Chapter

PERCEPTUAL BIASES FOR THREAT

Vanessa LoBue[*]
Rutgers University

ABSTRACT

When approached with a potential threat, it is vital that individuals act quickly and efficiently in order to escape. Because of its importance to survival, some researchers have suggested that humans adapted defensive mechanisms that allow for the rapid identification of threatening stimuli. Here I review evidence that humans and other animals have *perceptual biases* for the rapid detection of various threats, the potential origin of these biases, and their implications for behaving adaptively.

The way we perceive the world around us affects almost everything about our day-to-day experiences. Perception plays a role in a large variety of our cognitive and emotional processes, ranging from seemingly low-level functions, like how we physically navigate the environment or how we encode and remember information, to more complex functions, like the way we approach social interactions. Interestingly, research suggests that our perceptual system does not treat everything in our world equally—we assign

[*] Mailing Address: 101 Warren Street, Room 301, Newark, NJ 07102; Phone: 973-353-3950; email: vlobue@psychology.rutgers.edu

some stimuli priority in visual processing. For example, emotionally valenced stimuli have been shown to selectively drive perception, and attract attention more readily than neutral or non-emotional stimuli (Carretie, Hinojosa, Martín-Loeches, Mercado, and Tapia, 2004). Further, researchers have found that adults quickly detect stimuli that carry a *negative* valence, such as negative words, phrases, and facial expressions, more quickly than stimuli that are neutral or positively valenced (for a review, see Vaish, Grossmann, and Woodward, 2008). Finally, adults detect negative stimuli that are *threatening* the most quickly overall, even more quickly than negative stimuli that are non-threatening (LoBue, 2009).

Because of the large body of research documenting these irregularities in the way humans perceive emotional stimuli, several researchers have proposed that humans have low-level visual *biases* in perception that function to draw attention to important stimuli in the environment (LoBue, Rakison, and DeLoache, 2010). Such perceptual biases have been described in various domains beginning very early in development. For example, researchers have shown that infants have a perceptual bias for human speech sounds, which selectively draws their attention to human speech shortly after birth (Vouloumanos and Werker, 2007). Similarly, other researchers report that newborns have a perceptual bias for stimulus configurations that resemble human faces, resulting in a preference for face-like patterns early in life (Macchi Cassia, Turati, and Simion, 2004). In the same vein, humans have perceptual biases for the rapid detection of threatening stimuli in visual attention, detecting the presence of these stimuli particularly quickly. In this chapter, I review evidence in support of these biases for threat, debate their potential origins, and discuss the impact they might have on human behavior.

BIASES FOR ANCIENT THREATS— AN EVOLUTIONARY MODEL

Research has shown consistently that both humans and non-human animals have special biases in perception that quickly direct attention towards threatening stimuli. Because there is such clear adaptive value in rapidly detecting the presence of threat, some researchers have proposed an evolutionary origin for such biases. In other words, since there might have been a reproductive advantage for individuals that quickly detected the presence of threatening stimuli, evolution may have conferred an advantage for the rapid detection of certain threats (Öhman, Flykt, and Esteves, 2001). These threats would have constituted a recurrent and widespread threat for a particular species (Seligman, 1971).

Research from non-human animals certainly confirms the existence of such biases. For example, some reptiles use perceptual information from their olfactory systems to detect the presence of volatile chemicals emitted by potential predators (Miller and Gutzke, 1999). Wall lizards, for example, detect the presence of snakes based on chemical cues. Upon detection, they quickly seek shelter (Amo, Lopez, and Martin, 2004). Similarly, small-mouthed salamanders detect the presence of predatory fish based on chemical cues (Kats, 1988). Primates possess this ability as well, and use perceptual cues provided by the visual system to detect he presence of threats. Japanese monkeys, for example, use their visual system to quickly detect the presence of snakes, and detect them more quickly than flowers when presented in 3 by 3 matrices of photographs (Shibasaki, and Kawai, 2009). Thus, primates also use cues from their perceptual systems to quickly detect the presence of threat in the environment.

Importantly, a large body of work suggests that humans do the same. Öhman and colleagues (Öhman, Flykt, and Esteves 2001) were the first to examine whether adult humans detect evolutionarily threat-relevant stimuli more quickly than non-threat stimuli in a visual search task. The threat-relevant stimuli they used were photographs of snakes and spiders—two animals that were arguably recurrent and widespread threats to humans and other primates throughout evolutionary history (Öhman and Mineka, 2001; Seligman, 1971).

In the standard visual search procedure they used, participants were presented with an array of 9 pictures arranged in 3 by 3 matrices. The matrices contained either nine photographs from a single category, or eight photographs from one category and a single discrepant photograph from a second category. Two types of stimuli were used—threat-relevant (snakes and spiders) and threat-irrelevant (flowers and mushrooms). These comparisons are typically used in threat detection research because snakes and flowers and spiders and mushrooms can be well matched for color and are often photographed against natural backgrounds. Participants were instructed to detect as quickly as possible whether a discrepant photograph was present in each matrix. If all photographs were from the same category (e.g., 9 flowers), they were told to squeeze a lever held in one hand; if there was a single photo from a discrepant category (e.g., 8 flowers and 1 snake), they were told to squeeze a lever in the opposite hand.

The results were clear: Participants were significantly faster at detecting the presence of threat-relevant targets (snakes and spiders) than threat-irrelevant targets (flowers and mushrooms). They found this effect across several experiments. Further, two additional findings were interpreted by Öhman at al. (2001) as evidence that the detection of threat-relevant stimuli occurs *automatically*. If objects are processed automatically, detection of the targets should not be affected by variations in the number of distracters present in a visual search display (Treisman and Gelade, 1980). Accordingly, a second experiment demonstrated that the number of distracters present in each matrix does not affect the speed of detection for threat-relevant stimuli. In the same visual search paradigm, participants detected targets in both 2 x 2 and 3 x 3 matrices. When snakes and spiders were the target (i.e., discrepant) images, participants' performance did not vary as a function of the number of distracters (3 or 8). However, when flowers and mushrooms were the targets, participants were significantly slower at detecting their presence when more distracters were present in each matrix.

Additionally, speed of detection did not vary based on where the target appeared in the matrix when the targets were snakes and spiders. Participants' eyes were focused on the middle of the screen at the beginning of each trial. Hence, when the target was located in the middle position of the matrix, the targets should be detected the most quickly. This was true when the targets were threat-irrelevant: Threat-irrelevant targets located in the middle row were found more quickly than targets in the top and bottom rows. This was not the case when the targets were snakes and spiders—participants were equally fast at locating them regardless of placement in the matrix. This result suggests that participants were able to shift their attention more quickly to the snake and spider targets than to the flower and mushroom targets.

Further studies have shown that humans not only detect snakes and spiders very quickly, but they also detect threatening human faces very quickly. Angry human faces are a clear and direct social signal of threat, and may also share this evolutionary origin (Hansen and Hansen, 1988). Fearful faces have been considered threat-relevant as well, as they indicate that threat is somewhere in the immediate environment (LoBue, 2009; Whalen, et al., 2001). Using the same visual detection paradigm described above, countless researchers have found an advantage for angry faces over happy or neutral expressions (Calvo, Avero, and Lundqvist, 2006; Esteves, 1999; Fox, Lester, Russo, Bowles, Pichler, and Dutton, 2000; Lundqvist and Öhman, 2005; LoBue, 2009; Mather and Knight, 2006) and over other facial expressions, such as sad and fearful faces (Calvo, Avero, and Lundqvist, 2006; LoBue, 2009; Öhman, Lundqvist, and Esteves, 2001). In fact, ratings of negative valence have been directly correlated with detection latency: The more negatively participants have rated angry facial expressions, the faster they detected them (Lunqvist and Öhman, 2005).

There is evidence that negative facial expressions in general not only attract more attention than do other facial expressions, but they also distract from positive or neutral targets. Fenske and Eastwood (2003) presented participants with three images of schematic faces and asked them to identify the center image while ignoring the other two. Participants were slower at identifying the center image when the distracters were negative faces. Similarly, Eastwood, Smilek, and Merikle (2003) asked participants to count facial features embedded in different types of facial expressions (i.e., upward and downward curved arcs contained within each face). Counting took longer when the features were embedded in negative than in positive and neutral faces. Together, these results demonstrate that negative facial expressions can divert attention, thereby disrupting performance when they are not the target stimuli. Thus, when negative faces are the distracter stimuli, they also capture attention, taking it away from the target stimuli.

Although there are countless studies that have replicated the basic advantage for angry faces in detection, a few researchers report more ambiguous results. Calvo and Esteves (2005), for example, found that angry, happy, and sad faces are all detected more quickly than neutral faces. Williams, Moss, Bradshaw, and Mattingley (2005) similarly reported that adults detect both angry and happy faces faster than sad or fearful faces. Juth, Lundqvist, Karlsson, and Öhman (2005) found an advantage only for happy faces, reporting that adults find happy faces more quickly than both fearful and angry ones. Although some of these results provide partial support for an advantage for angry or threatening faces in detection, it is possible that the portions of these results that are inconsistent with other findings can be attributed to slight variations in procedure, such as the number of distracters present in the arrays of faces or the particular faces used.

Other researchers have since replicated the advantage for threatening stimuli in detection, but failed to replicate Öhman et al.'s (2001) findings with regard to automaticity (e.g., Cave and Batty, 2006; Batty, Cave, and Pauli, 2005). Further, many have argued that for stimuli like snakes, spiders, and angry faces to be detected pre-attentively, participants would have to be detecting very simple features of these stimuli. This is problematic for researchers who argue that participants are detecting these stimuli very quickly because of their *threat*-relevance: Detection based on threatening status would require more complex processing (Cave and Batty, 2006). Thus, if in fact threatening stimuli are detected pre-attentively, it is likely due to some low-level features of the stimuli and not because of their threat-relevant properties.

The research findings in this area have also been mixed. Schubo, Gendolla, Meinecke, and Abele (2006), for example, found no detection advantage when low-level features of threatening faces (i.e., the downward pointed “V” shape representing the eyebrows of threatening faces versus the inverted “V” representing the eyebrows happy) were presented alone, not in a face-like context. Similarly, Tipples, Atkinson, and Young (2002) presented participants with a series of visual search tasks in which the experimenters systematically removed some combination of the facial features of the stimuli (i.e., mouth, eyebrows, nose). The individual features of threatening facial expressions alone were not enough to elicit faster detection; only features that were embedded in a face-like configuration were detected more rapidly than non-threatening features. In contrast, LoBue and Larson (2010) found that both preschool children and adults more quickly detect the downward pointed “V” shape than the inverted upward pointing “V” shape when presented alone, in the absence of a face-like context.

Similarly, developmental researchers found that in both adults and children, a snake’s curvilinear shape makes it particularly easy to find. Using a modified touch screen visual search paradigm (discussed in more detail in the next section), LoBue and DeLoache (2011) report that 3-year-olds and adults detect snakes more quickly than flowers, but they also detect other coiled stimuli, such as ropes and wires, more quickly than flowers. Further, there were no significant differences when they examined detection of non-coiled snakes versus flowers, and snakes with only their faces displayed versus depictions of frog faces (LoBue and DeLoache, 2011). Again, these results remain mixed, and thus the findings with regard to automaticity of threat detection and the mechanisms by which we detect threat are still controversial. Future research is needed to disambiguate these mixed results.

As a whole, results from the studies discussed in this section demonstrate repeatedly that evolutionarily threat-relevant stimuli are detected more quickly than non-threat-relevant stimuli in visual search tasks. These evolutionarily threat-relevant stimuli include both threat-relevant animals, like snakes and spiders, and threat-relevant human facial expressions, like angry faces. Although there have been some studies that report mixed results, the overwhelming majority of this research reports a clear advantage for evolutionary threats. Thus, the findings discussed above provide strong support for the notion that some aspects of the human visual system quickly and efficiently detect the presence of evolutionarily threat-relevant stimuli.

BIASES FOR MODERN THREATS—A LEARNING MODEL

Although it is clear that humans detect evolutionary threats very quickly, other researchers argue against the evolutionary explanation for such findings and suggest that humans learn to detect *all* threats—not just ancient ones—through experience and learning. To support this view, there are a few studies that report an advantage in visual search for both evolutionary *and* modern-day threats, such as guns and syringes. Brosch and Sharma (2005), for example, presented human adults with both phylogenetic and ontogenetic threat-relevant and threat-irrelevant stimuli, comparing the detection of snakes and spiders (threat-relevant – phylogenetic) to flowers and mushrooms (threat-irrelevant – phylogenetic), and the detection of guns and syringes (threat-relevant – ontogenetic) to cups and mobile phones (threat-irrelevant – ontogenetic). They found that *both* types of threat-relevant stimuli were detected more quickly than the threat-irrelevant stimuli. Similarly, Blanchette (2006) examined detection of snakes and spiders versus flowers and mushrooms and also detection of guns and knives versus clocks and toasters. Again, all threat-relevant stimuli were detected more quickly than threat-irrelevant stimuli, regardless of ontogenetic versus phylogenetic threat-relevance.

Since humans could not have possibly evolved a bias for the detection of modern threats like guns and knives because of their recency in human history, the only explanation for these results is that humans develop perceptual biases for *all* threats through learning. Indeed, other researchers report that after conditioning participants to associate a neutral stimulus with an aversive outcome, participants detect that formerly neutral stimulus particularly quickly in a visual search procedure. Koster, Crombez, Van Damme, Verschuere, and De Houwer (2004), for example, examined whether adults would more quickly detect a neutral stimulus when it was predictive of an aversive noise than when it was predictive of a neutral tone. Participants were briefly presented with one of two boxes (gray or white) on a large screen, immediately followed by either a burst of noise or a neutral tone. Participants were told to indicate as quickly as possible whether each box appeared on the left or right side of the screen. They were faster at indicating where the boxes appeared when they were indicative of an aversive noise. The authors concluded that a potential threat, such as an indicator of an aversive noise, captures attention more quickly than a neutral stimulus. Of particular importance here, they also concluded that this attentional capture can be learned through experience.

Together, these results are problematic for the view that humans evolved perceptual biases for the rapid detection of evolutionary threats. Instead, they suggest that humans learn to be perceptually sensitive to threatening stimuli through experience, and by negative experience or conditioning in particular.

BIASES FOR THREAT IN CHILDREN AND INFANTS—A DUAL-PATHWAY MODEL

Thus far I have summarized research demonstrating the humans have perceptual biases for the rapid detection of various threats in the visual system, and two opposing views for how these biases develop—an evolutionary account that suggests that humans have evolved biases only for some threats that were recurrent and widespread over the course of human development, and a learning account that suggests instead that humans learn to be perceptually sensitive to all threats via experience or conditioning. A third possibility is that there are multiple pathways by which we develop biases for threat. In other words, while the detection of some ancient threats may be the product of evolutionary adaptations, other more recent threats may be detected quickly on the basis of domain general learning mechanisms (Blanchette, 2006; LoBue, Rakison, and DeLoache, 2010). This dual-pathway model would lead to the most adaptive behavior, conferring humans with biases for evolutionary threats, and allowing for the flexibility to learn sensitivity to threats that are particular to a given environment.

Although the research described above provides compelling evidence in support of both evolutionary and learning models, it is limited in that it only tested adult participants. Adults have a lifetime of experience and knowledge about threatening stimuli, and may already come into the lab with a variety of negative experiences with both evolutionary and modern threats. Thus, it is difficult to test the dual-pathway model in adults. However, if humans have evolved perceptual biases for evolutionary threats, these biases should be present across ages and varying levels of experience, whereas biases for modern threats should require negative experience with the relevant stimuli. Thus, research with infants and young children could provide particularly strong tests of the origins of perceptual biases for threat, because children have a limited amount of experience with the relevant stimuli.

Critically, the standard adult visual search paradigm is not suitable for use with young children. Thus, developmental researchers created a modified visual search procedure that is appropriate for studying threat detection in young children. In the general paradigm, children are presented with 3 × 3 matrices of photographs on a touch screen monitor, each containing 8 photos from a particular category and one photo from a different target category. Children are instructed to find and touch the target on the screen as quickly as possible (LoBue and DeLoache, 2008). The first studies using this procedure showed that the touch screen method produces the same results in adults that have been found using the standard button-press paradigm: Adults detect snakes more quickly than flowers (LoBue and DeLoache, 2008) and spiders more quickly than mushrooms (LoBue, 2010). They also detect angry faces more quickly than happy, sad, or neutral ones (LoBue, 2009). These findings thus replicate previous research discussed above with adults using the touch screen visual search procedure.

Most importantly, the new touch screen paradigm yields similar results in 3- to 5-year-old children: Just like adults, preschool children detect snakes more quickly than flowers. Further, both adults and children detect snakes more quickly than other animals that closely resemble snakes, such as frogs and caterpillars (LoBue and DeLoache, 2008). In a second group of studies, LoBue (2010) also found that 3-year-old children detect spiders more quickly than mushrooms, and more quickly than a perceptually similar animal—cockroaches. Importantly, across these experiments, only some of the children were afraid of snakes and spiders, and there were no differences in detection among participants who were reported to be afraid of snakes and spiders and those who were not.

In a similar line of studies, the same group of researchers examined children’s detection of threatening facial expressions using the touch screen visual search procedure. They found that both adults and 5-year-old children detected angry faces more quickly than happy or neutral faces, replicating previous results with adults. Interestingly, both adults and children detected all *negative* facial expressions (angry, fearful, sad) more quickly than positive or neutral faces. However, when comparing negative facial expressions that are not threatening (sad faces) to negative faces that are threatening (angry or fearful), the threat-relevant faces were detected the most quickly over all (LoBue, 2009).

Although this work presents strong evidence that even young participants with limited experience detect evolutionary threats particularly quickly, even preschool children have some experience and knowledge about snakes and spiders. Thus, to more strongly test the evolutionary hypothesis, LoBue and DeLoache (2010) extended this line of research to infants, who had no previous experience with such threats. In a simplified detection paradigm, 8- to 14-month-old infants were presented with only two images at a time—one snake and one flower, or one happy face and one angry face. Just like adults and older children, infants turned more quickly to look at threatening stimuli (snakes and angry faces) than at non-threatening stimuli (flowers and happy faces) (LoBue and DeLoache, 2010).

Rakison and colleagues similarly found that infants might have a "perceptual template" for the processing of evolutionary threats. They report that 5-month-old infants looking longer at schematic images of snakes and spiders than at scrambled versions of the animals, suggesting that the infants have some template for how these stimuli should be arranged. The same results were not found for non-threatening images like flowers—infants looked equally long at schematic images of flowers versus scrambled versions of the same image (Rakison and Derringer, 2008; Rakison, 2012).

Thus far, this developmental work provides support for the evolutionary view of threat detection, demonstrating that like adults, preschool children and even infants detect evolutionary threats like snakes, spiders, and angry faces more quickly than neutral or positive stimuli (LoBue and DeLoache, 2008, 2010, 2011; LoBue, 2009, 2010). This research does not, however, speak to the dual-pathway model of threat perception. As mentioned above, the adult literature cannot provide evidence for this view either, since adults have experience with both modern and evolutionary threats. Children, however, have a somewhat limited amount of experience with each. Although it is nearly impossible to fully account for experience, LoBue (2010) noted that preschool children have a predictable amount of experience with two modern threats that adults detect particularly quickly. Knives, for example, are modern threats that preschool children are rarely permitted to handle, and are unlikely to have negative experience with. Syringes, on the other hand, are modern threats that all American children should have negative experience with through mandatory vaccinations.

Accordingly, LoBue (2010) asked parents to report on their 3-year-old's experience with both knives and syringes and later asked the children to participate in two detection tasks. In one, they detected knives versus a perceptually similar neutral stimulus (spoons). In a second, they detected syringes versus a perceptually similar neutral stimulus (pens). Like adults, children detected the syringes more quickly than pens. However, in contrast to adults, they did not detect the knives more quickly than the spoons. These results suggest that children can learn to detect modern threats particularly quickly via negative experience.

Further evidence for the dual-pathway model comes from research with clinical populations, showing that biases for evolutionary threats can be tuned up or enhanced as the result of fear or anxiety. For example, Öhman, et al, (2001), found that participants with snake and spider phobias detect the object of their fear even more quickly than do non-phobic participants. Further, participants who have clinical anxiety have been reported to detect threatening facial expressions even more quickly than non-anxious participants (Byrne and Eysenck, 1995; Derryberry and Reed, 2002; Fox, Russo, and Dutton, 2002; Mogg and Bradley, 2002; Pishyar, Harris, and Menzies, 2004). This suggests that heighten fear or negative thoughts about threat-relevant stimuli results in enhanced detection of threat.

BEHAVIORAL IMPLICATIONS

The question that remains is whether these biases in perception lead to adaptive behavior when faced with an approaching threat. Such adaptive behaviors could include rapid escape, or activation of a fearful response once a threat has been detected. If perceptual biases for threat lead to a rapid fear response, fears of threatening stimuli might be acquired and maintained very readily. In fact, there is a large body of research with humans and non-human primates suggesting that snake and spider fears are learned more rapidly than other fears.

Snakes and spiders are two of the most highly feared stimuli among both humans and other mammals, and are highly represented in intense fears and clinical phobias in humans throughout the world (Öhman and Mineka, 2001). To explain the high incidence of snake and spider phobias, Seligman (1971) theorized that snakes and spiders constituted a significant threat to humans and other mammals for millennia and thus evolution conferred a reproductive advantage for rapid fear learning. Indeed, a consistent and robust body of work shows that both humans and monkeys learn to associate snakes with fearful or negative stimuli more readily than with neutral stimuli. For example, when human adults are conditioned to associate an electric shock with photographs of either snakes and spiders or flowers and mushrooms, extinction takes longer for snakes and spiders. Similarly, lab-reared rhesus monkeys are quickly conditioned to fear snakes after watching a wild-reared, con-specific react fearfully toward snakes. Conditioning is selective: In the same type of situation, monkeys do not learn to associate fear with stimuli such as flowers or rabbits (for a review, see Öhman and Mineka, 2001).

One explanation for these findings is that low-level perceptual biases for stimuli like snakes and spiders function to direct perceptual attention to these animals and may thus make us more susceptible to learning fear. Although these biases are not equivalent to fear, they may lead to more rapid fear learning of threat-relevant stimuli such as snakes and spiders (LoBue, Rakison, and DeLoache, 2010). There is some research demonstrating that perceptual biases for threat may facilitate fear learning of threatening stimuli, making fear learning for threat more rapid than fear learning for non-threatening or neutral stimuli (Öhman and Mineka, 2001; Seligman, 1971). DeLoache and LoBue (2009), for example, found that 7- to 16-month-old infants readily pair the occurrence of a snake with an aversive fearful voice. When shown two videos of animals side by side on a large screen, infants looked longer at videos of snakes when listening to a fearful voice than when listening to a happy voice. Rakison (2009) reports similar results with fearful faces—11-month-old girls more readily learn to pair images of snakes and spiders with fearful than with happy faces. The infants in each of these studies showed no signs of being afraid of the stimuli—they were merely making a perceptual match between snakes and spiders and something fear-relevant. In fact, there is no evidence that humans have an innate fear of any threatening stimuli (LoBue, Bloom-Pickard, Sherman, Axford, and DeLoache, 2012). This bias to pair the occurrence of snakes and spiders with threat coupled with our rapid attention to these stimuli might lead to rapid fear learning. Although one line of research has shown that humans do indeed have perceptual biases for threat, and another line of work has shown that fear of threats like snakes and spiders are common and might be learned very readily, there is no work examining how perceptual biases might function to facilitate fear learning, or escape. Future work in this area might better elucidate how the biases discussed here might lead to adaptive behavior.

Summary and Conclusions

In conclusion, this body of research demonstrates that humans have perceptual biases for the rapid detection of threatening stimuli. Some of these threats have evolutionary threat relevance, and constituted a recurrent and widespread threat throughout human history. It is possible that negative experience is not necessary for the rapid detection of these stimuli, as both preschool children and infants detect them particularly quickly (LoBue and DeLoache, 2008, 2010). Humans also have biases for modern threats that are more environmentally specific, such as knives and syringes. Research suggests that negative experience is required for the rapid detection of these stimuli (LoBue, 2010). Together, this work suggests that humans have multiple pathways by which we detect threat, leading to maximally adaptive behavior when confronted with both ancient and historically recent threatening stimuli.

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