Biased Attention to Threat: Answering Old Questions With Young Infants

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Abstract

For decades, researchers have been interested in humans' ability to quickly detect threat-relevant stimuli. Here, we review recent findings from infant research on biased attention to threat and discuss how these data speak to classic assumptions about whether attention biases for threat are normative, whether they change with development, and what factors might contribute to this developmental change. We conclude that although there is some stability in attention biases in infancy, various factors—including temperamental negative affect and maternal anxiety—also contribute to shaping the development of biased attention.

For decades, researchers from cognitive, social, and clinical backgrounds have been interested in humans' ability to quickly detect threat-relevant stimuli. As a result, two separate literatures have emerged on the topic. One literature suggests that because of its adaptive nature, biased attention to threat—which we define as prolonged or rapid attention to a perceived threat—should be normative, early emerging, and stable within individuals across development (Öhman & Mineka, 2001). Indeed, adults detect threat-relevant animals (e.g. snakes, spiders) and threat-relevant human faces (e.g. fearful, angry) more quickly than benign control stimuli (Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001). Furthermore, developmental work demonstrates that children as young as 3 to 5 years detect snakes and spiders more quickly than a variety of non-threat-relevant animals and detect angry and fearful faces more quickly than happy, sad, and neutral faces (see LoBue & Rakison, 2013, for a review).

However, despite a large literature showing stability in attention biases for threat over the life span, a second and equally large literature links variations in attention biases for threat to fearful temperament, anxiety symptoms, and anxiety disorders. For example, adults with snake and spider phobias detect the objects of their fears faster than do nonphobic individuals (Öhman, Flykt, & Esteves, 2001). Similarly, anxious individuals

detect threat-relevant faces more quickly than do non-anxious control participants (see Van Bockstaele et al., 2014, for a review). Furthermore, findings from several studies suggest a potential causal link between attention biases for threat and anxiety by demonstrating that systematically training individuals' attention away from threat decreases self-reported anxiety levels (see Heeren, Mogoaşe, Philippot, & McNally, 2015, for a review; but see Cristea, Mogoaşe, David, & Cuijpers, 2015, for contradictory evidence). In fact, the link between attention bias and anxious behavior has been established in children as young as 2 to 5 years (LoBue & Pérez-Edgar, 2014; Pérez-Edgar et al., 2011). Together, this second literature suggests that attention biases for threat might be linked to individual differences and experiences related to fear or anxiety, hinting at the potential for change across the life span.

To disentangle these seemingly divergent lines of research, Field and Lester (2010) posed a critical question: Is there room for development in attention biases for threat? They proposed several models of how attention biases for threat-relevant stimuli might develop

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over the first few years of life and how these biases may be linked to anxiety. The *integral-bias model*, like the traditional normative model described above, posits that development plays no role in attentional biases for threat; individuals who initially have an attention bias maintain that bias over time. The *moderation model* predicts that development moderates the expression of existing attention biases, suggesting that attention biases for threat are normative early in life, wane across development for most people, and persist only in a select group who go on to develop anxiety in adulthood. Finally, the *acquisition model* predicts that attentional biases are caused by specific events during development and are the result of direct experiences.

These models pointedly frame several critical questions for research: Are attention biases for threat present early in life? Do they diminish in some people over time but persist or become exacerbated in others, who then develop greater risk for anxiety? In addition, do these patterns develop primarily on the basis of individual differences or specific life experiences?

Until recently, there were very little data to speak to these questions, given that methodological limitations (e.g., tasks requiring button-press responses) prevented researchers from studying attention biases in children under the age of 3. However, recent advances in eye-tracking technology have allowed researchers to modify traditional attention-bias paradigms, such as the adult visual search and dot-probe tasks, into passive-viewing paradigms that are appropriate for infants (for a review, see Burris, Buss, LoBue, Pérez-Edgar, & Field, 2019). Here, we review recent findings from the infancy literature on attention biases for various threats and reflect on how we might use these data to test classic questions about whether attention biases for threat are normative, whether and for whom biases change over the course of development, and if so, what factors might contribute to this developmental change.

Is There Room for Development in Attention Biases for Threat?

Using new passive-viewing eye-tracking methodologies for capturing attention biases in infants (see Table 1 and Fig. 1), several studies have demonstrated that attention biases for threat begin to develop between 5 and 7 months of age and are relatively stable over the first 2 years of life. For example, 5-month-old infants do not differentially allocate attention to fearful versus happy faces, as determined by both looking and event-related-potential measures (e.g., Peltola, Leppänen, Mäki, & Hietanen, 2009). However, by 7 months of age, infants look longer at fearful faces (Peltola et al., 2009)

and show greater difficulty disengaging from fearful faces than from other facial expressions (Peltola, Hietanen, Forssman, & Leppänen, 2013). In addition, Burris, Barry-Anwar, and Rivera (2017) recently showed that infants and young children ranging from 9 to 48 months of age show group-level attention biases toward emotion in general, indicating cross-sectional stability of these biases from infancy to early childhood.

However, there is little correlation between within-subjects biased-attention patterns in earlier and later infancy, suggesting that change might be taking place on an individual level (e.g., Burris & Rivera, 2019; Peltola, Yrttiaho, & Leppänen, 2018). For example, Peltola at el. reported that biased attention to fearful faces in 7-month-olds declines over time, and there is no correlation between attention biases at 7 months and at 24 months. Burris and Rivera (2019) also tested infants longitudinally across a 2-year period and found that although group-level biases existed between 9 and 48 months and again 2 years later, they were not correlated. These recent longitudinal studies suggest that attention biases for threat are present early in development but can change at the individual level some time during the first 2 years of life.

Other recent work suggests that patterns of age-related changes vary across different types of threats. In a cross-sectional study of 4- to 24-month-old infants, LoBue, Buss, Taber-Thomas, and Pérez-Edgar (2017) reported that an attention bias for snakes is evident by 4 months of age, is evident at a group level across the age range, and is unrelated to negative affect. However, these infants showed age-related differences in their responses to angry faces, with a general increase in looking time toward angry faces with age. Furthermore, for infants temperamentally high in negative affect, attending longer to angry faces was related to slower subsequent fixations to a neutral probe (Pérez-Edgar et al., 2017). These findings suggest that attention biases for different kinds of threat-relevant stimuli might have different developmental trajectories and perhaps different underlying processes.

What Factors Drive Change in Biased Attention Over the Course of Development?

The research reviewed above suggests that attention biases for threat—and social threats in particular—can change over time. Several key factors may drive these changes in the first 2 years of life. As mentioned, several studies have reported a relation between rapid attention to threat and fear or anxiety. In addition, difficulty disengaging from threat-relevant faces has also been linked to higher negative affect (Nakagawa & Sukigara, 2012; Pérez-Edgar et al., 2017). There is evidence that

Table 1. Passive-Viewing Eye-Tracking Tasks Used To Measure Attention Biases for Threat in Infancy

Task	Definition and dependent measure	References
Dot-probe task (Fig. 1a)	Dot-probe tasks measure visual engagement with threat and how the presence of threat disrupts subsequent processing. The primary dependent measures are (a) overall looking duration to the stimuli before the probe and (b) latency to visually fixate the probe on congruent trials minus incongruent trials.	Burris, Barry-Anwar, & Rivera (2017); LoBue, Buss, Taber-Thomas, & Pérez-Edgar (2017); Mogg, Wilson, Hayward, Cunning, & Bradley (2012); Montagner et al. (2016); Pérez-Edgar et al. (2017)
Vigilance task (Fig. 1b)	Vigilance tasks measure rapid initial attention to threat. The primary dependent measure is the latency when visual attention is shifted from the central fixation point to the emotional face.	Fu, Morales, LoBue, Buss, & Pérez-Edgar (2019)
Overlap task (Fig. 1c)	Overlap tasks measure difficulty disengaging from threat. The primary dependent measure is the latency when visual attention is shifted from the central face to the peripheral target.	Morales et al. (2017); Nakagawa & Sukigara (2012); Peltola, Forssman, Puura, van IJzendoorn, & Leppänen (2015); Peltola, Hietanen, Forssman, & Leppänen (2013); Peltola, Leppänen, Palokangas, & Hietanen (2008); Peltola, Yrttiaho, & Leppänen (2018)
Visual paired-comparison task (Fig. 1d)	Visual paired-comparison tasks measure both engagement with threat and rapid attention to threat. The primary dependent measures are (a) latency to fixate each stimulus and (b) overall looking duration to each stimulus.	Leppänen, Moulson, Vogel-Farley, & Nelson (2007); Peltola, Leppänen, Mäki, & Hietanen (2009)

Note: For a comprehensive review of these tasks and how they were modified from classic adult visual-attention tasks for use with infants, see Burris, Buss, LoBue, Pérez-Edgar, and Field (2019).

negative temperamental traits in early infancy may impact future attentional patterns in some individuals. For example, attention biases to threat measured at age 5 mediate the relation between infants' behaviorally inhibited temperaments and social withdrawal at age 5 (Pérez-Edgar et al., 2011). Moreover, as discussed above, negative affect in infancy has been linked to concurrent measures of attention bias for angry faces (Pérez-Edgar et al., 2017).

There is also evidence that maternal psychopathology—a known risk factor for anxiety—can impact biased attention to threat. Several studies have shown that older children (aged 6 to 14) of anxious mothers demonstrate heightened attention to threat-relevant faces (Mogg, Wilson, Hayward, Cunning, & Bradley, 2012; Montagner et al., 2016). Recently, Morales et al. (2017) reported that this relation begins in infancy, as maternal anxiety is associated with difficulty disengaging from angry, but not happy, faces for 4- to 24-month-old infants.

Beyond individual factors such as negative affect and maternal psychopathology, attention bias to threat in infancy is also associated with social processes. For example, one recent study showed that disengagement from threat-relevant faces at 7 months was related to later attachment security (Peltola, Forssman, Puura, van IJzendoorn, & Leppänen, 2015). Another showed that increased attention to emotional faces at 7 months was related to more frequent helping behavior at 24 months and reduced callous-unemotional traits at 48 months,

suggesting that there may be social benefits to having early attentional systems tuned to emotion in general (Peltola et al., 2018). Finally, cognitive mechanisms, such as attentional control, may play an increasingly influential role in modulating attentional responses to threat, particularly in infants high in negative affect (Fu, Morales, LoBue, Buss, & Pérez-Edgar, 2019). Although this work is relatively new and requires replication, it suggests that various factors can influence the development of biased attention over the first few years of life.

Future Research

Altogether, emerging research with infants has begun to shed light on some of the classic questions surrounding attention biases for threat and their development. The tentative conclusion that we can begin to draw from this work is that there is some stability in attention biases for threat over the first 2 years of life, supporting the normative perspective. However, research reviewed here also suggests that there is indeed room for development in attention biases for threat, particularly in the development of biases for social threats such as angry and fearful faces. Factors such as negative affect and maternal anxiety, as well as attachment and attentional control, might play a role in shaping biased attention. In turn, biased attention might play a role in shaping the trajectory of children's socioemotional development. These findings (most consistent with Field and Lester's,
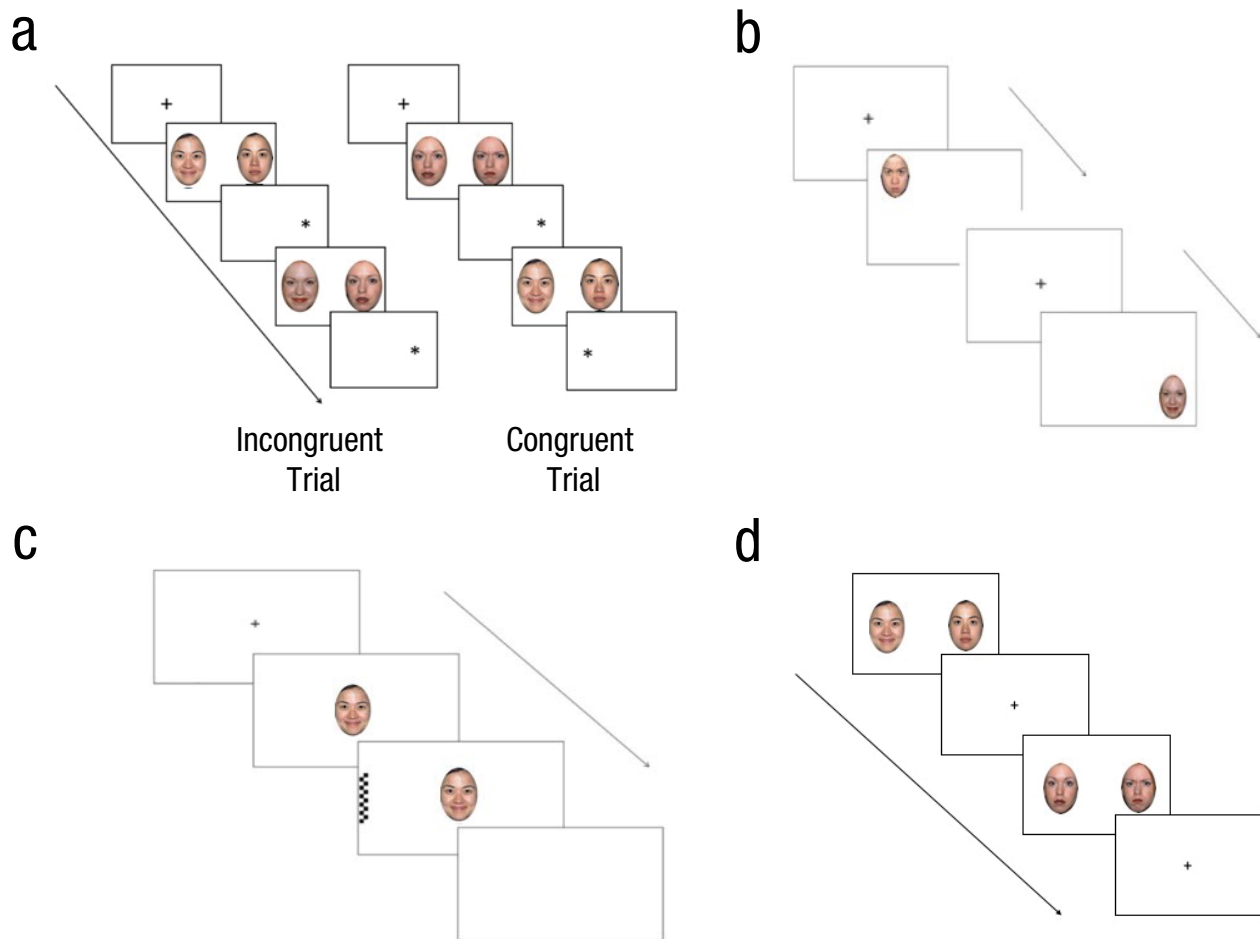
Fig. 1. Example trial sequences from the four tasks described in Table 1. In the dot-probe task (a), infants are generally presented with two images side by side, followed by a probe that appears in place of one of the two images. In congruent trials, the probe appears on the same side of the screen as the emotional face had previously appeared; in incongruent trials, the probe appears on the same side of the screen as the neutral face had previously appeared. In the vigilance task (b; two trials are shown), infants are presented with a central fixation cross followed by an image that appears in one of the four corners of the screen. In the overlap task (c), infants are presented with an image in the center of the screen, followed by a checkerboard probe that appears to the right or left side of the center image. In the visual paired-comparison task (d; two trials are shown), infants are presented with two images simultaneously. For a comprehensive review of these tasks and how they were modified from classic adult visual-attention tasks for use with infants, see Burris, Buss, LoBue, Pérez-Edgar, and Field (2019). Face stimuli shown here are from the NimStim Set of Facial Expressions (Tottenham et al., 2009).

2010, moderation model) suggest that attentional biases for threat are normative early in life, but infants who have a persistent bias for threat-relevant social information might be at the most risk for anxiety.

Despite the promise of this new work, a great deal of future research is still needed. First and foremost, to investigate how early attention biases develop and interact with other factors, longitudinal studies are particularly needed. One recent longitudinal study on attention biases for angry faces showed that there is instability in attention biases to threat across early childhood but that group-level biases persist from at least the first to fourth year of life (Burris & Rivera, 2019). Importantly, this study also showed that infants who exhibit a persistent bias toward threat across early childhood also show significantly higher levels of anxiety, again consistent with Field and Lester's (2010) moderation model.

Second, whereas some researchers have reported relations between attention biases for threat, negative affect, and maternal anxiety, others have not (e.g., negative affect: Morales et al., 2017, Burris et al., 2017; Pérez-Edgar et al., 2017; maternal anxiety: Leppänen, Cataldo, Enlow, & Nelson, 2018, Morales et al., 2017). It is possible that measurement differences or additional mediating variables could explain these inconsistent findings. However, future longitudinal research is needed to disambiguate inconsistencies in this emerging literature.

One problem is that across studies, researchers have lumped together different types of threat (e.g., snakes

and spiders, fearful and angry faces) even though attention biases for these threats may develop differently, and different studies have used different indices to measure biased attention. For example, some studies have used vigilance to threat as their primary index, as measured by latency, to detect a threat-relevant target (e.g., LoBue & DeLoache, 2008; Öhman, Flykt, & Esteves, 2001). Alternatively, others have used disengagement from threat or the amount of time it takes an individual to look away from a threat-relevant stimulus (e.g., Morales et al., 2017; Nakagawa & Sukigara, 2012; Peltola et al., 2013; Peltola, Leppänen, Palokangas, & Hietanen, 2008). Still other researchers have used visual engagement with threat, or the duration of time that a person remains fixated on a threat-relevant stimulus, and how the presence of threat influences subsequent processing, such as the detection of a neutral probe (e.g., LoBue et al., 2017; Pérez-Edgar et al., 2017; see Table 1 and Fig. 1 and Burris et al., 2019, for a detailed review).

It is not clear that these different components of attention are related to the same underlying process. Indeed, different components of visual attention are innervated by subtly different neural pathways and mechanisms and may differentially impact the overall attentional profile of an infant or whether that infant is at risk for developing anxiety. For example, on the basis of the findings reviewed here, it is possible that vigilance in infancy is normative but that problems disengaging from threat develop over time in conjunction with other factors, such as temperamental negative affect or maternal anxiety. The infant literature is currently too sparse for any concrete conclusions to be drawn in this domain, so future work that disambiguates the components of attention as they relate to biased attention patterns is needed.

Another important avenue for future work is investigating the underlying neural processes at play in the development of attention to threat. A number of researchers have reported that infants show differential neural responses to threat-relevant stimuli (Hoehl & Striano, 2008; Leppänen, Moulson, Vogel-Farley, & Nelson, 2007). These differences are evident as young as 7 months of age (Peltola et al., 2009) and may be influenced by environmental factors, such as parenting (Taylor-Colls & Pasco Fearon, 2015). What we currently lack is an understanding of how different attentional patterns to threat in infancy relate to concurrent changes in the brain and how different neural patterns may relate to other factors that influence biased attention. Future research investigating how neural responses to threat are related to attention might help elucidate the mechanisms for developmental change in infancy and early childhood.

In conclusion, we hope that this review inspires new developmental research on biased attention to threat in infancy so that we can more clearly disambiguate how normative biases diverge into potentially maladaptive pathways of socioemotional development. To do so, we recommend that researchers take a more nuanced approach to studying biased attention and consider different types of threat (social, nonsocial), different mechanisms of attention (e.g., vigilance, difficulty disengaging) and, of course, development. These avenues of investigation are invaluable for current theories of human threat perception and for the practical development and implementation of empirically supported and developmentally appropriate treatments for anxiety.

Recommended Reading

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