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UNDERSTANDING EARLY PERCEPTUAL BIASES TOWARD THREATENING ANIMALS: A POSSIBLE PRECURSOR TO FEAR

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Abstract

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Snakes and spiders are common human fears, and are animals that posed a significant threat to survival throughout evolutionary history. It is possible that humans have evolved a predisposition to quickly detect and learn to fear these animals. Studies have shown that people demonstrate biased spatial perception toward snakes and spiders and, when searching for these animals, are able to locate them more quickly than they are able to locate nonthreatening animals. This perceptual bias is evident early in life, even before children display behavioral signs of fear, and it is possible that this bias may prepare children to learn to fear these animals later in life. The present study used a visual search task with 3-to-5 year old children to explore perceptual biases toward snakes and spiders and to examine individual differences in these biases. We also explored the association between child reaction time to locate threatening animals and parent fears of snakes and spiders. Our results showed that children found threatening animals significantly faster than they find nonthreatening animals, and that within the category of threatening animals, children located snakes faster than they located spiders. Reaction times to locate snakes were correlated with reaction times to find spiders. There was no correlation between parent fear and child reaction time. This study provides further support for perceptual biases toward evolutionarily threatening stimuli early in life.

Keywords: threat perception, fear, perceptual biases

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Understanding Early Perceptual Biases toward Threatening Animals: A Possible Precursor to Fear

Fear is a particularly significant emotion with the power to alert an individual to an impending threat and with the capacity to affect functioning, sometimes in very debilitating ways (Hirshfeld-Becker & Biederman, 2002; LoBue, 2012). Animals, in particular, are objects of fears and even full-fledged clinical phobias. For example, snakes and spiders are well-known common fears among non-clinical samples as well among the most common specific phobias, even in industrialized and urban areas where these animals are relatively uncommon (Becker et al., 2007; Fredrikson, Annas, Fischer, & Wik, 1996; LoBue, Rakison, & DeLoache, 2010). Nevertheless, snakes and spiders once posed a threat to human ancestors, so awareness and wariness of these stimuli would have been important for survival and may remain in modern humans, leading researchers to argue for an evolutionary basis of certain animal fears (Öhman & Mineka, 2001).

One view of fear acquisition suggests that people may have a neurological fear module based in the amygdala to facilitate reactions to evolutionarily significant threats (Öhman & Mineka, 2001). An automatic, unconscious system in a dedicated area of the brain would provide rapid detection of threats and swift associations between these stimuli and fear. This neurological system would have been adaptive throughout evolutionary history, allowing an individual to quickly process threats, thereby avoiding danger and surviving to reproduce. As evidence for such a fear module, researchers point to studies of rapid fear acquisition in both nonhuman primates and humans. Rhesus monkeys with no prior experience with snakes became fearful of them after watching another monkey demonstrate a fear response to an interaction with a snake, but not with a flower (Öhman & Mineka, 2001). Indeed, the animals’ fear response did not diminish after several months, suggesting a bias toward developing snake fear. Humans also learned to fear snakes and spiders more rapidly than they learned to fear neutral stimuli, and when conditioned to associate a shock with threatening or nonthreatening images, fear associations with the threatening stimuli were much more resistant to extinction than other stimuli (Öhman & Mineka, 2001).

While a fear module can help explain the high prevalence of fear toward snakes and spiders it does not address the issue of individual differences. In the fear module account, it would seem that if all individuals have the neurological module, then in general, all individuals who receive negative information about snakes or spiders should acquire fear responses to these animals (Öhman & Mineka, 2001). This is not the case. A more moderate view of the development of common animal fears suggests that there is a preexisting perceptual bias that facilitates later development of snake and spider fears (e.g., LoBue, 2012; LoBue et al., 2010). The enhanced perception of snakes and spiders leads to rapid detection of these animals, which then facilitates later learning to associate the animals with fear, a phenomenon described as "prepared learning" (Seligman, 1971).

Empirical studies provide support for perceptual biases toward threatening animals across species, in multiple paradigms, and across development. Shibasaki and Kawai (2009), for example, found that monkeys with no prior experience with snakes detected images of snakes faster in a visual search paradigm than images of flowers, showing heightened perceptual awareness of the animals. In studies with humans, accumulating evidence suggests differences in spatial perception and attention toward threatening and non-threatening stimuli. One study found that adults perceive looming images of snakes and spiders as approaching faster than non-threatening images, a bias which would allow the observer more time to avoid a threatening stimulus in a real-life encounter (Vagnoni, Lourenco, & Longo, 2012). Differences in attention toward snakes and spiders are also evident in studies that show that people searched systematically for non-threatening stimuli, such as flowers and mushrooms, by looking at each picture from one end of the array to another, but threatening stimuli had a “pop-out” effect, in which participants detected these animals without scanning each individual image (Öhman, Flykt, & Esteves, 2001).

The perceptual bias for evolutionarily relevant threatening stimuli causes humans to detect threatening images more rapidly than non-threatening ones (LoBue & DeLoache, 2008; LoBue, 2010; Öhman et al., 2001). When searching for a target animal in a 3 × 3 matrix of distractor images, human adults located a snake or spider in an array of distractors more rapidly than they detected flowers and mushrooms. These attentional differences favoring snake and spider perception would have been useful throughout evolutionary history to make potentially dangerous animals particularly salient, helping quickly alert an individual to the presence of a threat (Seligman, 1971).

Studies with young children suggest that perceptual biases appear early in life and before behavioral evidence of fear of snakes and spiders is evident, beginning as early as infancy (e.g., LoBue & DeLoache, 2008; LoBue & DeLoache, 2010; Rakison & Derringer, 2008). Evidence of heightened awareness of threatening stimuli across development provides support for a possible evolutionary influence, since infants and young children have little to no experience with snakes and spiders and therefore have not yet learned that these animals merit heightened attention and awareness (LoBue et al., 2010). Researchers have found that infants pay more attention to, and spend more time looking at, threatening stimuli than at nonthreatening stimuli (DeLoache & LoBue, 2009; LoBue & DeLoache, 2010, Rakison & Derringer, 2008). One such study discovered that 8-to- 14 month old infants oriented faster to snakes compared to non-threatening stimuli (LoBue & DeLoache, 2010). Additionally, infants looked longer at schematic drawings of spiders than at scrambled spider images or at other non-threatening images, thus paying more attention to the evolutionarily significant stimuli (Rakison & Derringer, 2008). At this young age, these responses are distinct from fear: while infants did not show any behavioral signs of fear when looking at threatening stimuli, they were able to associate threatening video stimuli with fear-relevant auditory stimuli (DeLoache & LoBue, 2009).

Since fear develops over ontogenetic time, it is necessary to examine perceptions of animals and attitudes toward animals throughout childhood. Once children reach an age where behavioral fear measures can be made, research shows that most preschool children enjoy interacting with live animals as well as looking at images of animals, indicating that most children have not yet acquired fears of snakes and spiders (LoBue, Pickard, Sherman, Axford, & DeLoache, 2013). Although preschoolers do not yet fear these animals, they do show perceptual biases toward snakes and spiders. In a similar visual search paradigm to that previously used with adults, researchers found that preschoolers detected snakes in a 3 × 3 array of distractor images faster than they detected flowers or non-threatening animals that resemble snakes, such as frogs and caterpillars (LoBue & DeLoache, 2008). Similarly, preschoolers in a separate study, detected spiders more rapidly than distractors such as cockroaches (LoBue, 2010). Taken together, results across studies with young children suggest that a perceptual bias toward snakes and spiders may exist before the development of fear for these threatening animals.

While humans may be evolutionarily predisposed to pay more attention to threatening stimuli, snakes and spiders must still become associated with fear. Models of fear acquisition include those that emphasize genetics, learning through classical conditioning or observation, or a combination of these factors (Rachman, 1977). In the case of genetics, it is possible that fears may emerge due to maturation of the nervous system alone, without influence from any outside factors (Menzies & Clarke, 1995). Twin studies with children and adults have shown that fears are, in fact, moderately heritable, but genetics may be associated with a general tendency toward fearfulness rather than specific fears and phobias (King, Muris, & Ollendick, 2000; Lichtenstein & Annas, 2000; van Houtem, Laine, Boomsma, Ligthart, van Wijk, & de Jongh, 2013). Genetic predispositions may be somewhat involved in acquisition of fear, but only to a limited extent (LoBue, 2012; Rachman, 1977).

If genetic influences only contribute moderately to fears, it is likely that learning is a significant component of fear acquisition (LoBue et al., 2010; LoBue, 2012; Rachman, 1977). Fear learning may include observational learning, in which one learns to fear a stimulus by watching others' negative experiences with it, or classical conditioning, in which the individual's own experiences condition him or her to fear (Rachman, 1977). Classical conditioning alone does not fully explain fear development, however, since many people do not report traumatic experiences as a factor in the development of their fears, which means that not all fears are learned from an association between a stimulus and a negative event (Mineka & Zinbarg, 2006; van Houtem et al., 2013). One study found that a majority of children did not cite a negative experience with fearful stimuli as a cause of their fear, suggesting that direct experience leading to animal fear may be uncommon (King et al., 2000). Another possibility, then, is that observational learning contributes to fear learning. Observational learning and transmission of information about fear from caregivers to children are important mechanisms for learning in general, and allow children to acquire information about threatening animals without direct experience (LoBue, 2012; Rachman, 1977).

Despite their putative role in fear acquisition, general learning mechanisms alone do not explain why fears appear to be non-randomly distributed (Seligman, 1971). The high prevalence of fears and phobias of certain evolutionarily relevant stimuli, such as snakes and spiders, suggests that fear learning to these stimuli may be privileged (Mineka & Zinbarg, 2006; Seligman, 1971). Perceptual biases facilitate rapid learning by increasing awareness of threatening stimuli and processing of these stimuli (LoBue et al., 2010). These biases may prepare particular stimuli, such as snakes and spiders, to become the objects of fear learning more easily than other, less salient, stimuli (Seligman, 1971). As previously described, observational learning specific to threatening animals has been observed in rhesus monkeys, which rapidly learned to fear snakes but did not learn to fear flowers when watching other monkeys (e.g., Mineka, Davidson, Cook, & Keir, 1984, as cited in Öhman & Mineka, 2001). The finding that conditioned fear responses to threatening stimuli are more resistant to extinction than conditioned fear responses to non-threatening stimuli are also supports the idea of prepared learning, since only the evolutionarily relevant threats maintained the conditioned fear response (Öhman & Mineka, 2001).

Although prepared fear learning due to perceptual biases toward threatening stimuli explains why certain animals, such as snakes and spiders, are more common fears than other animals, the concept of prepared learning does not address the issue of individual differences in fear. Degrees of snake and spider fears vary immensely from person to person, with some individuals showing no signs of fear at all (Mineka & Zinbarg, 2006). The matter of individual differences in fears is an important research question. Previous studies have found a relationship between potentiated perceptual biases and heightened fear, suggesting that these mechanisms affect each other in some way (Lonigan, Vasey, Phillips, & Hazen, 2004; Lourenco, Longo, & Pathman, 2011; Vagnoni et al., 2012; Vasey, El-Hag, & Daleidin, 1996). Individual perceptual differences, such as heightened perceptual biases, are associated with increased levels of anxiety overall (Lonigan et al., 2004). Heightened perceptual differences also correlate with individual differences in specific fears, such as claustrophobia and test anxiety as well as animal fears (Lourenco et al., 2011; Vasey et al., 1996). Previous studies have found that spider-fearful women located spiders in an image significantly faster than women who are not afraid of spiders, and snake or spider fearful participants (men and women) perceived the objects of their fears as even closer to them than nonfearful participants did (Peira, Golkar, Larsson, & Wiens, 2010; Vagnoni et al., 2012). Since adult differences in perceptions of threatening targets are correlated with differences in fear, there are important questions about how these associations develop. It is possible that similar individual differences in childhood perceptual biases may indicate future differences in fear.

While individual differences in fear have been previously examined in adults, individual differences in child reactions to animals have not been widely assessed. Although young children usually do not demonstrate behavioral signs of animal fear, it is possible that some early individual differences in animal perception may be noticeable. The present study seeks to assess these childhood individual differences, which may be related to later fears, and how these differences may relate to caregivers' attitudes towards animals. This aim will be accomplished by first replicating and extending the findings of previous developmental studies with preschoolers using a visual search task (e.g., LoBue & DeLoache, 2008) to ensure that children do, in fact, locate threatening stimuli faster than non-threatening stimuli. Subsequently, this study will examine individual differences among child reaction times to the different types of animal stimuli. Finally, the degree to which child differences in reaction time relate to their parents' trait fear of the same animals will be assessed to provide insight on the potential role of learning via parental attitudes in individual differences in children's perceptual biases.

To this end, the present study implements the visual search paradigm used in previous studies to assess participants' reaction times to find threatening stimuli (i.e., snakes and spiders) and to find non-threatening stimuli (i.e., frogs and butterflies). Previous studies have separately examined preschooler perception of only snakes or only spiders (LoBue, 2010; LoBue & DeLoache, 2008). In addition to investigating the overall differences in reaction times to threatening and non-threatening animals, the present research adopts a within-subjects design such that children's responses to snakes and spiders in the visual search task can be compared to each other. We will compare average reaction times to snakes and spiders to determine whether or not the perceptual bias effect is stronger for one threatening stimulus over the other.

In addition to determining if, on average, children react faster to snakes or to spiders, we will study the relationship between individuals' reaction times to locate snakes and to locate spiders. Since perceptual biases for snakes and spiders and fears of these animals are known to be related in adults (Vagnoni et al., 2012), it is expected that there should be a correlation in perceptual biases to snakes and spiders early in life. Obtaining data on reaction time to both snakes and spiders under the same experimental conditions may help to elucidate the individual differences in perception of threatening stimuli across multiple animals. Since previous studies with adults have shown that fearful adults show an exaggerated perceptual bias toward the objects of their fears (Gerdes & Alpers, 2013; Peira et al., 2010; Vagnoni et al., 2012), it is possible that similar individual differences in reaction time in children may indicate a trajectory toward future fear of these animals. Individual differences in child reaction time data will be assessed as a possible indicator of potential fear of snakes and spiders, since these factors are known to be related in adults (Gerdes & Alpers, 2013; Peira, 2010; Vagnoni et al., 2012).

A further research question is whether or not there is a correlation between child reaction time and parent fear of snakes and spiders. Such a relationship would suggest that information provided by caregivers may affect child perceptual biases. According to the prepared learning theory, it is possible that the children’s perceptual biases may make them more sensitive to information about fearful stimuli presented by parents, therefore affecting future fears.

Overall, we predict that children will locate target threatening animals in an array of distractor images faster than they will locate non-threatening target animals in similar arrays. In addition to replicating this finding from previous studies, we will address individual differences in reaction times by comparing reaction times specifically to snakes and spiders. Individual differences in child reaction time may indicate a higher likelihood of development of an animal fear later in life, providing information on acquisition of fears and early sensitivities to fear and possibly even providing a mechanism for early identification of potential future fears and perhaps even phobias. Finally, we will determine if there is a relationship between parent fears and child reaction times to investigate the possible role of observational learning in fear acquisition.

Method

Participants

Thirty-two 3- to 5-year-olds (*M* = 4.49 years, *SD* = 1.1 years, 15 males) participated in this study. In all cases, the caregiver that accompanied them to the laboratory also participated, filling out trait and state questionnaires of fear; in a minority of cases (*n* =12), a second caregiver also participated. An additional child (and her caregiver) was excluded from statistical analyses for failure to follow procedural instructions. All children received a small gift for their participation, and informed consent was provided by the primary caregiver. All procedures were approved by the Institutional Review Board at Emory University.

Tasks

All children were tested individually on a computerized visual search task, in which they were instructed to locate a target animal (e.g., snake) in an array of distractor images (e.g., frogs). Parents who accompanied children to the laboratory respond filled out trait questionnaires while the child participated, and then completed a state fear task following their child's participation in the visual search task.

Visual Search Task.

Materials. Following LoBue and DeLoache (2008), each trial on the visual search task consisted of a 3 × 3 matrix of animal photographs (see Figure 1). Each photograph measured 5.5 × 5.5 cm. Children were tested with a laptop computer (40 cm screen; Dell, Inc.), and sat approximately 40 cm away from the screen. The computer was fitted with a touch screen (Keytec, Inc.), which was used for responding. On each trial, children placed their hands on a set of foam handprints, which rested on a sturdy tray on top of the laptop keyboard. This served to minimize bias to a particular location onscreen.

Photographs belonged to one of two stimulus categories: threatening or non-threatening animals. Snakes and spiders comprised the threatening group, whereas frogs and butterflies comprised the non-threatening group. Photographs were obtained from an Internet search for the different animals. Each photograph was cropped and resized using Adobe Photoshop CS5 (Adobe Systems, San Jose, CA). Photographs consisted of a single animal, taking up most of the image, on a naturalistic background. Each animal type included exemplars of a variety of colors and photographs with both light and dark backgrounds.

We chose a bank of 48 photographs for each animal type (snakes, spiders, frogs, and butterflies) following ratings by 15 naïve raters who assessed how threatening each animal appeared. For each photograph, raters responded to the question “On a scale of 1 to 7, how threatening do you find this image?” Ratings were made using a Likert scale ranging from 1 (not at all) to 7 (extremely). The mean threat scores for the snake (M = 5.83, SD = .22) and spider images (M = 5.87, SD = .20) were not significantly different from each other, $t(28) = -.52$, $p > .05$. Although the frog images (M = 2.73, SD = .32) were rated as significantly more threatening than the butterfly images (M = 1.73, SD = .17), $t(28) =10.68$, $p < .005$, both frogs and butterflies were rated as less threatening than both snakes and spiders. Overall, the threatening images (M = 5.85, SD = .21) were rated as significantly more threatening than the non-threatening images (M = 2.23, SD =.56), $t(28) = 23.45$, $p < .005$.

Procedure. Each child participated in 4 blocks of trials, with each animal serving as the target in one block. There were 4 preliminary trials and 12 test trials in each block, for a total of 48 test trials overall. The target animal used in the first block of trials was counterbalanced across children and the subsequent blocks were presented in a random order. On a given test trial, 9 photographs were displayed in a 3 × 3 matrix on the computer. Each matrix contained 1 target image from one category (e.g., snakes) and 8 distractor pictures from another category (e.g., frogs).

At the start of each trial block, participants completed four preliminary trials to ensure familiarity with the animals and procedure. Each block of preliminary trials included two familiarization trials and two practice trials. In the familiarization trials, the relevant target image was presented with each distractor animal while the experimenter labeled the animals and asked the child if he knew what each animal was. In the practice trials, the target animal appeared in a

3 × 3 array with distractor images, just as it would in the test trials. Before each preliminary trial, a virtual red “start” box appeared centrally on screen. The experimenter touched the box with a stylus to initiate the next trial when the child was paying attention to the screen. In all trials, the child was asked to find the target animal as quickly as possible, touch it on the screen, and return his or her hands to the handprints. Feedback was provided to the participant following each of the preliminary trials. Images used in these trials were chosen randomly from the original sets of animal images.

Test trials followed the preliminary trials for each block. These were identical to the preliminary trials except no feedback on child performance was provided. The experimenter initiated each trial by touching the “start” box onscreen when the child was attentive and prompted the participant to “Find the ‘X’ (target).” A different picture matrix containing one target and eight distractors was presented on each trial.

When a threatening animal was the target (e.g., spider), a nonthreatening animal was the distractor (e.g., butterfly), and when a nonthreatening animal was the target (e.g., butterfly), a threatening animal was the distractor (e.g., spider). Snakes and spiders never appeared in the same matrix, and frogs and butterflies never appeared in the same matrix. Each of the 48 pictures in each target category could be randomly selected as the target no more than two times per block, and the location of the target animal within the array was randomized in each trial. Each of the 48 pictures in each distractor category was randomly selected and appeared multiple times throughout the trials, but never multiple times in the same trial.

Latency was automatically recorded by the computer program from the onset of the matrix to when the child touched one of the pictures on the screen. After completing all trials for each block, the child was offered a break and given the opportunity to select a sticker as a reward.

Fear measures.

Caregivers were given both trait and state measures for each of the target animals. Trait questionnaires were given to measure overall, stable attitudes toward animals, whereas state assessments provided individuals' immediate reactions when presented with animal stimuli. The trait questionnaires included the Fear of Spiders Questionnaire (FSQ), an 18 question measure in which participants rated their degree of agreement with various statements about spiders. The FSQ uses a Likert scale from 0 to 7, with 0 representing "Totally Disagree," and 7, representing "Totally Agree" (Szymanski & O'Donohue, 1995). Since there were no phobia questionnaires specifically constructed for frogs and butterflies, the FSQ was modified (FSQ-M) to create questionnaires about frogs and butterflies by replacing the word "spider" in each question with the names of the other animals. To assess fear of snakes, caregivers also completed the Snake Questionnaire (SNAQ), which contained 30 true/false statements about attitudes toward snakes. Both the FSQ and the SNAQ have acceptable psychometric properties. The FSQ has high internal consistency (Cronbach's $\alpha = .92$) and adequate test-retest reliability ($r = .63$ to .97 in different studies) (Szymanski & O'Donohue, 1995). The SNAQ has both high internal consistency (Cronbach's $\alpha = .78$ to .90 in different samples) and test-retest reliability ($r = .84$) (Fredrikson, 1983, as cited in Antony, Orsillo, & Roemer, 2001; Klorman, Hastings, Weerts, Melamed, & Lang, 1974).

Guardians who came to the lab completed a paper version of the trait questionnaire whereas caregivers who did not accompany their children on the day of testing completed the questionnaires online. In both the paper and online versions, the FSQ was presented first, followed by the SNAQ and the FSQ-M. Since the SNAQ was the only measure that was not a Likert scale rating, it was presented second to break up the series of rating questionnaires to avoid a fatigue effect.

For the state assessments, guardians watched individual videos of a snake, spider, frog, and butterfly, with each animal appearing in a separate video. After viewing each video, caregivers reported their subjective units of distress (SUDS) on a scale from 0 to 100, with 0 signifying no fear and 100 signifying extreme fear. Parents used the SUDS ratings to respond to questions such as "As you watched the video and saw the snake in the video, what was your level of fear?" The videos were between 11 and 13 seconds each, did not have any sound, and each showed a single animal moving slowly but not eating or displaying any aggressive behavior.

Results

The first goal of this study was to assess child reaction times (RTs) to locate threatening animals (i.e., snakes and spiders) and nonthreatening animals (i.e., frogs and butterflies) in a visual search task. Given previous findings, we expected that children would detect the threatening targets faster than the nonthreatening targets (LoBue & DeLoache, 2008). We initially computed the number of children who located threatening targets more rapidly than nonthreatening targets, and found that 81% of children showed the predicted effect (see Figure 2), and analyses showed that there was no significant difference in accuracy to locate threatening vs. nonthreatening stimuli, $t(31) = .016$, $p > .05$). We analyzed children's RTs on this task in a 2 (target stimulus: threatening vs. non-threatening) × 2 (gender: male vs. female) × 2 (median spilt: below vs. above median) analysis of variance (ANOVA). This analysis used a mixed design since the target stimulus factor was within subjects while age and gender were between subjects.

The ANOVA on latency to touch the target yielded a significant main effect of target stimulus, *F*(1, 28) = 13.28, *p* = .001, with children responding faster to threatening animals than non-threatening animals (see Figure 3). This analysis showed no significant effects of gender, *F*(1, 28) = .013, *p* = .78, or age, *F*(1, 28) = 2.83, *p* = .10. There were also no significant interactions (*p* > .05).

We subsequently analyzed the correlation between reaction times to the different threatening animals (snake RTs vs. spider RTs) and the correlation between RTs to the different nonthreatening animals (frog RTs vs. butterfly RTs). This analysis was performed to provide support for a perceptual bias specifically toward threatening animals and rule out an effect of general performance ability on reaction time. Correlations were computed using difference scores by subtracting the mean RT to the targets of the opposite category from the mean RT for the target of interest (e.g., the difference score for spiders was computed by subtracting the mean nonthreatening RT from the mean spider RT). There was a strong positive correlation between RTs to threatening animals, *r*(30) = .73, *p* < .001 (see Figure 4), but no correlation between RTs to nonthreatening animals, *r*(30) = -.24, *p* = .18 (see Figure 5). Even when age is accounted for, the correlation between snake and spider reaction times remained strongly positive, *r*(30) = .71, *p* < .001, and the correlation between frog and butterfly reaction times remained weakly negative, *r*(30) = -.24, *p* = .19, suggesting that faster reaction times to threatening stimuli are due to a bias toward these animals rather than a general performance effect.

Because it has been suggested that snakes were a greater evolutionary threat than spiders (Isbell, 2006) and may be detected faster than spiders (Öhman, Soares, Juth, Lindström, & Esteves, 2012), we conducted a follow-up analysis to test for differences between reaction times to different threatening animals. This analysis revealed that the relatively faster responses for threatening stimuli reported above were even stronger for snakes (*M* = -619.78, SD = 802.90) than spiders, (*M* = -385.01, *SD* = 868.22), *t*(31) = 2.14, *p* = .04, although, as reported above, both threatening animals were located faster than nonthreatening animals.

The second goal of our study was to analyze the relationship between child perceptual biases and parent fear scores, so we examined correlations between caregiver fear ratings and studied correlations between child RTs and parent fears. First, we computed correlations between caregiver trait fears of the different target animals. Since there was a low response rate for secondary caregivers (34%), this analysis included only data from the primary caregivers (see Table 1). There was a strong positive relationship between caregiver trait fear scores for snakes and spiders, *r*(30) = .44, *p* = .01, consistent with previous work (Vagnoni et al., 2012). Although we collected state data for all available caregivers, there was insufficient variability in the data to include these scores in further analyses (see Table 1).

We then examined the relationship between child RTs to particular target animals and parent fear scores to the same animals. There was a no significant relationship between parent fear scores on the snake trait questionnaire and children's reaction time to find target snakes, *r*(30) = -.07, *p* = .71. There was also a nonsignificant relationship between parent fear scores on the spider trait questionnaire and children's reaction time to find target spiders, *r*(30) = -.19, *p* = .29.

To summarize, there was a significant effect for type of stimuli on reaction time. Children located threatening stimuli faster than nonthreatening stimuli, although within the threatening stimuli category, they located snakes faster than spiders. There was a very strong positive correlation between snake RTs and spider RTs, and parent fears of snakes were positively correlated with fears of spiders. The data did not show a strong relationship between caregiver fear scores for threatening animals and child RTs to threatening stimuli.

Discussion

The aim of this study was to better understand factors that may lead to fears of snakes and spiders, including perceptual biases and individual differences in perception of these animals. The results from this study provide further evidence for the idea of an evolutionarily predisposed perceptual bias toward threatening animals. The significant difference between reaction times to locate threatening and nonthreatening stimuli replicates the previous findings of LoBue and DeLoache (2008), as well as strengthening the evidence for a perceptual bias toward evolutionarily significant threats through modifications to the original experimental paradigm. The use of only animate stimuli (i.e., frogs and butterflies) as distractor images provided strict controls, since previous studies using a visual search task compared animal stimuli with inanimate plant stimuli such as flowers or mushrooms. These inanimate stimuli differed from the threatening images on multiple dimensions, so using all animal stimuli with some similar characteristics (i.e., similarities between snakes and frogs, similarities between spiders and butterflies) provided an especially strong test for bias toward threatening stimuli rather than toward animal stimuli in general (LoBue & DeLoache, 2008; Öhman & Mineka, 2001).

This study was also the first to use a within-subjects design to compare responses to snakes and spiders in preschoolers. The use of a within-subjects design provides particularly strong evidence for a perceptual bias toward threatening animals. This experimental design allowed us to observe the relationship between relatively faster reaction times to locate spiders and snakes compared with frogs and butterflies. Both snakes and spiders would have been considerable threats throughout evolutionary history, so it would be expected that similar perceptual biases exist for both animals within an individual. Our data support this prediction, since there was a strong positive correlation between reaction time to locate snakes and spiders but no general response style, as indicated by the lack of correlation between time to locate frogs and time to locate butterflies. If reaction times for all animals were correlated within an individual, it would suggest that reaction times were determined by some kind of general ability, but this is not the case, which further supports the idea of perceptual biases toward evolutionarily significant threats.

While the data showed a general perceptual bias to detect threatening stimuli (snakes and spiders) faster than nonthreatening stimuli, we also found that snakes were detected significantly faster than spiders were. Snakes may be a stronger indicator of threat than spiders are, since snakes have constituted a more significant threat to humans and nonhuman primates throughout history than spiders have (Isbell, 2006). Previous studies have shown faster reaction times to locate snakes than to find spiders, suggesting that perceptual biases may be even stronger toward snakes than toward spiders (Öhman et al., 2012). In addition to being more threatening, it is possible that there are some physical features of snakes that make them even easier to perceive rapidly than spiders. Research has suggested that certain physical attributes of snakes may facilitate rapid detection by humans, such as their sinusoidal shape and their long, thin, limbless bodies (LoBue, 2008). One study found that participants located photographs of snakes in a striking posture faster than snakes in a resting posture, suggesting that specific attributes of the stimulus do affect reaction time and that more urgently threatening stimuli are processed faster than less immediately threatening stimuli (Masataka, Hayakawa, & Kawai, 2010). While some traits of spiders, such as their curvilinear bodies and arched limbs, have been proposed to activate a perceptual bias, there is less variability in the possible postures of spiders than of snakes (Rakison & Derringer, 2007). In the present study, the snake images included snakes in a variety of positions, including a small number of snakes in striking positions; while there were no images available for a spider analog of a striking position (see Figure 6). It is possible that these differences in perceptual features of snakes and spiders may have affected reaction times to locate threatening stimuli, since some of the snake images may have appeared more immediately threatening than the spider images.

This study also found a strong correlation between adult fears of spiders and snakes, which parallels the strong correlation in childhood reaction times toward these animals. Based on these results, it may be that responses to snakes and responses to spiders are correlated throughout development, in the form of perceptual biases during childhood and in the form of fears later in life. Based on the theory of prepared learning, it makes sense that both reaction times to threatening stimuli and fears of threatening stimuli are correlated, since the heightened effects on attention in childhood should put an individual on a trajectory toward later fear (Seligman, 1971). There is, however, currently no direct empirical data on causal direction, so we do not yet know the exact nature of the relationship between individual differences in perceptual biases and fears. It is possible that heightened perceptual biases lead to greater fear, or that fear can augment preexisting perceptual biases. The relationship between these factors potentially could be bidirectional, with perceptual biases causing a predisposition to fear, and then fear causing a further intensification of perceptual biases.

The current study also sought to provide information about a possible relationship between child individual differences in perceptual biases toward threatening animals and adult individual differences in fear. There are several possible explanations for the lack of correlation between child reaction time to threatening stimuli and parent fear of snakes and spiders.

Primarily, it is possible that evolutionary perceptual biases toward threatening animals exist independently of parent fears. The existence of perceptual biases toward snakes and spiders in infancy suggests that there is at least some component of these biases in existence before the child has time to obtain extensive information about these animals from caregivers. Since these biases are probably independent of caregiver fears in infancy, they may continue on their own trajectory toward fear throughout development with relatively little influence from parents.

It is also possible that a correlation between parents and children was not visible because fear questionnaire data from only one caregiver per child was analyzed. Although we did collect data from all caregivers possible, the low response rate for caregivers who were not present in the lab prevented us from using secondary caregivers' data in our analysis. We cannot assume that all caregivers for a given child would indicate the same amount of fear toward the target animals, and it is likely that different caregivers for a child have their own individual differences in fear. If caregiver fears are, in fact, associated with child perceptual biases, then all caregivers might contribute to this association rather than just the caregiver who brought the child into the lab.

It may be the case that there was not enough variation in intensity of parent fears of target animals to demonstrate a correlation with individual differences in child reaction time (see Figures 7 and 8). Only one adult scored high enough on the FSQ to be considered phobic, and only two respondents reported clinically significant levels of snake fear on the SNAQ (Gerdes & Alpers, 2013; Lueken et al., 2011). The majority of respondents reported very little fear of snakes and spiders, so this small amount of variability in parent fears may not account for the individual differences in child reaction times, since less variability leads to smaller *r* values (Goodwin & Leech, 2006).

The possible influences on the relationship between parent fears and child reaction time, such as number of caregivers surveyed and low variability in caregiver fear reports should be addressed in future studies. A larger sample size would also increase the power of the correlation analyses completed. In addition to addressing these limitations of the current study, future research could also expand upon the current understanding of early perceptual biases toward snakes and spiders and elucidate the relationship between child reaction times and development of fears later in life. If future studies do find a relationship between parental fears of snakes and spiders and child reaction times to these animals, this would suggest that caregiver attitudes may shape child biases toward animals, even before the child develops his own explicit animal fears. It is also possible that caregiver fears may also exaggerate already pronounced perceptual biases in children.

To further explore the association between child reaction times to locate threatening animals and fears later in life, a longitudinal study should be conducted. Such a study would be instrumental in assessing whether or not a particularly pronounced early perceptual bias toward an animal predicts whether or not later in life the child will develop a fear of that animal. In addition to predicting the existence of later fear, a longitudinal study could also help determine the degree to which individual differences in perceptual biases toward an animal predict future severity of fear. For example, this research may determine if an extremely fast reaction time to locate spiders in early childhood is indicative of a future phobia of spiders, or if a faster reaction time provides a more general indicator of development of some level of fear. Directly comparing reaction times to threatening stimuli in early childhood and animal fears later in development within the same child would provide the best indicator of whether or not increased early perceptual biases lead to later fears.

A related research question that necessitates future investigation is whether or not there are particular visual features of snakes and spiders that may facilitate rapid detection. As previously mentioned, there may be particular attributes of threatening animals that rapidly attract visual attention. While the current study provides support for a bias toward rapid perception of snakes and spiders, which may be elevated to an even greater degree in snakes, further studies should explore the specific traits of these animals that swiftly attract attention. Information about specific perceptual cues of threatening stimuli could help reveal a neurological pathway for perceptual biases, since such spatial cues may provide information about the specific regions of the brain involved in perceiving the stimuli and activating the perceptual bias.

In addition to strengthening evidence of an evolutionary perceptual bias in humans, the current study provides an avenue for future research that may be useful in developing a better understanding of fear in general as well as elucidating some attributes of clinical phobias. Since fear is a particularly salient human emotion and has been significant throughout evolutionary history, it is important to understand this universal and basic emotion and its role in daily life (Ekman, 1999; LoBue, 2012). Persistent fears, such as those of snakes and spiders, can be very unpleasant, especially in the case of clinically significant phobias, which can cause significant distress and impairment in daily functioning (American Psychiatric Association, 2013). Specific phobias are the most common mental disorder in women and are frequently comorbid with other psychological disorders. Within the category of specific phobias, animal phobias, such as those of snakes and spiders, are most common, so are of particular research interest (Becker et al., 2006).

Investigation of possible precursors to fear and phobias, such as perceptual biases, and mechanisms for fear acquisition, such as observational learning, may help inform methods of future fear and phobia detection and treatment. Such research may be useful for early targeting of children in need of treatment for animal fears. If the possible association between individual differences in child perceptual biases and future fear is supported by continued investigations, screening for exceptionally pronounced perceptual biases toward threatening animals in children may provide a method to reliably recognize early signs of fears and phobias. Since these perceptual biases appear earlier in life than behavioral markers of fear, interventions could be implemented for individuals with abnormally heightened perceptual biases to help them avoid development of debilitating phobias (LoBue, 2012). Researchers have found that behavioral and cognitive-behavioral treatments for phobias are effective in children, so implementing these treatments as early as possible could be useful to reduce severe fears and phobias (Ollendick & King, 1998).

This study provides strong evidence for a perceptual bias toward evolutionarily threatening stimuli beginning early in life. Almost all children tested located both snakes and spiders significantly faster than frogs and butterflies, even when using particularly stringent distractor images and comparing a child’s reaction times to locate snakes with the same child’s reaction times to locate spiders. The perceptual biases demonstrated in this study may affect later development of some of the most common fears, which could explain why fears of snakes and spiders are so common. Furthermore, the current study demonstrated the existence of individual differences in perception of threatening animals in children, which has previously been shown in adult fears. While the children in this study do not yet show behavioral signs of fear, they do show individual differences in perceptual biases toward these animals. Finally, the results from this study suggest that some component of perceptual biases toward evolutionarily threatening stimuli may exist independently of learning and may later account for fear throughout the lifespan. While future studies are necessary to fully examine the relationship between child individual differences in perceptual biases and the development of subsequent fear, the current study provides a strong introduction to this research.

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). Arlington, VA: American Psychiatric Publishing.

Antony, M. M., Orsillo, S. M., & Roemer, L. (Eds.). (2002). *Practicioner's Guide to Empirically Based Measures of Anxiety*. New York: Kluwer Academic Publishers.

Becker, E.S., Rinck, M., Türke, V., Kause, P., Goodwin, R., Neumer, S., & Margraf., J. (2007). Epidemiology of specific phobia subtypes: Findings from the Dresden Mental Health Study. *European Psychiatry, 22,* 69-74.

DeLoache, J. S., & LoBue, V. (2009). The narrow fellow in the grass: Human infants associate snakes and fear. *Developmental Science, 12*(1), 201-207.

Ekman, P. (1999) Basic Emotions. In T. Dalgleish and M. Power (Eds.), *Handbook of Cognition and Emotion* (45-60). John Wiley & Sons, Ltd, Chichester, UK.

Fredrikson, M., Annas, P., Fischer, H., Wik, G. (1996). Gender and age differences in the prevalence of specific fears and phobias. *Behavior Research and Therapy, 34*(1), 33-39.

Gerdes, A. B. M., & Alpers, G. W. (2013). You see what you fear: Spiders gain preferential access to conscious perception in spider-phobic patients. *Journal of Experimental Psychopathology.* Advance online publication. doi: 10.5127/jep.033212

Goodwin, L. D., & Leech, N. L. (2006). Understanding correlation: Factors that affect the size of *r. The Journal of Experimental Education, 74*(3), 251-266.

Hirshfeld-Becker, D. R., & Biederman, J. (2002). Rationale and principles for early intervention with young children at risk for anxiety disorders. *Clinical Child and Family Psychology Review, 5*(3), 161-172.

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

King, N., Muris, P., & Ollendick, T. H. (2000). Specific phobias. In Morris, T. L., & March, J.S., eds. *Anxiety Disorders in Children and Adolescents* (263-279). New York: Guilford.

Klorman, R., Weerts, T. C., Hastings, J. E., Melamed, B. G., & Lang, P. J. (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy, 5,* 401-409.

Lichtenstein, P., & Annas, P. (2000). Heritability and prevalence of specific fears and phobias in childhood. *Journal of Child Psychology, 41*(7), 927-937.

LoBue, V. (2010). And along came a spider: An attentional bias for the detection of spiders in young children and adults. *Journal of Experimental Child Psychology, 107*, 59-66.

LoBue, V. (2012). What are we so afraid of? How early attention shapes our most common fears. *Child Development Perspectives, 7*(1), 38-42.

LoBue, V., & DeLoache, J. S. (2008). Detecting the snake in the grass: Attention to fear-relevant stimuli by adults and young children. *Psychological Science, 19*(3), 284-289.

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

LoBue, V., Pickard., M. B., Sherman, K., Axford, C., & DeLoache, J. S. (2013). Young children's interest in live animals. *British Journal of Developmental Psychology, 31,* 57-69.

LoBue, V., Rakison, D. H., & DeLoache, J. S. (2010). Threat perception across the life span: Evidence for multiple converging pathways. *Current Directions in Psychological Science, 19*(6), 375-379.

Lonigan, C. J., Vasey, M. W., Phillips, B. M., & Hazen, R. A. (2004). Temperament, anxiety, and the processing of threat-relevant stimuli. *Journal of Clinical Child and Adolescent Psychology, 33*(1), 8-20.

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

Lueken, U., Kruschwitz, J. D., Muehlhan, M., Siegert, J., Hoyer, J., & Wittchen, H. U. (2011). How specific is specific phobia?: Different neural response patterns in two subtypes of specific phobia. *Neuroimage, 56*(1), 363-372.

Masataka, N., Hayakawa, S., & Kawai, N. (2010). Human young children as well as adults demonstrate 'superior' rapid snake detection when typical striking posture is displayed by the snake. *PLoS One*, *5*(11), e15122.

Menzies, R. G., & Clarke, J. C. (1995). The etiology of phobias: A nonassociative account. *Clinical Psychology Review, 15*(1), 23-48.

Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist, 61*(1), 10-26.

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

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

Öhman, A., Soares, S. C., Juth, P., Lindström, B., & Esteves, F. (2012). Evolutionary derived modulations of attention to two common fear stimuli: Serpents and hostile humans. *Journal of Cognitive Psychology, (24)*1, 17-32.

Ollendick, T. H., & King, N. J. (1998). Empirically supported treatments for children with phobic and anxiety disorders: Current status. *Journal of Clinical Child Psychology, 27*(2), 156-167.

Peira, N., Golkar, A., Larsson, M., & Wiens, S. (2010). What you fear will appear: Detection of schematic spiders in spider fear. *Experimental Psychology, 57*(6), 470-475.

Seligman, M. E. P. (1971). Phobias and preparedness. *Behavior Therapy, 2*, 307-320.

Shibasaki, M., & Kawai, N. (2009). Rapid detection of snakes by Japanese monkeys (Macaca fuscata): An evolutionary predisposed system. *Journal of Comparative Psychology, 123,* 131-135.

Szymanski, J., & O'Donohue, W. (1995). Fear of Spiders Questionnaire. *Journal of Behavior Therapy and Experimental Psychiatry, 26*(1), 31-34.

Rachman, S. J. (1977). The conditioning theory of fear acquisition: A critical examination. *Behavior Research and Therapy, 15,* 375-387.

Rakison, D.H., & Derringer, J. (2008). Do infants possess an evolved spider-detection mechanism? *Cognition, 107*(1), 381-393.

Vagnoni, E., Lourenco, S. F., & Longo, M. R. (2012). Threat modulates perception of looming visual stimuli. *Current Biology, 22*(19), 826-827.

van Houtem, C. M. H. H., Laine, M. L., Boomsma, D. I., Ligthart, L., van Wijk, A. J., & de Jongh, A. (2013). A review and meta-analysis of the heritability of specific phobia subtypes and corresponding fears. *Journal of Anxiety Disorders, 27*, 379-388.

Vasey, M. W., El-Hag, N., & Daleidin, E. L. (1996). Anxiety and the processing of emotionally threatening stimuli: Distinctive patterns of selective attention among high and low test-anxious children. *Child Development, 67*(3), 1173-1185.

Tables and Figures

Table 1

Caregiver Questionnaire Responses

	Trait Questionnaire Responses				State Questionnaire Responses			
Target Animal	Mean		SD		Mean		SD	
	Score	%	Score	%	Score	%	Score	%
Snakes	12.81	24.48%	6.64	22.12%	64.44	21.48%	67.75	22.58%
Spiders	7.34	10.17%	17.89	14.20%	57.78	19.26%	64.76	21.59%
Frogs	6.66	5.28%	9.87	7.84%	8.75	2.92%	21.18	7.06%
Butterflies	2.44	1.93%	2.97	2.36%	1.72	0.57%	8.85	2.95%

Note. The highest score possible for the snake trait questionnaire was 30 points, the highest score possible for the spider, frog, and butterfly questionnaires was 126 points, and the highest score possible for all state questionnaires was 300 points.

Figure 1. Experimental design for current study. Adapted from a visual search task paradigm used with preschoolers (LoBue & DeLoache, 2008), children were presented with a 3×3 matrix of images that included one target image (in this case, a snake) and eight distractor images (in this case, butterflies). Children were instructed to locate the target image as fast as possible and touch it on the touch screen. This figure also shows the tray with foam handprints placed over the keyboard for each child to rest his hands on between trials. Image sources are listed in Appendix.

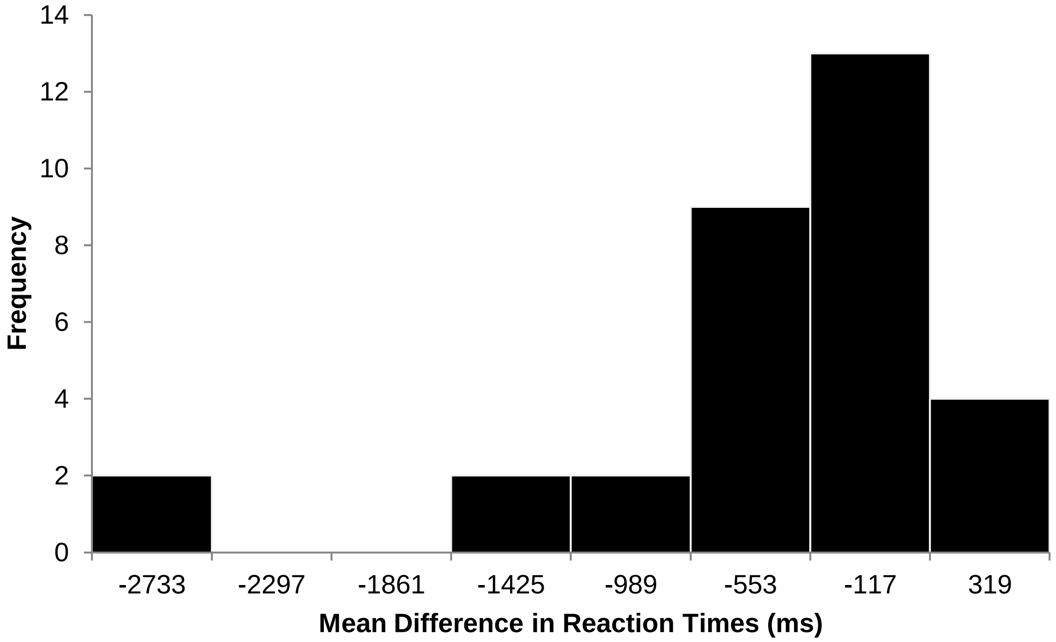

Figure 2. Distribution of individual mean reaction time difference scores. This histogram shows the difference in mean reaction times to locate threatening and non-threatening targets for each individual, computed by subtracting non-threatening target reaction time from threatening target reaction time. Negative difference scores indicate a faster reaction time to locate threatening images than non-threatening images. Most individuals located snake and spider targets faster than frog and butterfly targets.

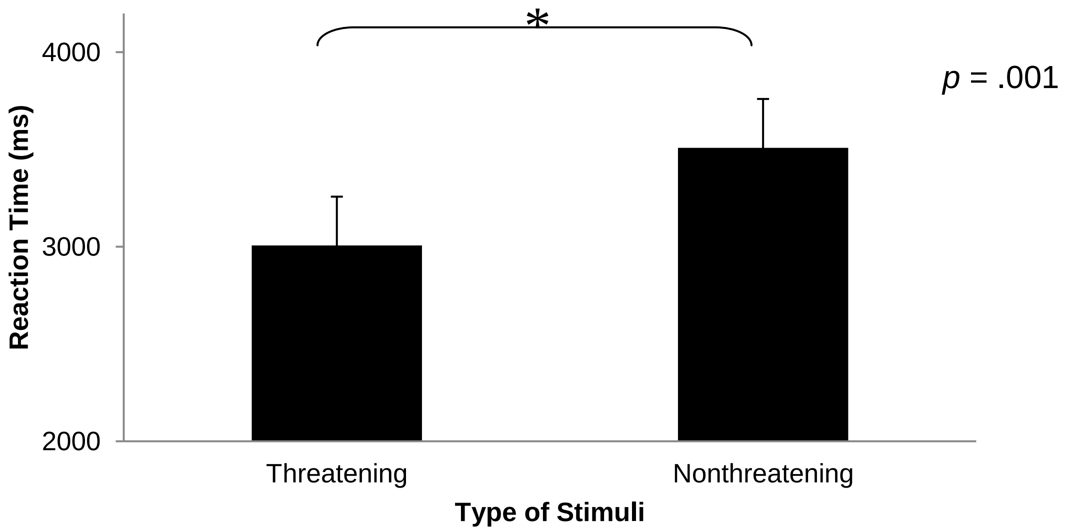

Figure 3. Mean child reaction times to locate target images of different stimuli categories. This figure illustrates the significant difference between mean reaction time to locate a threatening stimulus (i.e. snakes, spiders) and mean reaction time to locate a non-threatening stimulus (i.e., frogs, butterflies). Time to locate a threatening stimulus was much faster than time to locate a non-threatening stimulus.

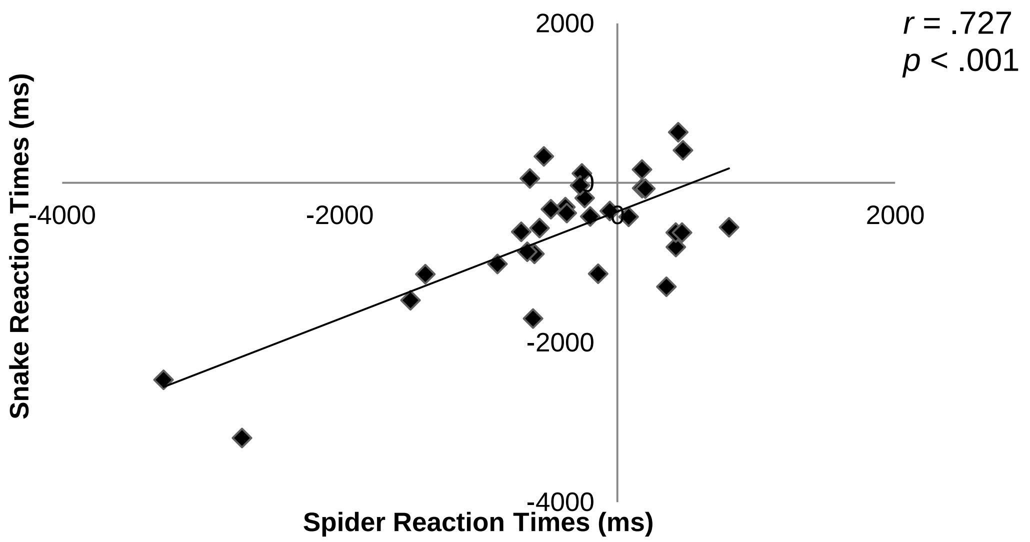

Figure 4. Relationship between child reaction times to locate snakes and spiders. This figure shows the correlation between difference scores computed for mean reaction time to spiders and mean reaction time to snakes. These difference scores were computed by subtracting mean reaction time to threatening animals from mean reaction time to each threatening target animal. Latency to find spiders increased with latency to locate snakes in a strongly positive correlation, showing an association between reaction times to locate both threatening stimuli.

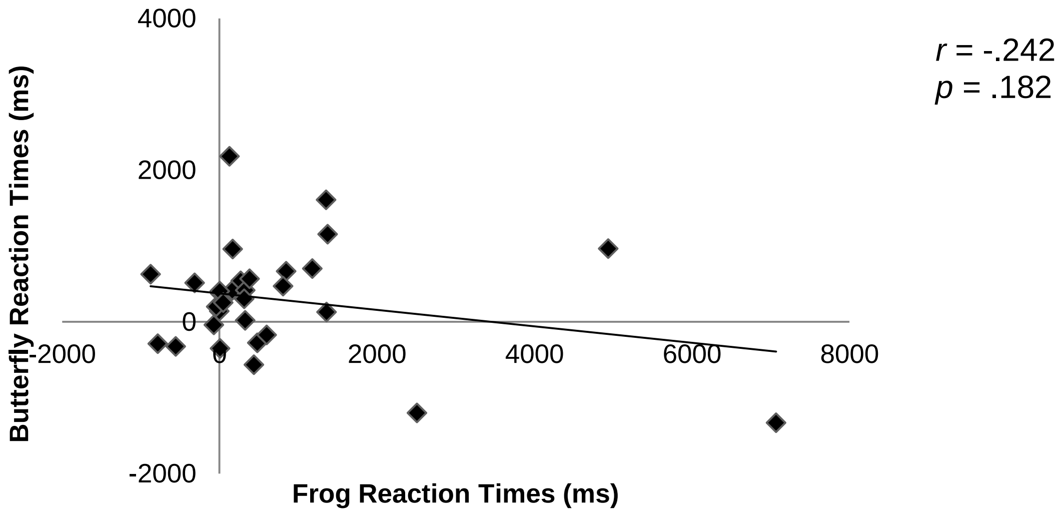

Figure 5. Relationship between child reaction times to locate frogs and butterflies. This figure shows that there is no strong correlation between difference scores computed for mean reaction time to frogs mean reaction times to butterflies. These difference scores were computed by subtracting the mean reaction time for threatening animals from the mean reaction time for each non-threatening stimulus. Latency to find frogs and latency to locate butterflies show a weak correlation and no significant association.

Figure 6. Example images of snake and spider stimuli similar to those used in the child search task. Based on the nature of the animals used, there was more variation in the position of snakes in snake images than of the position of spiders in spider images. Some snake images included snakes in a striking posture, while no analogous striking posture exists for spiders. Image sources are listed in Appendix.

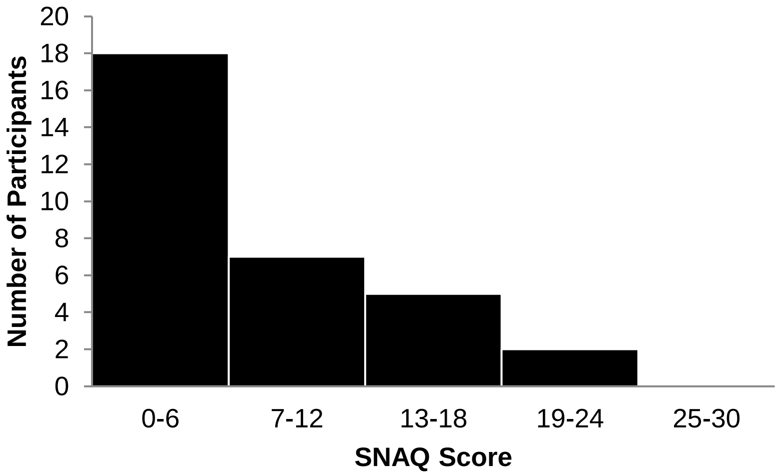

Figure 7. Distribution of caregiver scores on SNAQ trait fear measure. Most participants scored low on this measure, with only two participants scoring above the criterion score of 20 for a clinically relevant phobia (Lueken et al., 2011). The maximum score possible on the SNAQ was 30 points.

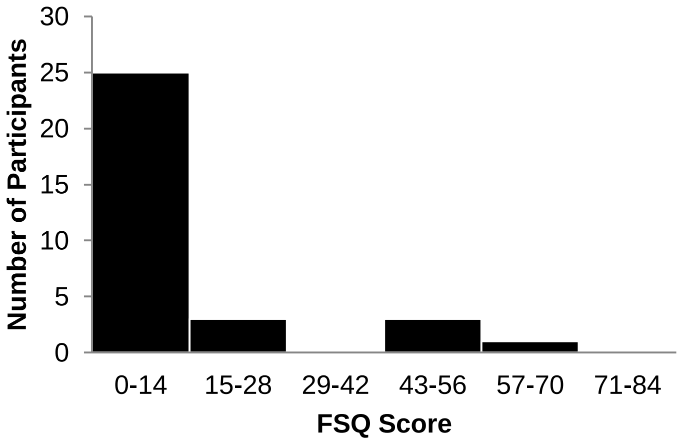

Figure 8. Distribution of caregiver scores on FSQ trait fear measure. Most participants scored very low on this measure with very little variability in scores, with 78% of participants scoring 14 points or lower out of a maximum 126 points possible. Only one participant scored above 61 points, which is the criterion score to be considered spider phobic (Gerdes & Alpers, 2013).

Appendix

Original Sources for Animal Images in Figures[1]

Anonymous. (2009). *Pointing hand* [Clipart image]. Retrieved April 14, 2014 from: http://openclipart.org/detail/ 24382/pointing-hand-by-anonymous-24382

Bittner, Zack. (2005). *Mexican X Louisiana milk snake intergrade* [Photograph]. Retrieved April 12, 2014 from: https://www.flickr.com/photos/zackbittner/139537941/in/photolist-4QHCq3-6qTBp8-dkaLz-Bo4L9-7Ak1r2-4QHxx5-9nDHeW-Bo4Jm-9nAEZc-4QHE2u-4gCwkT-87bVkD-m6qxD-4QDjoP-fqWRaN-8dDUJA-7DoCwo-4UDFoj-4J3F3j-eWmwaz-9h31EF-77k3bK-6zTDGT-9h31Qz-j4BpY-j4B1x-m6q8s-j4Bo3-73Um1W-6ug5X7-6gqjax-m6pZ5-m6qdc-j4AX2-j4AW6-j4Bhk-j4AZF-m6qbQ-j4B2k-j4B3k-m6qzM-j4Bmh-9nQPRL-j4B8A-j4BkB-m6oGy-m6qqt-29xRkq-9nQQZL-9Rw3pz

GLady. (2012). *Papilio rumanzovia butterfly animal black green* [Photograph]. Retrieved April 12, 2014 from: http://pixabay.com/en/papilio-rumanzovia-butterfly-animal-44882/

Hartgroves, W. (2005). *Vanessa tameamea1* [Photograph]. Retrieved April 12, 2014 from: http://en.wikipedia.org/wiki/File:Vanessa_tameamea1.jpg

Helland, F. I. (2006). *Spider Araneus diadematus.* [Photograph]. Retrieved April 12, 2014 from: http://commons.wikimedia.org/wiki/File:Spider_Araneus_diadematus.jpg

Hisgett, T. (2010). *Brown butterfly (4611211643).* [Photograph]. Retrieved April 12, 2014 from: http://commons.wikimedia.org/wiki/File:Brown_Butterfly_(4611211643).jpg

Horváth, D. (2004). *Haplopelma lividum* [Photograph]. Retrieved April 12, 2014 from: http://commons.wikimedia.org/wiki/File:Haplopelma_lividum.jpg

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Jurvetson, S. (2007). *Coast garter snake* [Photograph]. Retrieved April 14, 2014 from: http://en.wikipedia.org/wiki/File:Coast_Garter_Snake.jpg

Kattekrab. (2008). *Hand prints* [Clipart image]. Retrieved April 14, 2014 from: http://openclipart.org/detail/16340/hand-prints-by-kattekrab-16340

Mozaffari, O. (2011). *Naja oxiana IMG 9612* [Photograph]. Retrieved April 13, 2014 from http://en.wikipedia.org/wiki/File:Naja_oxiana_IMG_9612.JPG

Myers, J. (2011). *Wasp spider, Argiope bruennichi* [Photograph]. Retrieved April 12, 2014 from http://www.geograph.org.uk/photo/2532412

Nemo. (2012). *Computer laptop cartoon silhouette electronics* [Clipart image]. Retrieved April 14, 2014 from: http://pixabay.com/en/computer-laptop-silhouette-cartoon-24890/

Shazz. (2009). *Meadow brown butterfly by footpath in Verdley Wood* [Photograph]. Retrieved April 12, 2014 from http://commons.wikimedia.org/wiki/File:Meadow_Brown_butterfly_by_footpath_in_Verdley_Wood_-_geograph.org.uk_-_1409673.jpg

Tigerhawkvok. (2008). *Crotalus cerastes mesquite springs CA* [Photograph]. Retrieved April 14, 2014 from: https://en.wikipedia.org/wiki/File:Crotalus_cerastes_mesquite_springs_CA.JPG

Trapp, B. n.d. *Benny Trapp Rhinechis scalaris Portugal* [Photograph]. Retrieved April 13, 2014 from: https://commons.wikimedia.org/wiki/File:Benny_Trapp_Rhinechis_scalaris_Portugal.jpg

Warby, W. (2012). *Monarch butterfly* [Photograph]. Retrieved April 12, 2014 from: https://www.flickr.com/photos/wwarby/8190406715/

Warby, W. (2009). *Numata longwing butterfly* [Photograph]. Retrieved April 12, 2014 from: https://www.flickr.com/photos/wwarby/3895138075/

West, L. (2010). *Green butterfly on green* [Photograph]. Retrieved April 12, 2014 from: http://commons.wikimedia.org/wiki/File:Green_butterfly_on_green.jpg

Yankech, G. (2013). *Wolf spider-Alopecosa aculeata male?* [Photograph]. Retrieved April 12, 2014 from: https://www.flickr.com/photos/49663413@N08/9098886172/