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Maternal Anxiety Predicts Attentional Bias Towards Threat in Infancy

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Although cognitive theories of psychopathology suggest that attention bias toward threat plays a role in the etiology and maintenance of anxiety, there is relatively little evidence regarding individual differences in the earliest development of attention bias toward threat. The current study examines attention bias toward threat during its potential first emergence by evaluating the relations between attention bias and known risk factors of anxiety (i.e., temperamental negative affect and maternal anxiety). We measured attention bias to emotional faces in infants (N = 98; 57 male) ages 4 to 24 months during an attention disengagement eye-tracking paradigm. We hypothesized that (a) there would be an attentional bias toward threat in the full sample of infants, replicating previous studies; (b) attentional bias toward threat would be positively related to maternal anxiety; and (c) attention bias toward threat would be positively related to temperamental negative affect. Finally, (d) we explored the potential interaction between temperament and maternal anxiety in predicting attention bias toward threat. We found that attention bias to the affective faces did not change with age, and that bias was not related to temperament. However, attention bias to threat, but not attention bias to happy faces, was positively related to maternal anxiety, such that higher maternal anxiety predicted a larger attention bias for all infants. These findings provide support for attention bias as a putative early mechanism by which early markers of risk are associated with socioemotional development.

Keywords: attention bias, temperament, anxiety, development

A wealth of research suggests that attentional bias toward threat—the propensity to selectively attend to threatening environmental cues—may play a role in the etiology and maintenance of anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). Anxiety most often first emerges by midadolescence (Beesdo et al., 2007), suggesting that causal mechanisms should also be evident in childhood. However, there is relatively little evidence regarding the early development of attentional bias (Field & Lester, 2010a). The available data suggest that normative threat-related biases emerge during infancy. For instance, 7-month-old infants attend for longer periods of time toward threat-related stimuli compared to neutral stimuli while a distractor is present (Peltola, Leppänen, Palokangas, & Hietanen, 2008). While factors that place children at risk for anxiety are likely in play early in development, few studies have examined the relation between attentional biases in infancy and individual risk factors for the development of anxiety. Based on the broader literature, infant temperament (Clauss & Blackford, 2012) and maternal anxiety (Merikangas, 2005) are both likely to impact early anxiety processes. The present study examines (a) the pattern of attentional bias toward threat in a cross-sectional sample of young (4 to 24 months) infants, (b) the relation between attention bias toward threat and the infant's temperament, (c) the relation between attentional bias toward threat and maternal anxiety, and (d) the potential interaction between temperament and maternal anxiety in predicting attention bias toward threat.

A growing corpus of studies suggests that individuals with high trait or clinical anxiety show an attention bias to threat (Bar-Haim et al., 2007). This bias is pervasive across anxiety disorders: evident in children and adults, across type of anxiety diagnoses, and among individuals with clinical anxiety as well as high trait anxiety (Bar-Haim et al., 2007), making it an important marker for the disorder. A direct extension of these findings has been the creation of interventions designed to reduce anxiety by manipulating the level of bias (through attention bias modification training). Initial investigations showed great promise, as modulating attention bias subsequently reduced levels of anxiety and sensitivity to stress (Bar-Haim, 2010; Hakamata et al., 2010; MacLeod & Clarke, 2015),

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providing mechanistic evidence that attention bias to threat may play a causal role in the emergence of anxiety (Van Bockstaele et al., 2014). This has led attention bias modification training to be used as treatment for anxiety (e.g., Amir, Beard, Burns, & Bomyea, 2009) or as a complementary treatment together with cognitive–behavioral therapy (e.g., Shechner et al., 2014). However, recent findings indicate that attention bias *away* from threat is also related to anxiety (Brown et al., 2013; Salum et al., 2013; Waters, Bradley, & Mogg, 2014). Importantly, most of this work has been done in adults, even though vulnerability for anxiety has its roots early in development (Pine et al., 1998; Pine & Fox, 2015)—a period that may present a critical target for intervention. Understanding the normative developmental patterns of attention bias is a crucial step in delineating how and why opposing patterns of attention may emerge later in life.

A bias, or systematic preference toward threat-related emotional facial expressions, seems to emerge around 7 months of age. For instance, 7-month-olds spontaneously look longer at fearful facial expressions than at happy expressions (Nelson & Dolgin, 1985). Similarly, 8- to 14-month-olds orient faster toward angry faces over happy faces when presented side-by-side (LoBue & DeLoache, 2010). Beyond measures of visual attention, a bias is also evident in attention-related electrophysiological measures. In particular, infants display heightened brain responses to fearful faces compared to happy and neutral facial expressions (Leppänen, Moulson, Vogel-Farley, & Nelson, 2007; Nelson & De Haan, 1996; Peltola, Leppänen, Maki, & Hietanen, 2009). Finally, attention bias toward threat-related stimuli is not specific to human faces. From infancy through childhood and into adulthood individuals display a bias toward nonsocial threat-related stimuli like snakes and spiders (LoBue, 2010; LoBue & DeLoache, 2008, 2010). For example, 8- to 14-month-old infants were quicker to orient toward snakes compared to frogs (LoBue & DeLoache, 2010). Finally, 4- to 24-month-olds are faster to orient to stimuli that appeared in the same spatial location of previously presented snakes compared to frogs and angry faces versus happy faces (LoBue, Buss, Taber-Thomas, & Pérez-Edgar, 2016). Together, these findings suggest the presence of an attention bias toward social and nonsocial threat cues during infancy.

Given that attention is not a unitary construct (Petersen & Posner, 2012) and attention bias may emerge at different stages of the attentional process (e.g., orienting vs. disengagement; Cisler & Koster, 2010), recent research has examined attentional bias in the infant's ability to disengage from emotionally salient stimuli. These studies often use an affective version (Peltola et al., 2008) of the overlap task (Aslin & Salapatek, 1975; Hood, Willen, & Driver, 1998). In the affective overlap task, infants are presented with a central affective stimulus (e.g., an emotional facial expression). After a short delay (e.g., 1,000 ms), a peripheral target appears (i.e., a distractor), while the central stimulus remains present for the rest of the trial (e.g., 3,000 ms).

Using this paradigm, studies have found that by 7 months, infants are less likely to disengage from a fearful face than a happy or neutral facial expression when presented with a distractor (Leppänen et al., 2010; Peltola et al., 2008; Peltola, Leppänen, Vogel-Farley, Hietanen, & Nelson, 2009). Moreover, studies have found that difficulty disengaging from fearful faces is accompanied by cardiac deceleration, a psychophysiological marker of attention allocation (Leppänen et al., 2010; Peltola, Leppänen, & Hietanen, 2011). Emerging evidence suggests that biased disengagement patterns have implications in later socioemotional development, as heightened attention bias to fearful faces at 7 months predicts attachment security at 14 months, with a smaller bias associated with insecure attachment (Peltola, Forssman, Puura, van IJzendoorn, & Leppänen, 2015). Overall, these studies suggest a normative pattern of information processing that is biased toward threating stimuli from infancy.

Side-by-side, the adult and the infant literature may seem inconsistent. On the one hand, the developmental literature suggests that attention bias to threat is normative and predictive of a secure attachment. In contrast, the clinical literature considers attention bias to threat to be a mechanism for anxiety. This seeming inconsistency may arise from the fact that we know little regarding individual differences in these early biases and their potential role in the development of anxiety. It is likely that individual vulnerabilities to anxiety emerge from underlying, normative patterns of attention to threat (Field & Lester, 2010a; Morales, Fu, & Pérez-Edgar, 2016). In addition, much of the clinical and developmental literature with older children has used angry faces to represent threat (Roy, Dennis, & Warner, 2015). The normative infant literature, in contrast, has used fearful faces to represent threat (Peltola, Hietanen, Forssman, & Leppänen, 2013; Peltola et al., 2008; Peltola, Leppänen, Maki, et al., 2009). Although both angry and fearful faces are threat-related stimuli, angry facial expressions are believed to signal a threat from the individual making the expression to the receiver. In contrast, fearful facial expressions are believed to indicate to the receiver that the expresser perceives an external threat in the environment (Adams & Kleck, 2003). Because our core interest is in linking variations in early attention bias to the larger anxiety-risk literature, we use angry faces in the current study. Thus, the present study evaluates the relation between early attention biases and known risk factors for the development of anxiety, specifically children's temperament and maternal anxiety.

Fearful temperament is one of the best early predictors of anxiety (Degnan & Fox, 2007; Pérez-Edgar & Fox, 2005). Within the literature, fearful temperament is often approached as an overarching construct encompassing specific conceptualizations such as behavioral inhibition (Kagan & Fox, 2006), negative affectivity (Rothbart & Bates, 2006), shyness (Rapee & Coplan, 2010), dysregulated fear (Buss, 2011), and neuroticism (Eysenck, 1967), to name a few. These varying characterizations of fearful temperament share several key components (e.g., high withdrawal, inhibition to novelty, sensitivity to negative stimuli, and limbic/amygdala over activity; Nigg, 2006). Children who display these patterns of behaviors or responses are likely to be characterized as having a fearful temperament, and are at a four- to sevenfold increased risk for anxiety disorders, particularly social anxiety disorder (Buss et al., 2013; Chronis-Tuscano et al., 2009; Clauss & Blackford, 2012).

In infancy, many of the hallmark measures of fearful temperament (e.g., withdrawal, avoidance) are not developmentally appropriate. However, previous studies have noted that children characterized as temperamentally fearful also display high levels of negative affect and increased physiological reactivity in novel situations (Fox, Henderson, Marshall, Nichols, & Ghera, 2005).

Negative affect in infancy is associated with later fearful temperament (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001). Given the age range of the current sample (4 to 24 months), we use a well-validated measure of negative affect as our developmentally sensitive marker of fearful temperament. Thus, our current data will speak to the impact of negative affect.

Pérez-Edgar and colleagues (2010) found that children characterized as temperamentally fearful as toddlers displayed a bias toward threat as adolescents. Moreover, several studies have found that early fearful temperament when coupled with attention bias toward threat predicts later social withdrawal and anxiety (Cole, Zapp, Fettig, & Pérez-Edgar, 2016; Morales, Pérez-Edgar, & Buss, 2015; Pérez-Edgar et al., 2010, 2011; White et al., 2017). However, few studies have evaluated the relation between attention bias and temperament during the developmental period when these constructs first emerge. One exception is a recent study in which at 12 months of age, infants higher in negative affect displayed greater attention bias to threat—as measured by difficulty disengaging from fearful faces (Nakagawa & Sukigara, 2012). These data suggest that attention bias to threat may be associated with fearful temperament from early infancy.

Another strong predictor of the emergence of anxiety in children is maternal anxiety. Familial aggregation studies find that there is a three- to fivefold increased risk of anxiety disorders among children of anxious mothers (Merikangas, 2005). For example, children of mothers with an anxiety disorder had an heightened risk (hazard ratio = 1.3) of developing any anxiety disorder, relative to children of mothers without an anxiety disorder before adulthood (Schreier, Wittchen, Höfler, & Lieb, 2008). Moreover, children of anxious mothers display an attention bias toward threatening stimuli, compared to children of nonanxious mothers—although this effect may be specific to daughters (Mogg, Wilson, Hayward, Cunning, & Bradley, 2012; Montagner et al., 2015). In the only study examining the impact of maternal characteristics on attention bias during infancy, infants whose mothers reported high levels of stress and depression displayed a heightened attention bias toward fearful faces (Forssman et al., 2014).

Although temperament and maternal anxiety are established as independent risk factors of anxiety, it is likely they are in fact interrelated. For instance, children are more likely to be characterized as temperamentally fearful when their parents have an anxiety disorder (Rosenbaum et al., 2000; Shamir-Essakow, Ungerer, & Rapee, 2005). In addition, highly fearful children may be especially sensitive to anxiety-related behaviors of anxious mothers (e.g., mothers' expressed anxiety; Aktar, Majdandžić, de Vente, & Bögels, 2013), consistent with variations in differential susceptibility to the environment (Belsky & Pluess, 2009). This implies that there are shared underlying psychosocial (e.g., parenting; Whaley, Pinto, & Sigman, 1999) and biological (e.g., genetics; Robinson, Kagan, Reznick, & Corley, 1992) mechanisms. It is possible that both factors not only contribute to the development of attention bias toward threat, but also interact to predict attention bias.

The present study evaluates the relation between infant attention bias toward threat and known risk factors for the development of anxiety. Particularly, we examine infants' attention bias to threat and its relation to negative affect (as marker of fearful temperament) and maternal anxiety. Based on the reviewed literature we hypothesize that (a) there will be an attentional bias toward threat across the sample in infancy, replicating previous studies (e.g., Peltola et al., 2008); (b) the magnitude of attention bias toward threat will be positively related to negative affect; and (c) attentional bias toward threat will be positively related to maternal anxiety. Finally, (d) we explore if temperament and maternal anxiety interact to predict attention bias toward threat. We hypothesize that infants high in temperamental negative affect who also have mothers high in anxiety would display the highest levels of attention bias to threat.

Method

Participants

Participants in the current study (N = 98; 57 male; M_{age} = 13.30 months; SD_{age} = 5.64; $Range_{age}$ = 4–24 months) were part of a larger multitask study examining the relation between attention and temperament. Participants were identified either through a university sponsored database or recruited through community advertisement.

The initial sample of participants (N = 238) was predominantly Caucasian (87.8%), which reflects the surrounding rural community. The remaining 11.3% of families self-identified as Asian American, African American, Native American, or Hispanic. Infants were born within three weeks of their due date, experienced no major complications, and had adequate birth weight (M_{weight} = 7.67 pounds, SD_{weight} = 1.18). Infants met developmental milestones (rolling over, crawling, walking) within normal time windows. None of the study variables (other than age) were associated with the timing and attainment of motor milestones ($ps > .10$).

Of the initial 238 kids, 145 attempted the current task. We did not attempt the task if the infant was distressed or fussy. If the infant was unable to calibrate at the start of the task or stopped attending during the task, he or she was designated as not having completed the task (N = 24). We then assessed the quality of the collected data after the visit. We first examined calibration data using the X–Y coordinates of the infant's eye gaze relative to the location of the five calibration points. If the deviation of the coordinates was greater than four degrees from the calibration points, the child was excluded from further processing (N = 13). This is in line with reviews suggesting that initial calibration is crucial to providing robust and reliable data (e.g., Morgante, Zolfaghari, & Johnson, 2012). Infants were also excluded from the analysis if mothers did not provide data regarding their anxiety (N = 10). As such, eye tracking and questionnaire data were available from 98 infants. The only significant difference between infants who provided usable data and those who did not was age, in that older babies provided more usable data, $t(125) = -2.08$, $p = .04$, $d = 0.37$.

The Institutional Review Board of The Pennsylvania State University approved all procedures. Families provided written consent and were compensated for their participation.

Measures

Infant temperament. Due to the wide age range in the current study, we captured temperamental negative affect using one of two developmentally appropriate questionnaires.

Infant Behavior Questionnaire Revised (IBQ-R). Mothers of 4- to 12-month-old infants (N = 43, 27 males, M_{age} = 8.39 months, SD_{age} = 2.79) rated their infants' temperament on the IBQ-R short form (Putnam, Helbig, Gartstein, Rothbart, & Leerkes, 2014). The IBQ-R Short form is a 91-item scale, in which parents rate the frequency of specific infant behaviors as they occurred in the previous week using a seven-point scale with an eighth option for "does not apply." For this study, we used the Negative Affect factor, composed of the sadness, distress to limitations, fear, and reactivity/recovery subscales (M = 3.62, SD = 0.47, Cronbach's α = .795).

Toddler Behavior Assessment Questionnaire (TBAQ). For infants between 12 and 24 months (N = 55, 30 males, M_{age} = 17.21 months, SD_{age} = 4.06), mothers completed the TBAQ (Goldsmith, 1996). The TBAQ is a 120-item questionnaire, in which parents rate the frequency of specific toddler behaviors as they occurred in the past month using a seven-point Likert scale with an eighth option for "does not apply." The present study uses the Negative Affect factor, which is composed of the sadness, anger, social fear, and object fear subscales (M = 3.21, SD = 0.57, Cronbach's α = .813).

Questionnaire Composite of Temperament. There were no differences in sex, birth weight, or other demographics ($ps > 0.34$) between the young infants characterized by the IBQ and the older infants characterized by the TBAQ. We standardized negative affect scores within each group of infants characterized by either the IBQ or the TBAQ. We then merged each infant's score into a single negative affect variable used to capture variation in negative affect (M = −0.03, SD = 1.05 for overall sample).

Maternal anxiety. Mothers completed the Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988), a 21-item self-report scale that measures anxiety symptoms during the past month. Each item is rated on a 4-point scale from 0 (*not at all*) to 3 (*severely*). In the current sample, this measure had adequate reliability (Cronbach's α = .879). Given the skewness and kurtosis of our data (M = 4.46, SD = 5.62, median = 3.00, skew = 2.17, kurtosis = 5.94), we transformed Beck Anxiety Inventory scores by taking the log plus 1, log(x + 1). The transformed variable had a more adequate distribution (M = 1.26, SD = 0.95, median = 1.39, skew = 0.15, kurtosis = −0.98) and was used for the analyses, tables, and figures.

Attention bias. The overlap task consisted of 12 experimental trials. Trials were triggered by infant fixation rather than predetermined presentation timing (Oakes, 2012). Each trial began with a central fixation (a clip from a children's movie), which was presented until the infant fixated for at least 100 ms. The fixation stimulus was then followed by one of three types of faces taken from the NimStim face stimulus set (Tottenham et al., 2009): angry, happy, or neutral. As in Peltola et al. (2015), faces appeared on the screen for 1,000 ms followed by the distractor, which appeared together with the face for 3,000 ms. The distractor consisted of a static black-and-white checkerboard patterned rectangle that appeared vertically oriented on the edge of either the left or right side of the screen (counterbalanced). Twelve faces were used (half male). The face pictures were each 11.8 cm × 8.5 cm, the distractor was 12.0 cm × 2.0 cm with a distance of 22.5 cm between their centers. Task presentation was controlled by Experiment Center (SensoMotoric Instruments, Teltow, Germany).

Eye-Tracking. The eye-tracking data were obtained using a RED-m Eye Tracking System (SensoMotoric Instruments, Teltow, Germany) and an integrated 22-in. presentation monitor. Infants were seated approximately 60 cm from the monitor on either an adjustable highchair, or their mother's lap, such that their eye gaze was centered on the screen. Infants' eye gaze was calibrated using a 5-point calibration procedure using an animated multicolored circle. Gaze information was sampled at 60 Hz and collected by Experiment Center.

Areas of interest (AOIs) that delineated the top, bottom, and contour of the face and probe locations were created using BeGaze (SensoMotoric Instruments). Subsequent analyses were based on gaze data within the specified AOIs. Fixations, defined as gaze maintained for at least 80 ms within a 100-pixel maximum dispersion, were extracted with BeGaze. Dwell times within the face AOIs were extracted with BeGaze, supplemented with custom-made Python (Python Software Foundation, http://www.python.org/) and MATLAB (The MathWorks, Inc., Natick, MA) scripts. Dwell times were calculated as the total amount of time fixated on a face while the distractor was present for each trial. Although this measure is different than in previous studies using this task (e.g., Peltola et al., 2015), we believe this measure captures attention bias with our version of the task. As a continuous measure, dwell time allows us to create attention bias scores akin to the ones used in the broader attention bias literature (i.e., difference score). Moreover, previous studies utilizing the affective overlap task have used dwell time as their measure of attention (Heck, Hock, White, Jubran, & Bhatt, 2016). Data were subsequently analyzed using R (R Development Core Team, 2008).

Statistical Analyses

A repeated-measures analysis of variance under a mixed-effects modeling framework was used to evaluate the presence of an overlap effect by testing for differences in infants' average dwell time to each emotion face (angry, happy, and neutral) while the distractor was present. To evaluate the effects of age, maternal anxiety, and fearful temperament on the attention bias scores toward happy and angry faces, a mixed effects model equivalent to a repeated-measures analysis of covariance was run for each predictor. We used mixed-effects models as they allow us to examine the effects of the predictors as continuous variables and use all available data (as opposed to a generalized linear model, which uses listwise deletion). Given that mixed effects models do not produce standard effect sizes as variance parameters are estimated directly using maximum likelihood, we provided estimated effect sizes based on generalized linear models.

Given that our hypotheses are specific to attention bias toward threat, the effects of interest were the two-way interactions between the emotion of the attention bias scores (angry or happy) and each of the continuous predictor variables of interests (i.e., age, maternal anxiety, and negative affect). These interactions evaluated if the relation between attention bias scores and the continuous predictor variables differed across affect condition (angry or happy faces). Finally, to explore if negative affect and maternal anxiety interacted to predict attention bias toward threat, we evaluated one model with both temperament and maternal anxiety as continuous predictor variables. In this model, the effect of interest

was the three-way interaction: Emotion Condition × Negative Affect × Maternal Anxiety.

In completing our analyses, we also assessed the quality of the infant data. For dwell time we noted that the data were normally distributed (skew <|1|, kurtosis <|1|) and inspected for outliers. For the analyses presented below, almost half of the infants provided good data (i.e., at least one 80-ms fixation) for all 12 trials (43.88%), and most infants (77.55%) provided good data on at least 10 trials. To verify that the findings were not driven by the number of trials, we reran all analyses while controlling for number of trials. The results did not change. Moreover, we again reran all analyses removing participants with trials under 1.5 *SD*s (328.12 ms) in average dwell times and found the same results. Finally, in a more conservative analysis, we only analyzed the data for participants who had at least three valid trials per condition and again the pattern of results remained the same.

Results

Although 98 infants provided data for the analyses, not all infants provided data in every condition. On average, infants provided data on approximately 3.5 trials per condition ($M_{neutral}$ = 3.45, SD = 0.86, median = 4 trials; M_{happy} = 3.51, SD = 0.86, median = 4 trials; M_{angry} = 3.41, SD = 0.96, median = 4 trials). One child did not provide any valid fixations toward angry and happy faces and another child did not provide any valid fixations to happy faces. As illustrated in Figure 1, infant's dwell time to the central face after distractor presentation differed according to face emotion, $F(2, 191) = 3.21$, $p = .04$, $\eta_p^2 = .030$, suggesting a general effect of increased attention to emotion regardless of age ($M_{neutral}$ = 1255.58, SD = 646.90; M_{happy} = 1365.84, SD = 687.09; M_{angry} = 1394.06, SD = 673.27). As predicted, infants dwelled more to the angry face compared to the neutral face, $t(96) = -2.28$, $p = .03$, $d = -0.23$. Importantly, there was no main effect or interaction with sex ($ps > .36$). As such, sex was not analyzed further for parsimony.

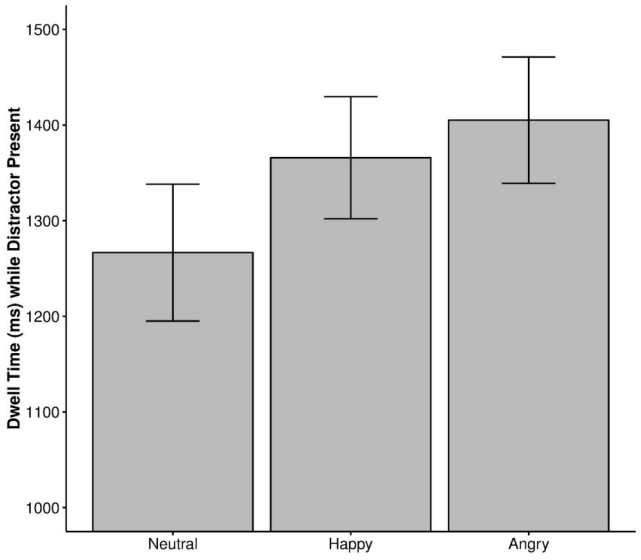

Figure 1. Dwell time to the face while the distractor was present for each emotion. Error bars indicate within-subject 95% confidence intervals (Loftus & Masson, 1994).

Next, we created bias scores by separately calculating the difference of dwell time to each of the emotion faces (angry and happy) versus neutral faces, yielding two bias scores (angry bias and happy bias); higher scores indicate increased bias to the emotion face. Four children were removed as outliers (>2.5 *SD*), one for bias to happy, one for bias to angry, and two for both. We then evaluated if these attention bias scores varied with age, negative affect, or maternal anxiety. The model evaluating the effects of age revealed no significant main effect, $F(1, 92) < 0.01$, $p = .99$, $\eta_p^2 = .000$, or interaction, $F(1, 89) = 0.11$, $p = .74$, $\eta_p^2 = .003$. Similarly, the main effect of, and interaction with, negative affect were not significant, $F(1, 93) = 0.04$, $p = .84$, $\eta_p^2 = .002$, and $F(1, 90) < 0.01$, $p = .96$, $\eta_p^2 = .000$, respectively.

However, the model with maternal anxiety showed a significant interaction, $F(1, 90) = 4.56$, $p = .04$, $\eta_p^2 = .042$, indicating that the effect of maternal anxiety significantly differed for happy and angry attention bias scores. Specifically, as illustrated in Figure 2 and Table 1, maternal anxiety positively correlated with attention bias toward angry faces, $r(92) = .22$, $p = .03$, but not with attention bias toward happy faces, $r(91) = -.02$, $p = .88$. The two correlations significantly differed from each other, $Z = 2.26$, $p = .02$.

Finally, we examined whether negative affect and maternal anxiety interacted to predict attention bias. This final model revealed no interaction, $F(1, 88) = 1.47$, $p = .23$, $\eta_p^2 = .013$. However, the interaction of maternal anxiety with emotion remained significant, $F(1, 88) = 4.94$, $p = .03$, $\eta_p^2 = .051$, while controlling for the effects of temperament.

Conclusion

The present study aimed to expand our knowledge of the development of attention biases by examining if (a) a sample of young (4 to 24 months) infants displayed a bias toward threat, (b) attention bias toward threat was related to the child's temperament, (c) attentional bias toward threat was related to maternal anxiety, and (d) the interaction between temperament and maternal anxiety predicted attention bias toward threat. Results suggest that the presence of an attention bias toward threat did not depend on the child's age, gender, or negative affect. However, attention bias toward threat was positively related to maternal anxiety.

We found evidence for an attention bias toward threat during infancy, as indexed by increased attention to the threat-related stimuli compared to neutral stimuli. This is in line with previous research demonstrating that infants display an attention bias toward threat-related stimuli using behavioral (LoBue & DeLoache, 2010; Nelson & Dolgin, 1985; Peltola et al., 2008) and psychophysiological (Leppänen et al., 2010, 2007; Nelson & De Haan, 1996; Peltola et al., 2011; Peltola, Leppänen, Maki, et al., 2009) measures. Previous studies examining the development of this bias have found that it emerges between 5 and 7 months (Peltola et al., 2008, 2015; Peltola, Leppänen, Maki, et al., 2009). However, we did not find age-related changes, probably due to the wider age range (4–24 months) than previous studies and our use of age as a continuous measure rather than a categorical comparison factor. The current study is best suited to find a significant effect of age that takes the form of attention bias increasing (or decreasing)

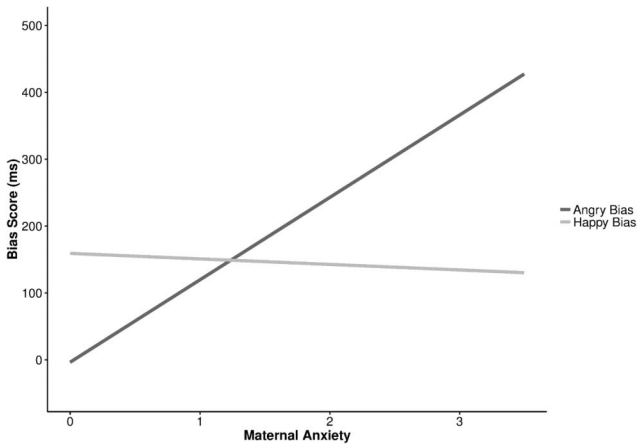

Figure 2. Relation between maternal anxiety and attention bias for each emotion.

linearly with age. This pattern is different than previous studies that show age differences, in which age-related changes are evaluated by using two groups (e.g., 5-month-olds vs. 7-month-olds; Peltola et al., 2013; Peltola, Leppänen, Maki, et al., 2009). The current study is not able do a comparable analysis because it focused on recruiting a range of ages (e.g., there are only 6 children aged 5 months or younger). Future studies with a larger sample size should help disentangle the differential findings. It may be that attention bias emerges around 7 months in this disengagement task, but once present this attention bias remains relatively stable and does not continue to increase with age.

The present study extended the current literature by examining the relation between attention bias and known risk factors of anxiety, namely fearful temperament and maternal anxiety. Due to the sample age, we employed negative affect as our marker of fearful temperament. Our data did not show a relation between attention bias and negative affect. This is in line with previous studies that fail to find a direct zero-order relation between fearful temperament and attention bias in infants (Forssman et al., 2014) as well as in older children (Cole et al., 2016; Pérez-Edgar et al., 2011; White et al., 2017). However, most of these studies find that attention bias to threat moderates the relation between fearful temperament and anxiety, such that only fearful children with an attention bias toward threat display high levels of social withdrawal and anxiety (Cole et al., 2016; Pérez-Edgar et al., 2010, 2011; White et al., 2017). The current study does not examine this interaction, as it would be developmentally inappropriate to evaluate anxiety in infants. Future longitudinal studies should evaluate this relation.

However, we did find that maternal anxiety was positively related to attention bias toward threat. Importantly, this relation was specific to attention bias toward threat and absent for attention bias toward reward (i.e., happy faces), even though the two bias scores were positively correlated ($r = .49$). This specificity is in agreement with previous studies that find a relation between maternal anxiety and attention bias toward threat in older children (Mogg et al., 2012; Montagner et al., 2015). Similarly, infants of mothers who reported high levels of stress and depression display an attention bias to threat (Forssman et al., 2014).

The cause of the link between attention bias and maternal anxiety should be examined in future studies. It is possible that both genetic and environmental factors, as well as their interplay, create the relation between attention bias and maternal anxiety. For example, genetic factors, such as variations in the 5-HTTLPR allele, are related to anxiety and attention bias (Pergamin-Hight, Bakermans-Kranenburg, van IJzendoorn, & Bar-Haim, 2012). Similarly, genetically informed studies (e.g., twin studies) find that attention bias toward physical and emotional symptoms of anxiety (e.g., a "racing-heart") have important genetic contributions (30–40% heritability; Eley & Zavos, 2010; but see Brown et al., 2013). This leaves environmental factors to explain a significant proportion of the variance.

There is evidence that learning through environmental transmission can lead to the development of anxiety and attention bias (Field & Lester, 2010b). For example, in the face of novel stimuli, parents provide cues and feedback that teach infants how to respond emotionally and behaviorally toward these stimuli. If

Table 1
Means, Standard Deviations, and Correlations With Confidence Intervals

Variable	*M*	*SD*	1	2	3	4	5
1. Sex	—	—					
2. Angry attention bias	155.23	523.18	.20 [−.01, .38]				
3. Happy attention bias	148.78	522.48	.08 [−.13, .28]	.49** [.32, .63]			
4. Maternal anxiety[a]	1.26	.95	.00 [−.20, .20]	.22* [.02, .40]	−.01 [−.22, .19]		
5. Age	13.30	5.64	−.05 [−.24, .15]	.00 [−.20, .21]	−.01 [−.22, .19]	−.04 [−.24, .16]	
6. Negative affect	−.05	1.06	.12 [−.08, .31]	.04 [−.17, .24]	.01 [−.19, .21]	.33** [.14, .49]	.17 [−.03, .36]

Note. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). Boys were coded as 0 and girls as 1.
[a] Transformed maternal anxiety.
* $p < .05$. ** $p < .01$.

parents provide fear-related information to older children (e.g., talking about or implying something is dangerous), it may lead to increased anxiety and attention bias (Field, 2006a, 2006b; Field & Lawson, 2003).

Finally, genetic and environmental factors do not operate independently. It is also possible that there are innate characteristics that predispose children to evoke specific environmental responses that in turn generate fear and anxiety. This may be at play here given the young age of our current sample. For instance, Brooker et al. (2015) found that infant's negative affect at 9 months predicted more anxiety symptoms in adoptive parents (mothers and fathers) 18 months later. This finding suggests that infants' constitutional characteristics contribute to the development of parents' characteristics that are believed to then impact children's socioemotional development (Brooker et al., 2015). Moreover, inborn characteristics may also make children more sensitive to fear information (Aktar et al., 2013). Future research should examine mother-child interactions during the first months of life within a genetically informed design to unveil the developmental process that leads to heightened bias toward threat.

In the current study, we examined if children high in negative affect are more susceptible to anxiety levels in their mothers (e.g., Aktar et al., 2013). However, the data did not support this proposition as the interaction between maternal anxiety and negative affect was not significant. The null finding should be interpreted with caution, as this was an exploratory analysis with a relatively small sample size. It is important to note that although maternal anxiety and negative affect were related (r = .33), the effect of maternal anxiety and attention bias toward threat remained significant even while controlling for negative affect. This suggests that maternal anxiety may impact children's processing of threat-related information from very early in development over and above any effects of temperament.

Interestingly, previous studies using the affective overlap task have found increased difficulty disengaging from fearful faces, compared to neutral and happy faces (e.g., Peltola et al., 2008, 2015). In the present study, we use angry faces as the threat-related stimulus, and find increased attention to the threat faces compared to neutral faces. However, we find no difference in attention bias between angry and happy faces. Few studies have examined attention bias toward angry faces, and to our knowledge, no study has examined angry and fearful faces in the same study. Thus, it is unknown if different threat-related emotional biases develop in a similar manner and/or play distinct roles in the development of children. For example, Peltola and colleagues (2015) found that attention bias toward fearful faces predicted a secure attachment relationship while the present study finds that attention bias toward angry faces is related to maternal anxiety.

As a cross-sectional study, the current study is not able to examine the developmental significance of risk factors for anxiety and attention bias toward threat across time. Prospective longitudinal studies should examine the developmental relations between risk factors for anxiety and attention bias toward threat, as well as the long-term implications of this early attention bias in the emergence of anxiety. Finally, the effect sizes of the current findings are modest, suggesting that larger samples will be needed to capture the multiple mechanisms that contribute to socioemotional profiles.

In conclusion, the present study aimed to inform our understanding of the development of attention bias toward threat. Results support a growing literature suggesting that attention bias toward threat is present in early development. Even though attention bias toward threat did not change with age, it was positively related to maternal anxiety, a known risk factor for the development of anxiety. Together, the current findings imply that attention bias toward threat during infancy, when combined with a focus on individual differences, shows promise as an early marker of socioemotional development.

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