Testing the role of evolutionary threat on speed perception: Evidence from predictive tracking

by

Adi Rosenthal

Stella Lourenco
Adviser

Psychology

Stella Lourenco
Adviser

Robyn Fivush
Committee Member

Susan Tamasi
Committee Member

2016

Testing the role of evolutionary threat on speed perception: Evidence from predictive tracking

By

Adi Rosenthal

Stella Lourenco
Adviser

An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Psychology

2016

Abstract

Testing the role of evolutionary threat on speed perception: Evidence from predictive tracking

By Adi Rosenthal

Research with human and non-human primates suggests specialized visual processing of evolutionary-based threats (e.g., Öhman & Mineka, 2001). For instance, human adults and infants underestimate the arrival time of looming animals that are evolutionarily threatening to a greater degree than those that are non-threatening (Ayzenberg, Longo, & Lourenco, 2015; Vagoni, Lourenco, & Longo, 2012). However, it is unclear what accounts for the relationship between threat and visual perception. In the current study, we used a predictive tracking paradigm to determine whether the perceived speed of laterally moving images differed depending on the threat value. Thirty-three infants (8- to 11-month-olds) were presented with horizontally moving images of threatening and non-threatening animals. A portion of the movement trajectory was covered in the center by an occluder, which has been shown to elicit predictive tracking (i.e., infants anticipate the reappearance of the image). Although we found that infants' anticipatory looking behaviors were modulated by the speed of the animal, we did not find evidence that the threat value of the images modulated these behaviors. These data are discussed in the context of threat perception and peripersonal space.

Keywords: Threat, infants, predictive tracking, speed

Testing the role of evolutionary threat on speed perception: Evidence from predictive tracking

By

Adi Rosenthal

Dr. Stella Lourenco
Adviser

A thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
Bachelor of Arts with Honors

Psychology

2016

Acknowledgements

Thank you to Dr. Stella Lourenco, my advisor on this project, as well as Vlad Ayzenberg and Samuel Hunley for their help throughout. I would also like to thank the rest of the members of the Spatial Cognition Lab as well as all the families of the Emory Child Study Center for their participation.

Table of Contents

Introduction

The ability to rapidly detect threats present in the environment is crucial for the survival of most species. For instance, being bitten by a venomous snake can have deadly consequences for a primate traveling in the forest or jungle. Thus, it is highly advantageous to detect such an animal prior to entering its striking range. Threat detection and avoidance are so critical to the survival of an organism that the famous zoologist Hediger (1955) argued that it is the most important behavior of any animal. While nourishment-seeking and reproductive behaviors can be postponed, threats need to be addressed immediately otherwise the creature in question would never have the opportunity to complete the former two behaviors. Given the importance of threat detection and avoidance to survival, it is crucial to examine these behaviors on a cognitive and perceptual level. The current study seeks to explore perceptual biases towards evolutionary-based threats that would be adaptive for survival. Specifically, biases in the form of spatiotemporal perception towards images of snakes and spiders are examined in human infants.

Threat avoidance has received a great deal of attention in evolutionary theory. A common premise among such theorists is that animals such as snakes and spiders were a critical threat throughout primate phylogeny and thus drove the evolution of a threat detection system (Öhman, 2007). Indeed, some researchers argue that the need to perceive venomous snakes was highly influential in the evolution of primate visual cortical areas (Isbell, 2006). In this vein, it has been proposed that the visual system may incorporate attentional and perceptual biases that aid in the detection of threat (LoBue & DeLoache, 2008; Öhman 2007; Rakison & Derringer, 2007; Van Le et al., 2013). Supporting these claims, research from the field of neuroscience has provided evidence of specialized visual pathways for processing threats (LeDoux, 1996; Öhman, Carlsson, Lundquvist, & Ingvar, 2007). Furthermore, single-unit recording in the macaque pulvinar has revealed neurons specially tuned to images of snakes (Van Le et al., 2013). This specialized processing may allow for the rapid detection of a threat and, thus, optimize the fight or flight response.

Neural specialization may also have behavioral implications for human and non-human primates. In visual search tasks, human adults are faster to detect threatening images than images of non-threatening stimuli (e.g., flowers and mushrooms; Öhman et al., 2007). Other research demonstrated that when the task required approximating various visual properties of threatening animals, participants judged these properties in an exaggerated manner (Cole, Balcetis, & Dunning, 2013; Vasey et al., 2012). For instance, individuals who reported high levels of fear were more likely to overestimate a live spider's size (Vasey et al., 2012). In another study, participants who report experiencing a greater amount of fear in the presence of a live tarantula also underestimated the distance between themselves and the animal to a greater degree than participants who were less fearful (Cole et al., 2013).

Studies with human children and non-human primates demonstrate that the attentional and perceptual biases observed in adults have common phylogenetic origins and arise early in human ontogeny. Preschool children and macaque monkeys, like adults, were faster to find threat-relevant targets (i.e., spiders and snakes) among threat-irrelevant distractors (i.e., mushrooms and flowers; LoBue & DeLoache, 2008; Shibasakim & Kawai, 2009). Moreover, there was no effect of the child's experience with spiders and snakes, suggesting that the attentional bias is unrelated to the development of explicit fear because children of this age neither report, nor demonstrate fear of spiders or snakes (LoBue & DeLoache, 2008). The effect in macaque monkeys have been found in lab-reared monkeys without prior snake exposure, suggesting that experience was not relevant in shaping these attentional biases (Shibasakim &

Kawai, 2009). Even earlier in development, human infants show attentional differences in response to threatening and non-threatening stimuli. Infants, ages 8 to 14 months, oriented more quickly to snakes than to flowers when both appeared on the screen simultaneously (LoBue & DeLoache, 2010). Furthermore, whereas 5-month-olds looked equally at schematic non-threatening images and scrambled non-threatening images, they showed significantly longer looking times to an image of a schematic spider than a scrambled version of the same image (Rakison & Derringer, 2007).

Although previous studies have examined the influence on attention by threat-value (LoBue & Deloache, 2008; LoBue & Deloache, 2010; LoBue et. al., 2010; Öhman & Mineka, 2001, Rakison & Derringer 2007), few studies have examined humans' responses to the speed of a stimulus' motion under conditions of threat. When a threatening stimulus is approaching, the importance of a quick response is intensified. Stimuli, real or virtual, that appear to be approaching the body on a direct collision course are known as "looming stimuli" (Gibson & Gibson, 1957). One form of such stimuli are visually looming stimuli that are typically simulated by an image that increases in size on a screen, giving the illusion that it is approaching the subject. Given that any object on a collision course with the body necessitates a defensive response, such stimuli have been used to examine defensive responses with a variety of populations, including rhesus monkeys (Schiff, Caviness, & Gibson, 1962), human adults (Vagnoni, Lourenco, & Longo, 2012), and human infants (Ayzenberg, Longo, & Lourenco, 2015).

In one such study, adults who were exposed to virtual looming animals significantly underestimated the time-to-contact (TTC) for threatening animals (i.e., snakes and spiders) relative to non-threatening animals (i.e., rabbits and butterflies). Furthermore, individual differences in adults' reported fear of snakes and spiders predicted the degree to which they underestimated TTC for the threatening animals (Vagnoni et al, 2012). Similarly, 6- to 12-month-old infants shown looming images of the same category of animals produced earlier defensive blinks in response to images of threatening animals (i.e., snakes and spiders) compared to images of non-threatening animals (i.e., rabbits and butterflies; Ayzenberg, Longo, & Lourenco, 2015). Importantly, these findings could not be explained by a novelty preference, as infants actually looked longer at the non-threatening images, suggesting that the threat value of the animal drove earlier defensive blinks, and suggesting a bias to perceive threatening animals as making contact sooner than non-threatening animals.

Though the results of the looming studies demonstrate clear underestimation with respect to TTC, it is unclear what accounts for the consistent underestimation. One possibility is that these effects are rooted in a spatiotemporal perceptual bias. That is, participants misperceive the speeds of the threatening stimuli, such that they are perceived as travelling more rapidly than their veridical speed. Indeed, one study showed that adult participants overestimated the speed of a zig-zagging threatening animal, on a display, when asked to block its approach with a digital paddle (Witt & Sugovic, 2013). A speed misperception in the presence of threat is consistent given the body of research that shows that other spatial properties, such as distance and size, are also modulated by threat (Vasey, 2012; Cole et al., 2013).

Another possibility is that these effects are due to a change in the perception of the space immediately around the body (i.e., peripersonal space). That is, the presence of threatening animals could lead to an enlarged peripersonal space, such that a threatening animal is perceived as entering the space around the body sooner. In regard to this latter possibility, research suggests that the presence of threat is associated with an expanded representation of peripersonal space (Previc, 1998). Indeed, adults demonstrated peripersonal space expansion in response to the sound of threatening dog barks relative to non-threatening animal noises (Taffou & Delmon 2014). Furthermore, the degree to which participants experienced expansion was predicted by their level of cynophobia (i.e., fear of dogs). Thus, one possibility is that in looming studies with threatening animals (Ayzenberg, Longo, & Lourenco, 2015; Vagoni, Lourenco, Longo, 2012; see also Witt & Sugovic, 2013), adults and infants respond earlier to threatening stimuli, not because those stimuli are perceived as moving faster, but because they make contact sooner due to expansion of peripersonal space.

In the current study, we aim to test whether the first possibility—namely, whether the modulatory effects of threatening stimuli in looming contexts are the result of a spatiotemporal bias. More specifically, we ask whether infants, who do not yet exhibit overt fear for evolutionarily threatening animals, nevertheless misperceive the speed of their trajectory. Thus, the primary goal of this research is to examine whether infants specifically misperceive images of threatening animals as moving faster than images of non-threatening animals. We will do so using a predictive tracking paradigm (Gredeback and von Hofsten, 2004), which has previously been used to measure infants' sensitivity to the directional and temporal properties of dynamic objects. Infants must track an object as it moves behind an occluder, forcing them to predict the location and timing of the object's reappearance based on the spatiotemporal properties of the image. This paradigm allows for the direct comparison of threatening and non-threatening stimuli, by isolating speed as a variable. If indeed their perception of speed is modulated by the threat value, infants should have earlier anticipatory looks to images of threatening compared with non-threatening animals.

Methods

Participants

Thirty-three infants (M = 9.04 months, range: 8-11.07 months, 22 females) were recruited from a metropolitan community to participate in this study. Seven additional infants were tested but failed to complete the procedure due to fussiness; their data are not included in the analyses below. Informed consent was obtained from each child's caregiver. All children received a small gift for their participation. Experimental procedures were approved by the local ethics committee.

Apparatus

Infants' gaze behaviors were recorded at 500 Hz using an EyeLink 1000 Plus eye tracker in remote mode. This mode allows for unrestrained head movement. Stimulus presentation and data recording was controlled using a custom Visual Basic Program. All stimuli were presented on a 22-inch computer monitor (1920 × 1080 pixel resolution).

Design and Procedure

Each infant was seated on his or her parent's lap, approximately 60 cm from the computer monitor. Infants gaze behaviors were calibrated using a five-point calibration and validation routine that involved cueing the infant's attention to a series of locations on the screen using a bouncing ball to ensure the eye tracker recorded the pupil's center with spatial accuracy.

The experiment began with the tracking paradigm, which was divided into two phases, training and test. During training and test phases, the stimuli started either on the left or right side of the screen (1.2 cm from either edge), and subsequently traveled right or left, respectively. To begin the trial, the target stimulus bounced in place with a "boing" sound until the infant fixated to it for 500 ms. Following fixation, the stimulus started its horizontal trajectory across the screen at one of two possible speeds: 50 mm/sec (henceforth referred to as 'slow') and 100 mm/sec (henceforth referred to as 'fast').

In the training phase, the stimulus was a bright green ball (4.2 cm diameter). During this phase, infants needed to track the ball moving across the screen at each of the two speeds, and moving in each direction (randomized order). This training was included to familiarize infants to the tracking paradigm.

Next, infants began the test phase. In the test phase, a portion of the stimulus' trajectory was occluded by a black box (11.6 ×17.3 cm) in the center of the screen (see Figure 1). Each trial included a pre-occlusion phase, an occlusion phase, and a post-occlusion phase. The pre-occlusion phase was the period of time the stimulus traveled before entering occlusion. The occlusion phase was the period of time the stimulus was hidden by the black box. Lastly, the post-occlusion phase was the period of time after the stimulus exited the occluder and completed its trajectory. The stimuli consisted of four animals: two threatening (a spider and a snake) and two non-threatening (a rabbit and a butterfly; see Figure 2). Images came from a previous study (Ayzenberg, Longo, & Lourenco, 2015) and were selected to roughly match in general shape, body position, and pattern. All stimuli were grayscaled, equated for luminance, and identical in overall size (4.2 × 4.2 cm). Thus, infants viewed each of the 4 animals, at each of 2 speeds (fast and slow), moving in each of the 2 directions in a randomized order, for a total of 16 trials.

Following the test trials, infants were presented with a preferential looking task consisting of 8 trials. At the beginning of each trial, a green ball bounced in the center of the screen until the infant fixated on it for 500 ms. Upon fixation, two images, one from the threatening category and one from the non-threatening category, appeared side by side onscreen for 6 seconds. Stimulus location was counterbalanced across trials, and time spent fixating on each stimulus was recorded.

On both tasks, the background was bright yellow (RGB: 250, 230, 92) to provide greater contrast for the grayscaled stimuli (see Figure 2).

Results

Are infants able to visually track laterally moving objects?

To confirm infants' ability to track a moving object, tracking accuracy was measured during pre- and post-occlusion phases. Gazes falling within 200 pixels on either side of the image were considered within the region of interest. Using this criterion, infants fixated within the region of interest 61.3% of the time (*SD* = 15.2%) during the pre-occlusion period and 40.0% (*SD* = 15.0%) during the post-occlusion period. To measure whether these fixations were indicative of accurate tracking, we calculated the slope between the x-axis coordinate of an infants' gaze and the x-axis coordinate of the image's location at every time point in the trial. We found a significant positive slope for the pre-occlusion phase ($M_{Slope} = 0.58$, $SD = 0.19$), $t(32) = 17.81$, $p < 0.001$, and for the post-occlusion phase ($M_{Slope} = 0.33$, $SD = 0.25$), $t(32) = 7.56$, $p < 0.001$), suggesting that infants' eyes were moving horizontally with the movement of the image (see Figure 2). This is consistent with previous research suggesting that infants are able to track visible, laterally moving objects (Gredeback et al., 2002; Bremner et al., 2005). For subsequent analyses, only trials in which infants showed pre-occlusion tracking with positive slopes were used. Of the total number of trials, 12.4% were discarded because they did not have positive pre-occlusion tracking slopes.

Next, to ensure that tracking accuracy occurred equally across all stimulus parameters, we conducted a 2 x 2 repeated-measures analysis of variance (ANOVA) with threat level and speed as within-subjects factors. We found a significant main effect of threat level, $F(1, 31) = 7.02$, $p = 0.013$, $\eta^2 = 0.185$, but no effect of speed ($p > 0.4$), nor a threat × speed interaction ($p > 0.2$), indicating that infants were equally accurate at tracking at both speeds, but were more accurate when tracking threatening animals than non-threatening animals. This was not due to a looking preference towards threatening animals, as infants looked equally at threatening and non-threatening animals during the preferential looking task ($p > 0.10$).

Are infants anticipating the object's re-appearance?

Next, we sought to confirm infants' ability to anticipate the animal's trajectory and shift their eyes to the exit-side of the occluder before the image re-appeared. A saccade was considered anticipatory if infants looked to the exit-side of the occluder after the image became occluded but before the image reappeared. This would suggest that after the image became occluded, they predicted where and when the image would re-appear, rather than looking at it only once it became visible. Prior research shows that it takes 200 ms to plan a saccade (Johnson, 1994); we thus restricted our analysis to infants' gaze behaviors that occurred 200 ms after the beginning of occlusion as well as gaze behaviors that were within 200 ms of the image's reappearance. From these data, we analyzed anticipatory looking by subtracting the time the infant's gaze fixated on the exit-side of the occluder from the time the image re-appeared after occlusion. A positive value indicates that the infant looked to the exit side of the occluder prior to the image re-appearing, suggesting that the looking behavior is anticipatory. A negative value indicates that the infant looked to the exit side of the occluder only after the image re-appeared, suggesting that the looking behavior is not anticipatory. We found that, overall, infants looked to the exit side occluder significantly earlier than the reappearance of the image, $t(32) = 6.309$, $p < 0.001$, consistent with anticipatory looking. For all subsequent analyses, only trials in which gazes were anticipatory were included. Of the total number of trials, 41.6% were discarded because they were not anticipatory.

Does evolutionary threat influence infants' perception of speed?

To examine the effect of evolutionary threat value on the timing of infant's anticipatory looking, we conducted a 2 x 2 repeated-measures ANOVA with threat and stimulus speed as within-subjects factors. Consistent with previous research (Gredeback & Von Hofsten, 2004), we found a main effect of speed, $F(1, 13) = 25.62$, $p < 0.001$. Infants' anticipatory looking were earlier for fast trials ($M = 1054.84$ s, $SD = 550.73$ s) compared with slow trials ($M = 1719.35$ s, $SD = 685.39$ s), suggesting that infants' visual tracking scaled to the speed of the moving object (see Figure 4). However, although infants' anticipatory looks were earlier for threatening animals than for non-threatening animals, we did not find a significant main effect of threat ($p = 0.70$), nor a significant speed × threat interaction ($p = 0.68$), suggesting that visual tracking was not modulated by the threat value of the moving object.

Discussion

The current study used a predictive tracking paradigm to test whether evolutionary threat value, associated specifically with snakes and spiders, modulated infants' perceptions of speed. We found that infants were able to visually track both threatening and non-threatening animals before and after occlusion at two different speeds. Consistent with previous findings, we also found that infants successfully anticipated the reappearance of objects from behind an occluder, replicating previous findings (Gredeback & Von Hofsten, 2004), and crucially, that their anticipatory looking scaled with pre-occlusion speed, verifying that the paradigm was a sound measure of speed perception. However, we did not find evidence that infants modulated their anticipatory looking behavior according to the threat value of the stimulus. That is, infants did not have different anticipatory looking times for the snake and spider compared with the butterfly and rabbit. Based on our findings, it would appear that evolutionary threat does not affect speed perception. In regards to the looming tasks, our finding suggests that an alternative explanation, aside from a speed misperception, is necessary in explaining TTC underestimation for threatening animals.

Before exploring these alternative explanations, it is important to note on limitation of the current study. One possibility is that the current study failed to capture the effect due to low statistical power. Due to the necessary number of trial types (i.e., threatening and nonthreatening; fast and slow), combined with stringent criteria for each trial's inclusion in the analysis (i.e., positive pre-occlusion tracking slope; anticipatory looking), many trials were not analyzed. The low power may have hindered our ability to detect an effect of threat on speed perception. However, lowering the inclusion criteria would introduce uncertainty in infants' abilities to track accurately and predictively. To resolve this issue, increasing the number of participants will be key. Indeed, ongoing research is continuing to increase the number of participants in the current study, which is needed to test whether speed is truly modulated by threat.

However, the current study did not find a statistically significant effect of threat on speed perception. One explanation is that the nature of the study eliminated the looming aspect of the threat. In visual looming studies with infants and adults (Vagoni, Lourenco, Longo 2012; Ayzenberg, Longo, & Lourenco, 2015), researchers found a difference in response to threatening and non-threatening animals. Specifically, both groups underestimated the time-to-contact of the threatening animals more so than the non-threatening animals. In the current study, the animal image was not directly approaching the infant. Thus, one possibility is that this change decreased the intensity of the threat, thereby decreasing the effect of threat on perception. In nature, a response to a non-approaching threat is less urgent than when a threat is actively approaching the body. Consequently, an exaggerated perception of a threat animal's speed is less adaptive (Schiff et. al., 1962; Vagoni et. al., 2012). Without the urgency produced by looming, threat may have a reduced effect on speed perception.

An alternative explanation is that the different response to threatening versus nonthreatening looming stimuli in previous studies is due to a size overestimation. Researchers have found that size is overestimated as a factor of threat (Vasey et al., 2012), and this could account for underestimation of time-to-contact in looming studies. As an image is looming, it appears to be increasing in size. If the physical size of the animal were overestimated from the start of approach, then looming images could be perceived as making contact earlier for this reason. In the case of our experiment, size had no bearing on an object's speed. Consequently, as speed in our, non-looming, paradigm was not modulated by threat level, an overestimation of size in the looming condition remains a viable alternative.

A third interpretation suggests that, rather than affecting speed perception, the threat value associated with animals affects peripersonal space. This interpretation suggests that in the presence of threat, one's peripersonal space expands, leading one to underestimate the moment at which an approaching threat makes contact with the body (De Haan et al., 2016). In the current study, the image's distance from the body remained constant, meaning that, even if peripersonal space expanded in reaction to threatening images, it would not affect infants' estimates of object speed. Future studies should focus on peripersonal space expansion in order to determine which of these possibilities underlies the effects found in looming studies.

Though infants showed no differences between threatening and non-threatening animals in the preferential looking task, which LoBue and DeLoache (2010) also found, infants were more accurate at tracking threatening animals compared to nonthreatening animals, regardless of speed. This is consistent with evidence suggesting attentional biases towards threatening stimuli (LoBue & DeLoache, 2010; LoBue & DeLoache, 2008; Öhman et. al., 2001). Given the lack of a preference in the preferential looking task, these results may suggest that motion is a critical component for cueing attention towards threatening stimuli. While we did not find differences in perception of spatiotemporal features, our findings suggest differences in attention towards the threatening stimuli compared to the non-threatening stimuli.

Nevertheless, the current study demonstrates that infants' modulated their predictive tracking based on the speed of an object. Though we did not find that threat affected speed perception, we did find increased tracking accuracy for threatening animals compared to nonthreatening animals. This finding could suggest that threat does have an affect on attentional processing. Yet, there remain open questions regarding the nature of threat perception.

References

A. Isbell, L. (2006). Snakes as agents of evolutionary change in primate brains. *Journal of Human Evolution, 51(*1), 1-35.

Ayzenberg, V., Longo, M.R., Lourenco, S.F. (2015, May). *Evolutionary-based threat modulates perception of looming visual stimuli in human infants*. Poster presented at the Vision Sciences Society (VSS), St. Pete Beach, FL.

Bremner, J. G., Slater, A., Foster, K., Johnson, S. P., Mason, U., Cheshire, A., & Spring, J. (2005). Conditions for Young Infants' Perception of Object Trajectories. *Child Development, 76*(5), 1029-1043.

Cisler, J., Bacon, A., & Williams, N. (2007). Phenomenological characteristics of attentional biases towards threat: A critical review. *Cognitive Therapy and Research, 33*(2), 221-234.

Cole, S., Balcetis, E., & Dunning, D. (2013). Affective signals of threat increase perceived proximity. *Psychological Science*. doi:10.1177/0956797612446953

De Haan, A. M., Smit, M., Van der Stigchel, S., & Dijkerman, C. H. (2016). Approaching threat modulates visuotactile interactions in peripersonal space. *Experimental Brain Research,* 1-10.

Gibson, J. J., & Gibson, E. J. (1957). Continuous perspective transformations and the perception of rigid motion. *Journal of Experimental Psychology, 54*(2), 129-138.

Gredebäck, G., & Von Hofsten, C. (2004). Infants' evolving representations of object motion during occlusion: A longitudinal study of 6- to 12-month-old infants. *Infancy, 6*(2), 165-184.

Gredeback, G., Von Hofsten, C., & Boudreau, J. P. (2002). Infants' visual tracking of continuous circular motion under conditions of occlusion and non-occlusion. *Infant Behavior and Development, 25*, 161-182.

Hediger, H. (1955). The animal and its enemies. In *The psychology and behaviour of animals in zoos and circuses,* (pp. 39-50). New York: Dover Publications.

Johnson, M. H. (1994). Visual attention and the control of eye movements in early infancy. *Attention and Performance Vol. XV: Conscious and Unconscious Processing*, 291-310.

LeDoux, J. E. (1996). *The emotional brain: The mysterious underpinnings of emotional life*. New York: Simon & Schuster.

LoBue, V., & DeLoache, J. (2008). Detecting the snake in the grass. *Psychological Science, 19*(3).

LoBue, V., & DeLoache, J. (2010). Superior detection of threat-relevant stimuli in infancy. *Developmental Science, 13*(1), 221-228.

LoBue, V., Rakison, D. H., & DeLoache, J. S. (2010). Threat Perception Across the Life Span: Evidence for Multiple Converging Pathways. *Psychological Science, 19*(6), 375-379.

Lourenco, S., Longo, M., & Pathman, T. (2011). Near space and its relation to claustrophobic fear. *Cognition, 119*(3), 448-453.

Öhman, A. (2007). Has evolution primed humans to "beware the beast"? *Proceedings of the National Academy of Sciences of the United States of America, 104*(42), 16396-16397.

Öhman, A., Carlsson, K., Lundqvist, D., & Ingvar, M. (2007). On the unconscious subcortical origin of human fear. *Psychology & Behavior, 92*, 180-185.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology, 130*(3), 466-478. doi:10.1037/0096-3445.130.3.466

Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review, 108*(3), 483-522.

Previc, F. H. (1998). The neuropsychology of 3-D space. *Psychological Bulletin, 124*(2), 123-164.

Rakison, D. H., & Derringer, J. (2008). Do infants possess an evolved spider-detection mechanism? *Cognitionn, 107*, 381-393.

Schiff, W., Caviness, J. A., & Gibson, J. J. (1962). Persistent fear responses in Rhesus monkeys to the optical stimulus of "looming." *Science, 136*(3520), 982-983.

Shibasaki, M., & Kawai, N. (2009). Rapid detection of snakes by Japanese monkeys (Macaca fuscata): An evolutionarily predisposed visual system. *Journal of Comparative Psychology, 123*(2), 131-135. doi:10.1037/a0015095.

Taffou, M., & Viaud-Delmon, I. (2014). Cynophobic fear adaptively extends peri-personal space. *Frontiers in Psychiatry, 122*(5).

Vagnoni, E., Lourenco, S., & Longo, M. (2012). Threat modulates perception of looming visual stimuli. *Current Biology, 22*(19).

Van Le, Q., A. Isbell, L., Matsumoto, J., Nguyen, M., Hori, E., S. Maior, R., Tomaz, C., Tran, A., Taketoshi, O., Nishijo, H. (2013). Pulvinar neurons reveal neurobiological evidence of past selection for rapid detection of snakes. *Proceedings of the National Academy of Sciences of the United States of America, 110*(47), 19000-19005.

Vasey, M., Vilensky, M., Heath, J., Harbaugh, C., Buffington, A., & Fazio, R. (2012). It was as big as my head, I swear! Biased spider size estimation in spider phobia. *Journal of Anxiety Disorders, 26*, 20-24.

Witt, J., & Sugovic, M. (2013). Spiders appear to move faster than non-threatening objects regardless of one's ability to block them. *Acta Psychologia,* 284-291.

Figures

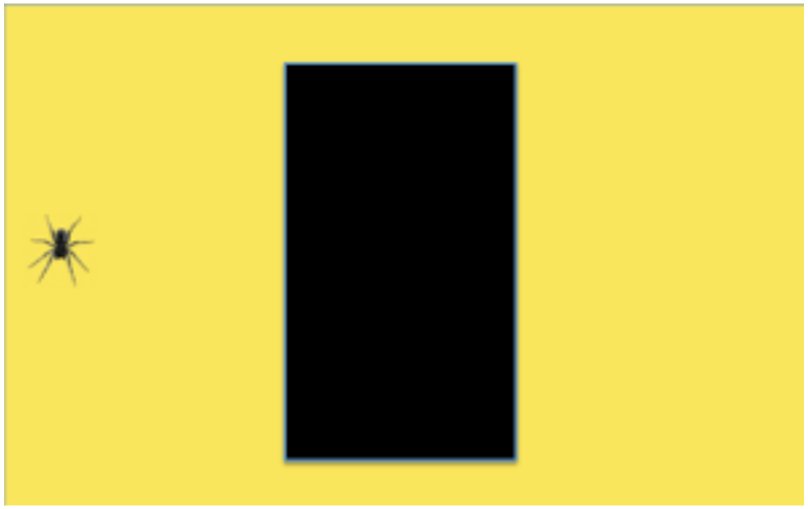

Figure 1. Test trials had a black occluder in the center of the screen and stimuli moved horizontally behind the occluder and across the screen.

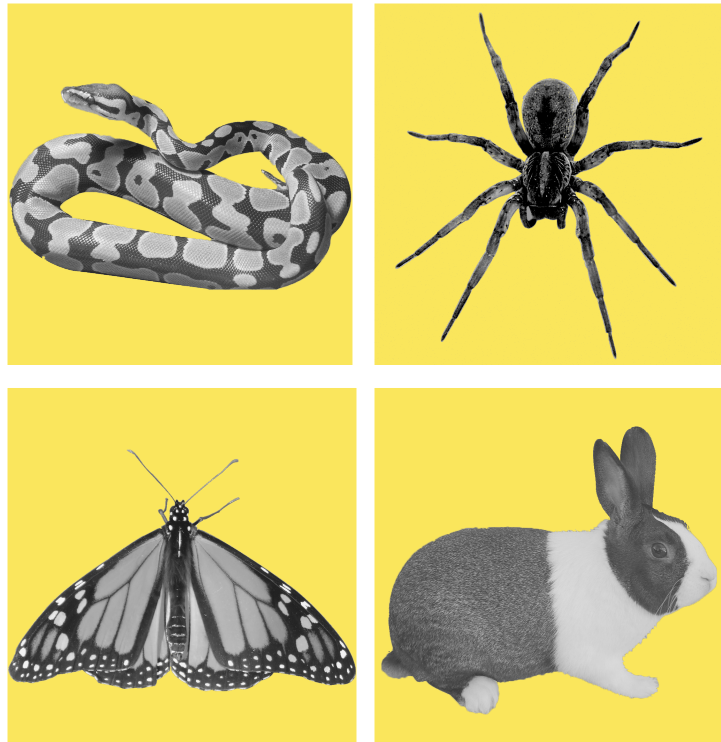

Figure 2. Threatening stimuli were the snake and the spider.
Nonthreatening stimuli were the butterfly and the rabbit.

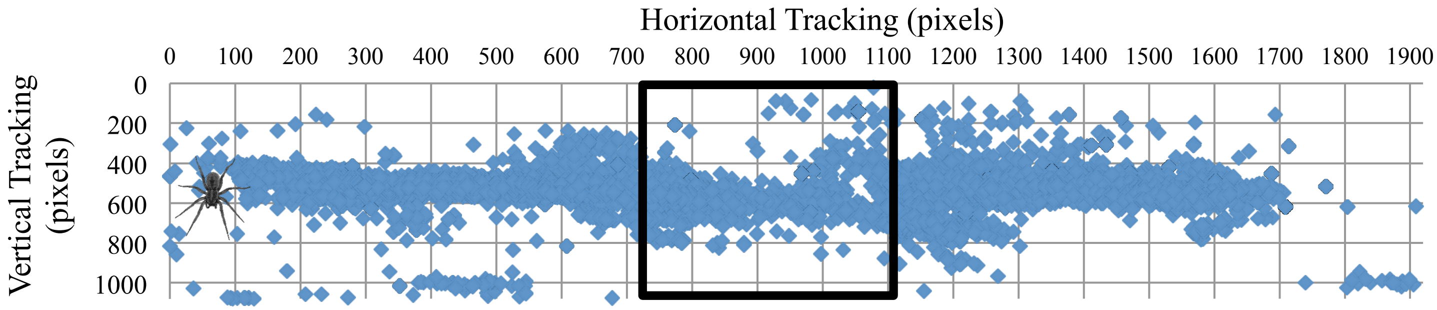

Figure 3. Example of one infant's tracking accuracy. Each data point represents the x and y coordinates of the infant's eye gaze on the screen every 10 miliseconds. The graph represents the length of the screen and the black box is the area of the screen that is occluded.

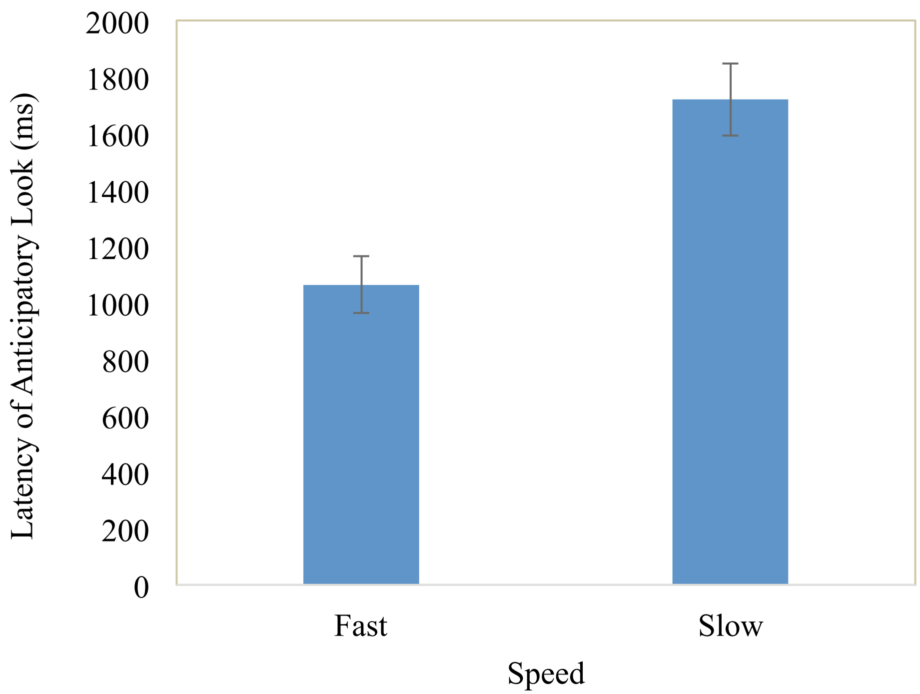

Figure 4. Latency of infants' anticipatory looks in miliseconds across speeds. Infants' gazes moved to the exit side of the occluder in anticipation of the image's re-appearance, earlier for faster moving images than for slower moving images.