Bldizar, 1993; Hatch & Dohrenwent, 2007). Thus, future research with very young infants is needed to examine the potential impact that factors related to adverse environments have on the development of attention biases to threat over time. Again, these results point to interventions that focus on caregiver emotionality and behavior very early in infancy—before 12 months of age—when trajectories of attention biases are first developing.

The current research suggests that a stressful home environment is related to changes in attention biases to threat in infants, and that this relation begins to develop at a very young age, between 4 and 12 months. The processing of emotional stimuli is critical for typical social development, and specific profiles of attention to emotional stimuli—such as rapid attention and difficulty disengaging from threat—have been linked to psychosocial outcomes across development. Thus, future work in this domain is vital to discovering how a stressful environment might contribute to divergent patterns of infant attention bias over time.

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DATA AVAILABILITY STATEMENT

The datasets for this study will be shared on Databrary as data are collected, processed, and curated. Inquiries regarding data sharing and the status of the data can be addressed to the corresponding author.

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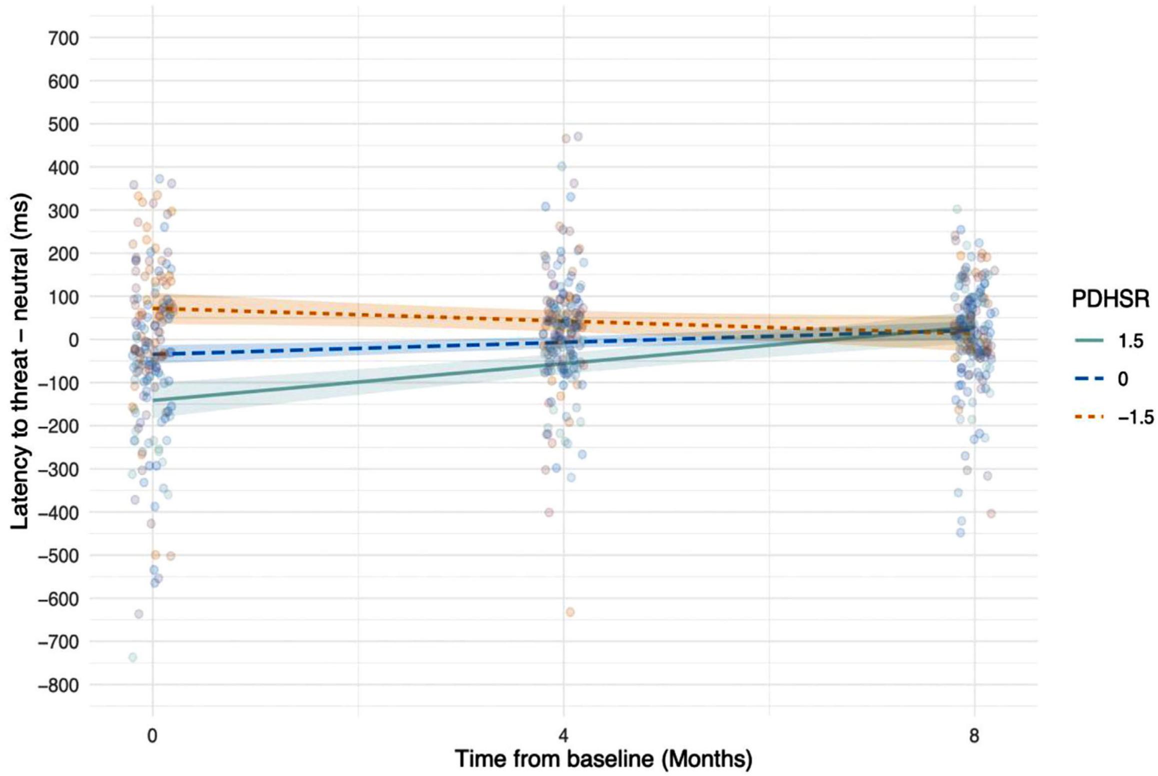

FIGURE 1.

Relation between bias to angry faces and parenting hassles from 4 to 12 months. At 12 months, infants with caregivers who are high on intensity of hassles are predicted to take 160 ms longer to react to angry faces than to neutral faces than they were at 4 months of age

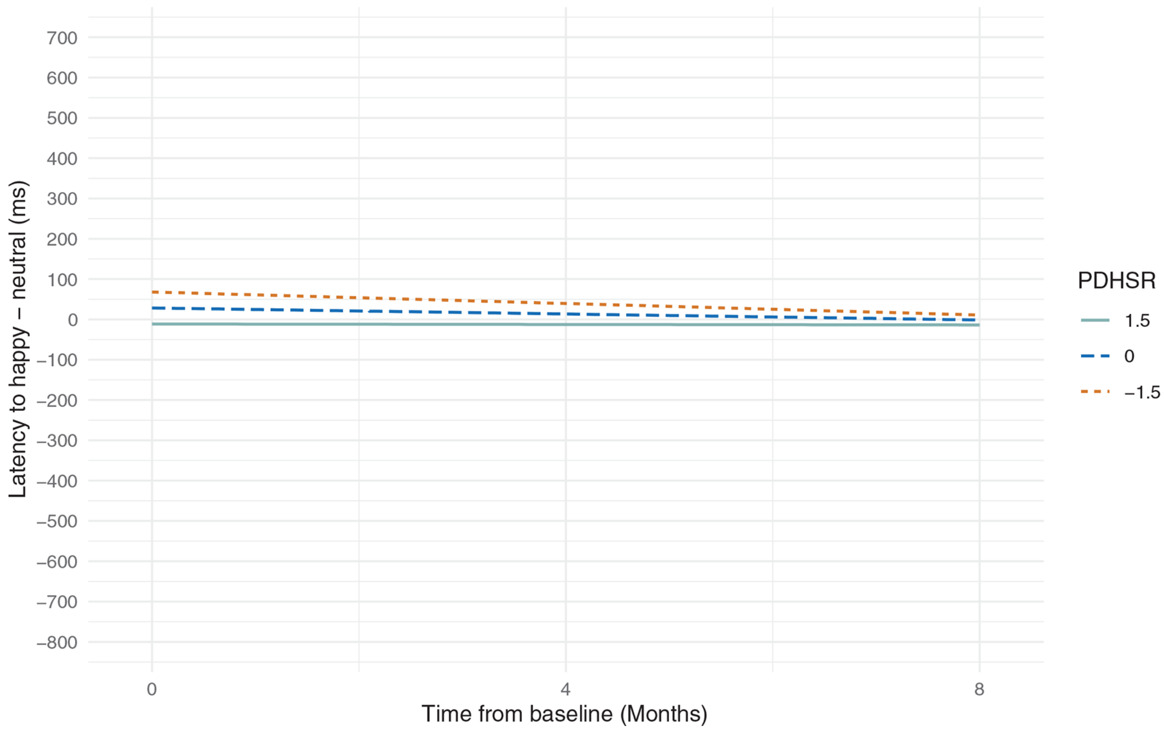

FIGURE 2.

Relation between bias to happy faces and parenting hassles from 4 to 12 months. No variables significantly predicted attention bias to happy faces or its rate of change over time

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TABLE 1

Missing value patterns for individual items

Measure	Time	0%	1–50%	50–100%	100% missing
BAI	4 months	226	16	4	111
BAI	8 months	191	11	1	154
BAI	12 months	151	17	1	188
PDHS-R (hassles)	4 months	182	22	7	146
PDHS-R (hassles)	8 months	145	32	2	178
PDHS-R (hassles)	12 months	123	19	6	209

Note. For PDHS-R the category “0% < missing < 50%” includes participants with exactly 50% missing.

TABLE 2

Valid cases for the vigilance task

Time	Angry	Happy	Neutral
4 months	73	74	72
8 months	141	145	140
12 months	112	112	110

TABLE 3

Summary statistics for continuous time-variant variables

Measure	Time	*n*	Range	*M*	SD	95% CI
BAI	4 months	246	0 – 53	6.71	7.83	[5.73, 7.70]
BAI	8 months	203	0 – 35	5.39	6.31	[4.52, 6.26]
BAI	12 months	169	0 – 42	7.01	8.66	[5.69, 8.32]
Mean latency (angry)	4 months	73	307.25 – 1336.39	651.18	208.43	[602.54, 699.81]
Mean latency (angry)	8 months	141	201.67 – 1086.69	497.45	148.26	[472.77, 522.14]
Mean latency (angry)	12 months	112	294.21 – 946.69	503.67	136.14	[478.18, 529.16]
Mean latency (happy)	4 months	74	242.95 – 1257.17	642.80	197.87	[596.95, 688.64]
Mean latency (happy)	8 months	145	265.91 – 1161.69	514.93	159.26	[488.78, 541.07]
Mean latency (happy)	12 months	112	320.15 – 923.93	476.84	114.75	[455.36, 498.33]
Mean latency (neutral)	4 months	72	331.42 – 1371.14	617.61	205.16	[569.39, 665.82]
Mean latency (neutral)	8 months	140	258.34 – 1158.36	493.38	142.85	[469.51, 517.25]
Mean latency (neutral)	12 months	110	302.51 – 901.53	488.12	124.47	[464.59, 511.64]
PDHS-R (hassles)	4 months	211	1 – 81	35.32	13.04	[33.55, 37.09]
PDHS-R (hassles)	8 months	179	1 – 76	36.33	12.50	[34.49, 38.17]
PDHS-R (hassles)	12 months	148	2 – 77	36.31	12.95	[34.21, 38.41]

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TABLE 4

Parameter estimates for unconditional growth model (angry vs. neutral stimuli)

Effect	***γ***	**SE**	**95% CI**	***t***	**DF**	***p***
Intercept	−17.45	22.12	[−61.76, 26.85]	−0.79	56.01	.433
Time	3.76	3.81	[−3.85, 11.37]	0.99	67.53	.328

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TABLE 5

Parameter estimates for unconditional growth model (happy vs. neutral stimuli)

Effect	γ	**SE**	**95% CI**	***t***	**DF**	***p***
Intercept	25.09	23.90	[−22.94, 73.11]	1.05	49.30	.299
Time	−4.05	3.96	[−11.97, 3.86]	−1.02	63.49	.310

TABLE 6

Parameter estimates for predictors of attentional bias to angry stimuli

Effect	***γ***	**SE**	**95% CI**	***t***	**DF**	***p***
Intercept	−22.78	22.85	[−68.69, 23.13]	−1.00	49.73	.324
Times	4.66	3.88	[−3.08, 12.41]	1.20	61.12	.233
BAI	−8.15	15.82	[−39.56, 23.26]	−0.51	96.84	.608
PDHSR	−69.35	26.39	[−122.70, −16.00]	−2.63	39.58	.012
Time × BAI	0.98	2.64	[−4.23, 6.19]	0.37	148.18	.710
Time × PDHS-R	9.54	4.42	[0.66, 18.41]	2.16	50.06	.036
BAI × PDHS-R	3.07	12.66	[−21.97, 28.12]	0.24	126.99	.808
Time × BAI × PDHS-R	0.44	2.38	[−4.27, 5.15]	0.19	150.93	.853

TABLE 7

Parameter estimates for predictors of attentional bias to happy stimuli

Effect	γ	SE	95% CI	*t*	DF	*p*
Intercept	23.09	25.38	[−28.03, 74.21]	0.91	44.63	.368
Times	−3.51	4.15	[−11.81, 4.79]	−0.85	58.20	.401
BAI	−4.76	18.17	[−40.96, 31.43]	−0.26	74.66	.794
PDHS-R	−24.40	29.61	[−84.47, 35.67]	−0.82	35.53	.415
Time × BAI	0.70	3.20	[−5.65, 7.05]	0.22	89.63	.827
Time × PDHS-R	1.71	4.87	[−8.10, 11.52]	0.35	45.67	.727
BAI × PDHS-R	−3.48	14.88	[−33.06, 26.09]	−0.23	86.74	.815
Time × BAI × PDHS-R	0.01	2.71	[−5.36, 5.37]	0.00	109.44	.999