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Do 5-Month-Old Infants Possess an Evolved Detection Mechanism for Snakes, Sharks, and Rodents?

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ABSTRACT

The 4 experiments reported here used the preferential looking and habituation paradigms to examine whether 5-month-olds possess a perceptual template for snakes, sharks, and rodents. It was predicted that if infants possess such a template, then they would attend preferentially to schematic images of these nonhuman animal stimuli relative to scrambled versions of the same stimuli. The results revealed that infants looked longer at a schematic snake than at 2 scrambled versions of the image and generalized from real snakes to the schematic image. The experiments also demonstrated that 5-month-olds showed no preferential looking for schematic sharks or schematic rodents relative to scrambled versions of those images. These data add to the growing support for the view that humans, like many nonhuman animals, possess an evolved fear mechanism for detecting threats that were recurrent across evolutionary time.

All species face adaptive problems that need to be solved for an organism to survive and reproduce. The adaptations that have emerged to overcome these problems were designed by natural selection and are often specific to the environment in which they evolved. One adaptive problem that is critical to survival is avoiding dangerous nonhuman threats: Those who fail to avoid such threats risk injury or death and consequently are unable to reproduce. Despite a significant database concerning the presence of these mechanisms in nonhuman animals (e.g., Kats, Petranka, & Sih, 1988; Kiesecker, Chivers, & Blaustein, 1996), only recently have researchers begun to examine how they might operate in humans.

There are currently three main models of fear acquisition. According to one view labeled the *general learning model*, fear is acquired through domain-general mechanisms such as classical conditioning and indirect learning, observation, and socially transmitted information (Rachman, 1977). Although there is considerable evidence for this model (for a review, see LoBue & Rakison, 2013), it fails to account for why humans' fears are commonly of recurrent evolutionary threats such as heights, spiders, and enclosed spaces. According to a second view labeled the *nonassociative model*, in addition to the three pathways outlined by the domain-general view, fear is also acquired through domain-specific mechanisms such that fear develops early in life and potentially without experience with the fear-invoking stimulus (Poulton &

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Menzies, 2002). There is empirical research to support this model, but it mostly relies on retrospective reports (e.g., Menzies & Clarke, 1993) and it has focused on direct conditioning experience while overlooking the role of indirect pathways through which fear is acquired.

According to a third view, which combines aspects of both the general learning and nonassociative models, humans and nonhuman primates are "prepared" (Seligman, 1971) to learn to fear evolutionary recurrent threats. As a result, it has been proposed that the ability to acquire fears of these threats is privileged and consequently rapid (LoBue, Rakison, & DeLoache, 2010; Öhman & Mineka, 2001; Rakison, 2005, 2009; for a review, see LoBue & Rakison, 2013). According to Rakison (LoBue & Rakison, 2013, 2009; Rakison & Derringer, 2008), this mechanism has two components: The first causes individuals to rapidly attend to fear-relevant stimuli when they are in the surrounding environment; the second facilitates learning of an association between the threat and the appropriate response—avoidance, for example—which is typically acquired as a result of personal negative experience or through social learning via observation of a conspecific's reaction (Barrett & Broesch, 2012; Barrett, Peterson, & Frankenhuis, 2016). In conjunction, these two components of the specialized fear mechanism mean that humans are "prepared" rapidly to learn appropriate behavioral and emotional responses for evolutionarily relevant stimuli (Öhman & Mineka, 2003; Rakison, 2009; Seligman, 1971). There is now growing evidence from work with adults and infants to support the existence of both these components. For example, human adults and 3-year-old children detected snakes and spiders against a background of non-fear-relevant stimuli (e.g., flowers and mushrooms) more quickly than they detected fear-irrelevant stimuli against a background of snakes and spiders (LoBue & DeLoache, 2008; Öhman, Flykt, & Esteves, 2001). These findings were supported by a recent study by New and German (2015) who found that adults in an inattentional blindness paradigm detected, localized, and identified iconic spiders and were less likely to perceive stimuli with different configurations of the same features, modern threatening stimuli such as a hypodermic needle, or fear-irrelevant nonhuman animals like houseflies. Finally, infants aged 7 to 9 months as well as 11 months of age showed evidence that they readily associated fearful facial and auditory cues with recurrent threats but did not do so for fear-irrelevant stimuli (DeLoache & LoBue, 2009; Rakison, 2009).

One explanation for infants' selective attention for recurrent threats—the first component of the fear mechanism—is that they possess an evolved perceptual template that specifies these threats' basic shape and configuration (Rakison, 2005; Rakison & Derringer, 2008). A mechanism that biases infants to attend to recurrent threats must include a basic mental representation that corresponds with the images of those threats in the real world. Although there is evidence that newborns possess such a mental representation—or *perceptual template*—for faces (Johnson, Dziurawiec, Ellis, & Morton, 1991; Morton & Johnson, 1991), to date, only one series of studies with infants has tested this explanation for infants' preferential attention to recurrent evolutionary threats. In one experiment, Rakison and Derringer (2008) presented 5-month-old infants with three schematic images of spiders that moved horizontally back and forth across a computer screen. One image was a schematic spider, a second was the same schematic spider except that it had reconfigured features, and a third was a linear image of the spider that was completely scrambled. It was predicted that if 5-month-olds possess a perceptual template for spiders, they would look longer at the schematic spider stimulus than the other two reconfigured stimuli; this pattern of looking was generated by infants in the experiment.

Subsequent experiments revealed that infants did not show the same effect for nonthreatening stimuli such as flowers or for square rather than curvilinear schematic spiders. A final experiment tested whether 5-month-olds' perceptual template generalizes to spiders in the real world. Infants were habituated to color photos of spiders and were then shown the three schematic images of spiders from the first experiment. Results revealed that infants showed a reversal of the pattern of looking in the first experiment; that is, they looked longer at the two reconfigured images than at the schematic spider, which suggests that they generalized from the real images of spiders and found the schematic image was familiar. These results suggest that infants may possess a perceptual template for spiders that specifies their shape and the location of their features (e.g., legs).

It remains to be seen, however, whether human infants possess a perceptual template for other recurrent evolutionary threats. This issue is important to address because to date, there exists evidence only to support the view that infants possess a perceptual template for faces and spiders (Morton & Johnson, 1991; Rakison & Derringer, 2008). However, implicit in the theory that there exists a two-part fear-learning mechanism is the notion that infants should possess a perceptual template for a number of recurrent evolutionary threats. However, it is difficult to identify for which recurrent threats humans may have evolved a perceptual template because it requires assumptions to be made about which nonhuman animals were particularly dangerous to ancestral humans. One approach in this regard is to determine which nonhuman recurrent threats are overly represented in clinical fears and phobias because one implication of the prepared-learning perspective is that fear of these stimuli should develop quickly and will be long-lasting (LoBue & Rakison, 2013). A second approach is to analyze the number of fatalities that occur currently from nonhuman recurrent threats, although this method assumes that current fatalities from nonhuman recurrent threats are analogous to fatalities for ancestral humans.

Based on these two criteria, one likely candidate for a perceptual template is snakes. Fear of snakes is among the most common found in adults and children and occurs in approximately 5.5% of the population (compared with 3.5% for spiders; Fredrikson, Annas, Fischer, & Wik, 1996). Venomous snake bites also cause a relatively high number of deaths per year (up to 94,000; Kasturiratne et al., 2008). Indeed, a 2001 Gallup Poll of 1,016 Americans indicated that snakes (53%) were feared more than anything including public speaking (40%) and heights (36%; Brewer, 2001). Isbell (2009) argued that venomous snakes—a critical predator on many nonhuman animals throughout their evolution—were a driving force in the vision development of advanced primates. In other words, because primates were recurrently the prey of snakes, there were strong selection pressures that favored the ability to detect snakes quickly (Isbell, 2009). This explanation is perhaps why vervet monkeys learn predator alarm calls and behaviors from conspecifics to avoid snakes (as well as martial eagles and leopards; (Seyfarth & Cheney, 1986), why a variety of nonhuman primates have demonstrated fearful reactions to snakes (e.g. Rumbaugh, 1968; Yerkes, 1943), and why captive rhesus monkeys can rapidly be taught to fear snakes but not flowers through social referencing (Cook & Mineka, 1990). Thus, the fear of snakes may have its origins in mammalian evolution when such threats were prevalent and recurrent threats to survival. In line with this idea, recent evidence has suggested the existence in human adults of neurons in the primate medial and dorsolateral pulvinar that respond selectively to visual images of snakes (Van Le et al., 2013). Thus, if humans possess a perceptual template for spiders, it is possible they also possess such a template for snakes.

It is less clear whether human infants possess a similar perceptual template for other nonhuman animals that are potentially threatening to humans. Two such candidates are sharks and rodents such as rats and mice. These animals have the potential to cause human fatalities and are often portrayed in the media as fear-inducing (e.g., Burgess, 1991). The incidence of clinical fears and phobias for rodents and sharks is relatively low (Fredrikson et al., 1996), although the 2001 Gallup Poll listed mice as the 7th most-feared stimulus (20% of adults; sharks were not listed in the top 13 fears). Thus, there is currently no basis to determine whether humans possess a specialized perceptual template for rodents or sharks or whether fears for these nonhuman animals are acquired through other pathways.

With this explanation in mind, the current experiments were designed to test whether 5-month-olds showed evidence of an orienting response to schematic snakes, rodents (rats and mice), and sharks by using a design similar to that of Rakison and Derringer (2008). It was predicted that if infants possess a perceptual template for snakes, rodents, or sharks, they would demonstrate a visual preference for the schematic version of those stimuli relative to the scrambled versions of those stimuli. If infants showed no preference for the schematic stimulus for snakes, rodents, or sharks, it may imply they have no perceptual template for those nonhuman animals, although such a pattern would not eliminate the possibility that infants have other specialized mechanisms to acquire fear for these potential threats.

Infants were tested at 5 months of age for three reasons: First, Rakison and Derringer (2008) used this age group, and therefore, the results of the current work could be compared directly to these previous findings; second, infants at 5 months of age were able to complete the potentially long procedure used here (which could last a maximum of 12 min); third, infants at 5 months of age rarely exhibit specific fears for objects or animals (Thrasher & LoBue, 2016), and because the current work was not designed to examine fear or fear learning, such a response on older infants could have contaminated looking behavior.

In Experiment 1, infants were shown three horizontally moving schematic snakes, and their looking times for each one were compared. Experiments 2 and 3 used the same basic design to test whether infants possess a perceptual template for sharks and rodents. For all these experiments, it was predicted that if infants possess a perceptual template for any of these nonhuman animals, then they would look longer at a schematic image of them than at the scrambled versions of the same image. Note that although the snake, shark, and rodent stimuli moved back and forth across the screen, the fact that these stimuli moved in reverse for half of each event should not have interfered with infants' ability to preferentially attend to them via a perceptual template; that is, a perceptual template should be applied to recognize recurrent threats regardless of their orientation or movement because it would be maladaptive if it only operated for such threats when presented in a canonical orientation or movement pattern. Finally, in Experiment 4, infants were habituated to real images of snakes and then were tested with the schematic images used in Experiment 1. The goal of this final study was to determine whether infants perceived the schematic snake as equivalent to images of real snakes. Note that the present studies did not examine whether infants possess fear of snakes, sharks, or rodents: Rather, they investigated whether infants demonstrated a visual preference for schematic versions of these nonhuman animals. Indeed, recent research by Thrasher and LoBue (2016) demonstrated that 6- and 9-month-olds showed no physiological cues of fear (e.g., accelerated heart rate or a large startle magnitude) when presented with snakes.

Experiment 1

Experiment 1 used a version of the preferential looking paradigm (Fantz, 1963) to compare infants' visual fixation to stimuli that were presented individually on a computer screen. As in Rakison and Derringer (2008), 5-month-old infants were presented with three stimuli, but in the current experiment, they were variations of a snakelike figure. One stimulus was an image of a schematic snake, a second stimulus was the same schematic snake but with reconfigured features, and the third stimulus was a completely scrambled version of the schematic snake. The rationale for the design of the two scrambled stimuli used here—and those in Experiments 2 and 3—was that they were akin to those implemented by Morton and Johnson (1991) and Rakison and Derringer (2008). Consistent with previous research that has posited that infants possess a perceptual template (e.g., Morton & Johnson, 1991; Rakison & Derringer, 2008), it was predicted that 5-month-olds would look longer at the schematic snake stimulus than at the two reconfigured images if they possess such a template.

Methods

Participants

Eighteen full-term infants with a mean age of 4 months, 30 days (range = 4 months, 2 days–5 months, 18 days) participated in this experiment. There were equal numbers of boys and girls. An additional 11 infants were excluded from the final analysis because of fussiness (6), parental interference (1), experimenter error (3), or looking for the maximum amount of time to all the trials (1). The rationale for excluding infants who looked for the maximum amount of time to each trial in this and the subsequent experiments was that these infants may not have discriminated the stimuli or actively encoded them. Experiments 1, 2, and 3 used 18 participants for two reasons. First, a statistical power analysis was performed for sample size estimation based on data from Rakison and Derringer (2008). With an alpha of .05 and power of 0.80, the projected sample size needed with the effect size in Rakison and Derringer was approximately $N = 16$ for within-group comparison. Second, 18 participants were used because this number allowed for complete counterbalancing of the presentation of the stimuli across infant participants.

Materials

Infants were shown three geometric images (see Figure 1) moving back and forth across a computer screen. Each stimulus took 5 s to cross the screen and return to its original position. The *schematic snake* stimulus was a geometric representation of a snake with a clearly defined head (with a protruding tongue) and tail; the *reconfigured-features* stimulus had the same features, but the head and tail were moved to a different location; and the *completely scrambled* stimulus had the same object features, but they were arranged in a nonsensical geometric formation. All images were black on a gray background. To assess the similarity of the reconfigured-features stimulus and completely scrambled stimulus to the schematic stimulus, I used computer software (imageDIFF, http://www.softpedia.com/get/Multimedia/Graphic/

Figure 1. Schematic images of snakes used as test stimuli in Experiments 1 and 4.

Graphic-Others/ImageDiff.shtml) to determine the percentage of overlap between each image. The schematic snake and reconfigured-features snake were different by 11.00%, and the schematic snake and the totally scrambled snake were different by 16.26%. These percentages were comparable to those for the shark stimuli in Experiment 2 (11.85% and 17.65%, respectively) and the rodent images in Experiment 3 (11.35% and 18.35%, respectively), which suggests that the manipulation of the snake, shark, and rodent images was relatively similar across the experiments. Each stimulus was presented twice, and the order of stimulus presentation was counterbalanced across infants. Although it is possible to present infants at 5 months of age with more than six presentations of a stimulus (e.g., see LoBue, Buss, Taber-Thomas, & Pérez-Edgar, 2017; Oakes, 2017), the rationale for this design was twofold: First, this design was the same used in a comparable experiment with spiders (Rakison & Derringer, 2008); second, the maximum potential total time of stimulus presentation under the current design with six trials was 12 min, and it is possible an increase in the number of trials may have caused infants to become bored or fatigued.

Procedure

Each infant sat on their parent's lap in front of a computer screen, and the parent was instructed to look above the screen. The screen was a 14-inch × 24-inch (35.6-cm × 61-cm) computer monitor that was approximately 24 inches (61 cm) from the infant's face. As in Rakison and Derringer (2008), each stimulus appeared on the monitor for a maximum of 2 min or until the infant looked away from the monitor for 5 consecutive seconds. Prior to the first trial and in between each subsequent trial, a green expanding and contracting circle on a dark background and a synchronous bell sound were presented to capture the infant's attention. The experimenter observed the infant via a video feed from a camera placed directly behind the computer monitor and coded the looking-time behavior online by pressing and releasing a preset keyboard key. After the original testing session, a second judge who was blind to which trial was presented recoded the looking times for 25% of the participants from a videotape of the session. Interrater reliability in all the experiments reported here was > 97%.

Results

Infants' looking times were averaged across the two trials of the same stimulus (Figure 2). The data were initially analyzed with a mixed-design analysis of variance (ANOVA) with

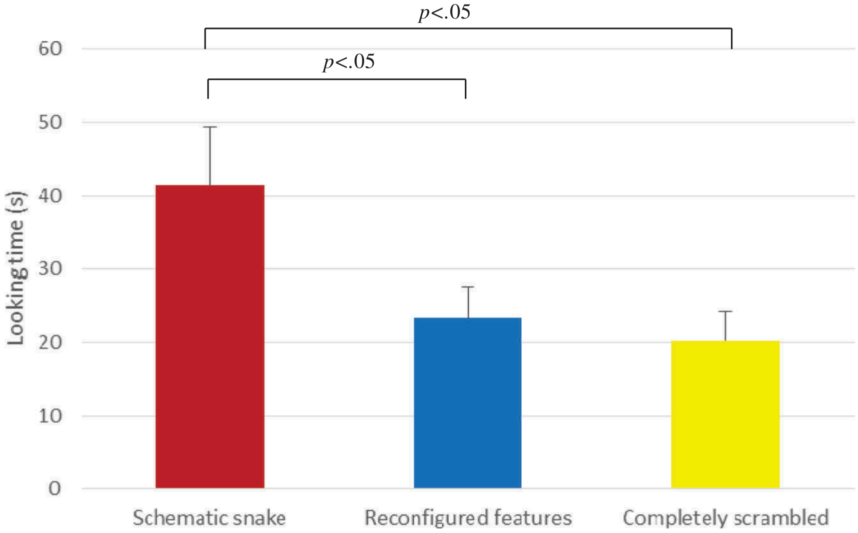

Figure 2. Infant looking times to the three snakelike images in Experiment 1. Five-month-olds looked significantly longer at the schematic snake than at the two scrambled versions of the same image. Visual fixations to the snake with reconfigured features and the totally scrambled snake were not significantly different. Error bars represent standard error.

test trial (schematic snake vs. reconfigured-features snake vs. completely scrambled snake) as the within-participants factor and sex (boy vs. girl) as the between-participants factor. The sex of the infant was included because one previous study has shown that infant girls and boys may process recurrent threats differently (Rakison, 2009). The analysis indicated that infants' looking times to the three stimuli were significantly different, $F(2, 32) = 9.86$, $p = .0001$, partial $\eta^2 = .38$. There was no main effect of sex, $F(1, 16) = 0.122$, $p = .73$, partial $\eta^2 = .01$, and no significant interaction between test trial and the sex of the infant, $F(2, 32) = 0.29$, $p = .75$, partial $\eta^2 = .02$. Planned comparisons indicated that infants looked longer at the schematic snake ($M = 46.93$, $SD = 29.46$) than at the reconfigured-features snake ($M = 23.89$, $SD = 16.68$), $F(1, 17) = 9.13$, $p = .008$, partial $\eta^2 = .35$, and the completely scrambled snake ($M = 20.30$, $SD = 18.57$, $F(1, 17) = 20.71$, $p = .001$, partial $\eta^2 = .549$. Infants looked equally long at the reconfigured-features snake and the totally scrambled snake, $F(1, 17) = 0.32$, $p = .32$, partial $\eta^2 = .02$

Previous analyses suggested that 5-month-old infants looked significantly longer at the schematic snake than at the two scrambled versions of the snake and that they looked equally long at the two scrambled versions of the snake. In regard to the latter finding, the analyses indicated only that there was no support for the hypothesis that infants looked longer at one of the scrambled trials than at the other. Consequently, I used a Bayes factor (BF) analysis to assess the strength of the evidence for the null hypothesis relative to the alternative hypothesis (i.e., infants looked longer at one of the scrambled test events than the other; Dienes, 2014). The BF analysis was computed with an online calculator (Dienes, 2008; http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm), and the alternative hypothesis (Hypothesis 1) was calculated with the corresponding mean difference scores and effect sizes from Rakison and Derringer (2008, Experiment 1) using the standard error correction for small sample sizes (Dienes, 2008). I used a half-normal distribution with a mean of 0 and a two-tailed parameter because the prediction for all conditions was bidirectional. The BF values were interpreted with the standards outlined by Dienes (2014) such that a BF of 3 or greater indicated substantial evidence for the alternative hypothesis relative to the null hypothesis and a BF of 0.33 or less indicated substantial evidence for the null hypothesis relative to the alternative hypothesis. Both the comparison between the schematic snake versus the partially scrambled snake, $B_{H(0,\ 8.6)} = 5.12$, and the comparison between the schematic snake versus the completely scrambled snake, $\mathrm{B}_{\mathrm{H}(0,\ 6.8)} = 4.60$, produced BF that indicated substantial support for the alternative hypothesis. However, the resulting BF, $\mathrm{B}_{\mathrm{H}(0,\ 1.8)} = 0.97$, for the partially scrambled snake versus the completely scrambled snake indicated that the data were indeterminate.

Discussion

The findings of the current experiment were consistent with those found with 5-month-olds for schematic and scrambled spiders (Rakison & Derringer, 2008). Here, infants' pattern of looking suggested they may possess a perceptual template for snakes; that is, 5-month-olds looked longer at the schematic snake than at two different scrambled versions of the same image. This finding is somewhat impressive given the overall perceptual similarity between the schematic snake and the reconfigured-features snake. Put another way, it is currently unknown to what extent perceptual templates specify the appearance of recurrent threats. The finding that infants do not preferentially attend to rectilinear spider images relative to scrambled versions of those images (Rakison & Derringer, 2008) suggests that the perceptual template for spiders includes curvilinear features. The current study added to this finding because it demonstrated that infants' perceptual template for snakes may specify the location of important object parts such as facial features. Moreover, it is unlikely that the observed pattern of infant looking was found because the schematic snake was more coherent or continuous rather than more fragmented and biologically plausible than the other two images. This belief is based on the fact that 5-month-olds looked equally long at a schematic flower and scrambled versions of the same flower (Rakison & Derringer, 2008; see Experiments 2 and 3 reported here).

Experiment 2

Experiment 1 demonstrated that 5-month-old infants looked significantly longer at a schematic image of a snake than at scrambled versions of the snake. It currently remains unknown whether infants would demonstrate the same pattern of behavior for other nonhuman animals that have the potential to kill humans but for which it is unknown whether they were recurrent threats throughout evolutionary history. One such candidate is sharks. Although data are not available for ancestral humans' fatalities from sharks, of the 370 known species of sharks, only 32 have been documented to attack humans, and sharks kill relatively few humans each year (an average of 5 to 15 deaths; Burgess, 1991; Caldicott, Mahajani, & Kuhn, 2001). Indeed, statistically, one is more likely to die while driving to the beach than by a shark attack (Caldicott et al., 2001). Moreover, sharks are rarely, if ever, listed among the most feared stimuli by human adults (Brewer, 2001; Fredrikson et al., 1996). Thus, it remains an open question whether sharks posed a recurrent evolutionary threat to humans. With this in mind, Experiment 2 tested whether 5-month-old infants respond to schematic sharks in the same way as they do schematic snakes and spiders. As with Experiment 1, it was predicted that if infants have a perceptual template for sharks, then they would look longer at a schematic shark than at scrambled versions of a shark.

Methods

Participants

Eighteen healthy full-term infants with a mean age of 4 months, 26 days (range = 4 months, 15 days–5 months, 12 days) participated in this experiment. There were 10 boys and 8 girls. An additional 3 infants were excluded from the final analysis, including 2 because of equipment malfunction and 1 because of fussiness.

Materials and procedure

As in Experiment 1, infants were shown three geometric images (see Figure 3) moving back and forth across a computer screen. The schematic shark stimulus was a geometric representation of a shark with a clearly defined shape, fins, head, and tail; the reconfigured-features stimulus had the same features, but the fins and tail were rotated or moved to a different location; and the completely scrambled stimulus had the same object features, but they were arranged in a nonsensical geometric formation. The two scrambled images maintained the same linear shape as the schematic stimulus. To assess whether the schematic stimulus was perceived as a shark, the image was shown to 15 adult participants (M_{age} = 20;5) who were asked whether the image was of a shark or fish. All 15 participants judged the schematic image to be a shark. The same adults were also asked to rate how similar the reconfigured shark and completely scrambled shark were relative to the schematic shark (from 1 to 7 where 1 was “not at all similar” and 7 was “completely similar”). Ratings from the same adults were also gathered for the snake stimuli in Experiment 1 and the rodent stimuli in Experiment 3. The question of interest was whether the reconfigured shark and completely scrambled shark were similarly different from the schematic shark as the reconfigured snake and completely scrambled snake were from the schematic snake in Experiment 1. Analyses revealed that adults judged the reconfigured shark (M = 3.87, SD = 0.99) as similarly different from the schematic shark as the reconfigured snake (M = 4.07, SD = 0.88) was from the schematic snake, $t(14)$ = 0.64, p = .53. Similarly, the completely scrambled shark (M = 2.40, SD = 0.91) was judged as similarly different from the

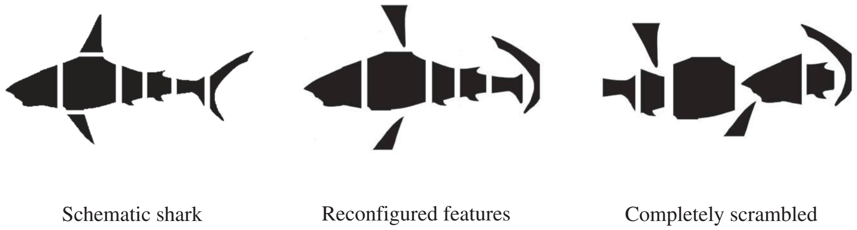
Schematic shark Reconfigured features Completely scrambled

Figure 3. Schematic images of sharks used as stimuli in Experiment 2.

schematic shark as the completely scrambled snake (*M* = 2.33, *SD* = 0.97) was from the schematic snake, *t*(14) = 0.19, *p* = .85. These findings suggest that the manipulation of the two scrambled shark stimuli was equivalent to the manipulation of the two scrambled snake stimuli. All other aspects of the materials and procedure were identical to those in Experiment 1.

Results

Infants' looking times were averaged across the two trials of the same stimulus. The data were initially analyzed with a mixed-design ANOVA with test trial (schematic shark vs. reconfigured-features shark vs. completely scrambled shark) as the within-participants factor and sex (boy vs. girl) as the between-participants factor. The analysis indicated no significant difference in the looking times to the three stimuli, *F*(2, 32) = 0.52, *p* = .60, partial η^2 = .03. Infants looked equally long at the schematic shark (*M* = 34.91, *SD* = 21.31), the reconfigured-features shark (*M* = 28.97, *SD* = 17.81), and the completely scrambled shark (*M* = 34.03, *SD* = 21.79). The analysis revealed a main effect of sex that indicated that overall, boys (*M* = 39.69, *SD* = 15.34) looked longer than girls (*M* = 23.85, *SD* = 21.78) at the three stimuli, *F*(1, 16) = 5.99, *p* = .026, partial η^2 = .27. However, there was no significant interaction between test trial and the sex of the infant, *F*(2, 32) = 1.27, *p* = .29, partial η^2 = .07.

As in Experiment 1, BF was computed for the three test trial comparisons to calculate the relative strength of the evidence for the null hypothesis versus the alternative hypothesis. According to the conventions described by Dienes (2014), all the resulting BF indicated that the data provided evidence that was indeterminate but approached evidence to support the null hypothesis. Thus, the comparison between the schematic shark and partially scrambled shark, $B_{H(0,\ 8.6)}$ = 0.85, the comparison between the schematic shark and the completely scrambled shark, $B_{H(0,\ 6.8)}$ = 0.74, and the comparison between the partially scrambled shark and completely scrambled shark, $\mathrm{B}_{H(0,\ 1.8)}$ = 0.98, produced BF values of 0.33 to 3.

Discussion

Experiment 2 detected no difference in infants' looking to different versions of a shark. This finding suggests that infants may not possess a perceptual template for sharks, whereas they do for snakes (Experiment 1) and spiders (Rakison & Derringer, 2008). Although caution must be taken when interpreting null results, these findings imply there was insufficient selection pressure for humans to have evolved a perceptual template that identifies the shape or features of sharks. This finding is perhaps not surprising given the low number of human fatalities from shark attacks each year (Caldicott et al., 2001) and the fact that a shark's overall shape under water would have been difficult for our ancestors to discern. However, these findings do not eliminate the possibility that humans have an evolved, specialized mechanism for fear acquisition for sharks that does not involve a perceptual template.

Experiment 3

Another category of animal that is often the target of fear is rodents such as mice and rats. Rats are often considered to be dangerous because of their physical abilities, which could be potentially fatal to an infant, and rats and mice are also known to carry disease (e.g., Lyme disease through ticks, typhus, salmonella). However, although mice were listed as the seventh most feared stimulus in the 2001 Gallup Poll (Brewer, 2001), there exist no statistics on rodent attacks on humans and a search of the literature (via Google Scholar) revealed no articles on human fatalities from rodent attacks. Thus, it remains an open question whether human infants possess a perceptual template for rodents like rats and mice. As with the previous experiments, it was predicted that if infants possess a perceptual template for rodents, they would look longer at a schematic rodent than at scrambled versions of a rodent.

Methods

Participants

The final sample consisted of 18 infants with a mean age of 5 months, 5 days (range = 4 months, 17 days–5 months, 14 days). There were 11 boys and 7 girls. An additional 5 infants were excluded from the final analysis, including 2 because of fussiness, 2 because of experimenter error, and 1 because of equipment malfunction.

Materials and procedure

As in Experiments 1 and 2, infants were shown three geometric images (see Figure 4) moving back and forth across a computer screen. The schematic rodent stimulus was a geometric representation of a rodent with a clearly defined eyes, head, body shape, and tail; the reconfigured-features stimulus had the same features, but the head and tail were moved to a different location and the legs were revolved; and the completely scrambled stimulus had the same object features, but they were arranged in a geometric formation. The same 15 adult participants who rated the shark stimulus for Experiment 2 were asked whether the schematic rodent represented a rat or a mouse. Thirteen of the 15 participants judged the schematic rodent to be a rat, and 2 judged it to be a mouse. As in Experiment 2, 15 adult participants evaluated the two scrambled stimuli for their similarity to the schematic rodent. Adults judged the reconfigured rodent (M = 4.27, SD = 0.88) as similarly different from the schematic rodent as the reconfigured snake (M = 4.07, SD = 0.87) was from the schematic snake, $t(14) = 0.56$, $p = .58$. Likewise, the completely scrambled rodent (M = 2.40, SD = 0.91) was judged as similarly different from the schematic rodent as the completely scrambled snake (M = 2.33, SD = 0.97) was from the schematic snake, $t(14) = 0.12$, $p = .86$. All other aspects of the materials and procedure were identical to those in Experiments 1 and 2.

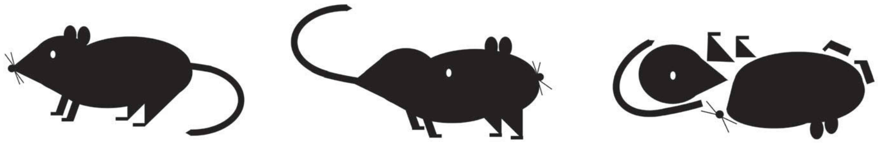

Figure 4. Schematic images of rats/mice used as stimuli in Experiment 3.

Results and discussion

Infants' looking times were averaged across the two trials of the same stimulus. The data were entered into a mixed-design ANOVA with test trial (schematic rodent vs. reconfigured-features rodent vs. completely scrambled rodent) as the within-participants factor and sex (boy vs. girl) as the between-participants factor. The analysis indicated that infants looked equally long at the schematic rodent (M = 22.67, SD = 14.27), the reconfigured-features rodent (M = 21.78, SD = 20.70), and the completely scrambled rodent (M = 31.71, SD = 26.92), $F(2, 32) = 2.19$, $p = .13$, partial $\eta^2 = .12$. There was no main effect of sex, $F(1, 16) = 1.16$, $p = .30$, partial $\eta^2 = .07$, and no significant interaction between test trial and the sex of the infant, $F(2, 32) = 1.29$, $p > .2$, partial $\eta^2 = .08$.

As in Experiments 1 and 2, BF was computed for the three test trial comparisons to calculate the relative strength of the evidence for the null hypothesis versus the alternative hypothesis. The BF value for the comparison between the schematic rodent and the partially scrambled rodent, $B_{\mathrm{H}(0,\ 8.6)} = 0.59$, was toward support of the null hypothesis but was indeterminate. The BF values for the comparison between the schematic rodent and the completely scrambled rodent, $B_{\mathrm{H}(0,\ 6.8)} = 1.02$, and the comparison between the partially scrambled rodent and completely scrambled rodent, $\mathrm{B}_{\mathrm{H}(0,\ 1.8)} = 1.01$, produced BF values that were also indeterminate.

The results of the current experiment provided no evidence that infants have a preference for a schematic rodent image relative to two scrambled versions of the same image; that is, the experiment detected no difference in looking to different versions of the rodent. This finding, in conjunction with Experiments 1 and 2 and previous research (e.g., Rakison & Derringer, 2008), implies that human infants may possess a perceptual template for snakes and spiders but not for sharks or rats. However, as was the case for Experiment 2, this finding does not necessarily mean that infants do not have a specialized evolved mechanism for learning to fear rodents but only that this mechanism likely does not involve a perceptual template for rodents.

Comparison across experiments

The data presented here suggested that 5-month-old infants looked longer at a schematic snake than at scrambled versions of a snake, but they did not exhibit the same pattern for schematic rodents and sharks. One question that remains is whether infants' pattern of looking across Experiments 1, 2, and 3 was reliably different—that is, whether infants behaved significantly differently across the experiments for schematic stimuli, reconfigured-features stimuli, and completely scrambled stimuli. The data from Experiments 1, 2, and 3 are presented as boxplots in Figure 5. This figure suggests that the findings of the first three experiments were not overly affected by one or two infants with extremely long or short looking times to the events. The data were analyzed with a mixed-design ANOVA with test trial (schematic stimulus vs. reconfigured-features stimulus vs. completely scrambled stimulus) as the within-participants factor and experiment (Experiments 1, 2, or 3) as the between-participants factor. The analyses revealed a significant effect for test trial, $F(2, 102) = 4.29$, $p < .025$, partial $\eta^2 = .78$, which was mediated by a significant interaction between test trial and experiment, $F(4, 102) = 4.79$, $p < .001$, partial $\eta^2 = .16$. Additional comparisons indicated that infants' looking times to the schematic images were significantly different across the experiments, $F(2, 51) = 5.21$, $p = .009$, partial $\eta^2 = .17$, but looking times

Figure 5. Real images of snakes used as habituation stimuli in Experiment 4.

to the reconfigured stimuli, $F(2, 51) = 0.742$, $p = .48$, partial $\eta^2 = .03$, and completely scrambled stimuli, $F(2, 51) = 1.89$, $p = .16$, partial $\eta^2 = .07$, were not reliably different. Planned comparisons revealed that infants looked significantly longer at the schematic snake than at the schematic rodent, $t(34) = 3.14$, $p = .003$, and they looked marginally longer at the schematic shark than at the schematic rodent, $t(34) = 2.03$, $p = .051$. The looking times to the schematic snake and schematic shark were not reliably different, $t(34) = 1.40$, $p = .17$. Note, however, that these analyses across experiments failed to take into account the fact that looking times within each experiment were affected by the relative difference between three stimuli that were presented to the infants within each experiment.

Experiment 4

Experiment 1 provided initial support for the notion that infants have a perceptual template for snakes. It is important to show, however, that infants' perceptual template facilitates learning about snakes in the real world. It is plausible, for example, that 5-month-olds prefer to look at continuous snakelike shapes, but that it is unconnected to a specialized fear mechanism for learning about snakes. This question was addressed in the current experiment, which was analogous to that in Rakison and Derringer (2008, Experiment 3). Infants at 5 months of age were habituated to four static color images of different snakes and then were shown the same schematic stimuli that were used in Experiment 1. The motivation for this design was that if a perceptual template for snakes is used to learn about real snakes in the world, then the schematic image should be familiar (and therefore less interesting) following habituation to real images of snakes. Thus, it was predicted that if 5-month-old infants possess a perceptual template for snakes that helps them learn about snakes in the real world, then they should look longer at the reconfigured and completely scrambled snake than at the schematic snake. In other words, infants should exhibit a shift from a preference to look at the schematic snake, as in Experiment 1, to a preference to look at the scrambled versions of the snake. It was also predicted that if infants do not have such a perceptual template for snakes, then following habituation, they should look longer at the schematic snake than at the other two schematic images as they did in Experiment 1.

Methods

Participants

Sixteen healthy and full-term infants with a mean age of 4 months, 18 days (range = 3 months, 18 days–5 months, 6 days) acted as participants. There were an equal number of boys and girls. Ten additional infants were tested but were excluded from the final analysis because of failure to habituate (7), fussiness (1), and looking for the maximum time to all test trials (2).[1]

Materials and procedure

The habituation stimuli were four different-colored images of snakes (see Figure 6). During habituation, each snake image was presented until the infant looked away from the monitor for more than 1 s or until the infant had 30 s of continuous looking. The habituation phase ended when an infant's looking time for a block of 3 trials decreased to 50% of that in the first 3 trials or until 16 trials were presented. These parameters were the same as those used by Rakison and Derringer (2008, Experiment 3). The test trials were the same as those in Experiment 1. A green expanding and contracting circle on a dark background and a synchronous bell sound were presented on the screen prior to the first habituation trial and between each habituation and test trial.

Results

As in Experiment 1, infants' looking times were averaged across the two presentations of the same stimulus. Infants' looking times are presented in Figure 7. The data were entered

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[1] Although the number of babies who failed to habituate was relatively high (N = 7) compared with the comparable study in Rakison and Derringer (2008, Experiment 4), their test trial data indicated the same general pattern of looking as that of the infants who habituated in the current study (schematic snake, M = 10.76; partially scrambled snake, M = 14.2; completely scrambled snake, M = 15.4).

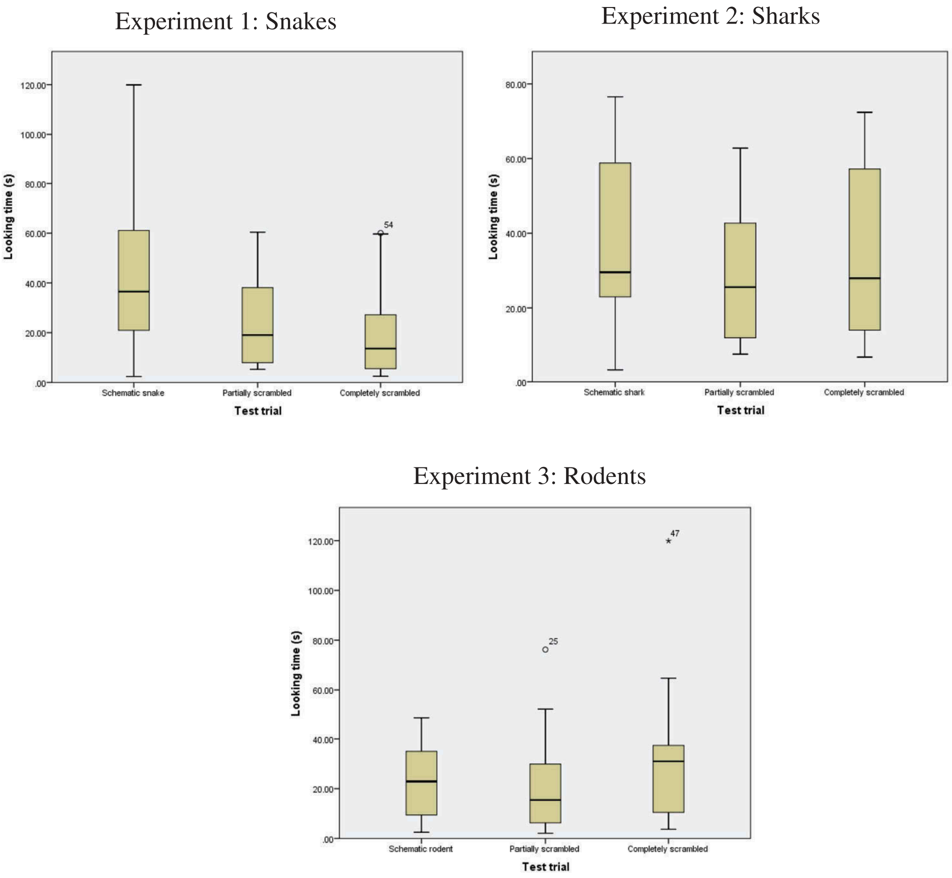

Figure 6. Boxplots of the data from Experiments 1 through 3.

into a repeated-measures ANOVA to examine infants' visual fixation to the three test trials. The analysis revealed that looking times to the three test stimuli were significantly different, $F(2, 28) = 4.02$, $p = .03$, partial $\eta^2 = .22$. There was no significant effect for sex of the infant, $F(1, 14) = 0.75$, $p = .40$, partial $\eta^2 = .05$, and no significant interaction between sex of the infant and test trial, F(2,2 8) = 0.91, $p = .42$, partial $\eta^2 = .06$. Planned comparisons showed that infants looked significantly longer at the snake with reconfigured features ($M = 10.04$, $SD = 6.89$) than at the schematic snake ($M = 7.11$, $SD = 5.64$), $F(1, 15) = 5.15$, $p = .04$, partial $\eta^2 = .26$. Likewise, infants looked significantly longer at the totally scrambled snake ($M = 11.94$, $SD = 9.96$) than at the schematic snake, $F(1, 15) = 9.60$, $p = .007$, partial $\eta^2 = .39$. Infants looked equally long at the snake with reconfigured features and the totally scrambled snake, $F(1, 15) = 0.95$, $p = .35$, partial $\eta^2 = .06$. As in the previous experiments, I used a BF analysis to assess the strength of the evidence for the null hypothesis relative to the alternative hypothesis (Dienes, 2014). In contrast to the previous experiments, the mean difference score and effect sizes for these analyses were garnered from the habituation experiment in Rakison and Derringer (2008, Experiment 3). The analyses revealed that comparison between the schematic snake and the reconfigured-features snake, $B_{H(0,\ 5.3)} = 0.8$, the comparison between the schematic

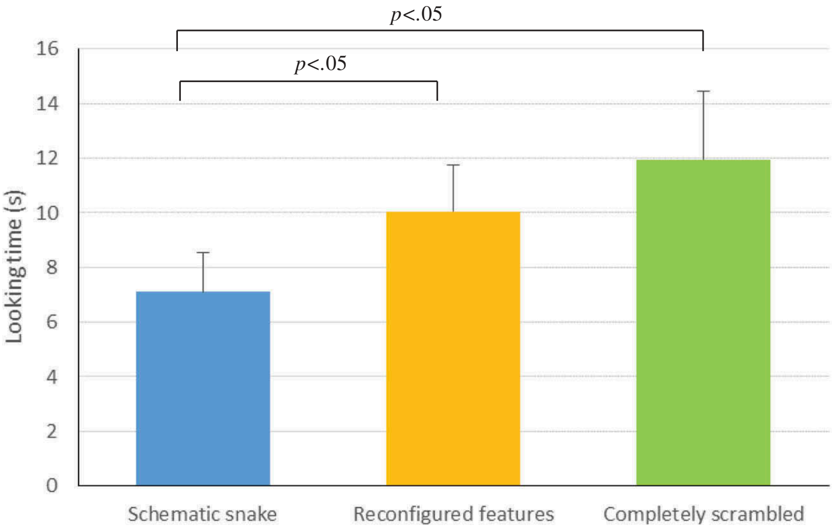

Figure 7. Infant looking times to the three snakelike images following habituation to real images of the snake. Infants' visual fixations to the snake with reconfigured features and the totally scrambled snake were longer than to the schematic snake. Infants' visual fixations to the snake with reconfigured features and the totally scrambled snake were not significantly different. Error bars represent standard error.

snake and completely scrambled snake, $B_{H(0,\ 6.8)} = 1.35$, and the comparison between the reconfigured-features snake and the completely scrambled snake, $B_{H(0,\ 1.4)} = 0.95$, generated BF values that were indeterminate.

Discussion

The parametric analysis for Experiment 4—but not the BF—suggested that 5-month-old infants looked longer at the two scrambled images of snakes than at the schematic snake following exposure to images of real snakes. This finding implied that infants generalized from the real snakes they saw during habituation to the schematic snake but not to the other two scrambled snakes that were presented in the test phase. The fact that infants responded to the schematic snake as familiar after exposure to real snakes implies that the preference for the schematic snake in Experiment 1 resulted from their perception of it as a snake and not due to an unrelated preference for continuous shapes rather than discontinuous shapes. However, given that the BF analysis suggested that these data were indeterminate, caution must be taken in interpreting the results of Experiment 4.

General discussion

It has been theorized that humans possess a two-part specialized fear mechanism, the first of which orients infants to recurrent threats when they are in the immediate environment and the second of which allows infants to rapidly associate that threat with the appropriate emotional and behavioral response (LoBue et al., 2010; Öhman & Mineka, 2001; Rakison, 2009; Rakison & Derringer, 2008). Previous research has supported the notion that infants may preferentially attend—as a result of a perceptual template—to spider-like images relative to scrambled versions of those images but not to nonthreatening images such as flowers relative to scrambled flowers (Rakison & Derringer, 2008).

The experiments reported here were designed to investigate the existence of other perceptual templates for potentially threatening nonhuman animals by examining whether 5-month-old infants preferentially looked at images of schematic snakes, sharks, and rodents. The results of the experiments provided the first data in support of the notion that infants possess a mental perceptual template for snakes. Experiment 1 showed that 5-month-old infants look longer at a schematic image of a snake than at scrambled versions of a snake, and the parametric analysis for Experiment 4—although not the BF—indicated that their perceptual template for snakes was related to real-world images of snakes. Experiments 2 and 3 revealed that 5-month-olds detected no difference in infants' looking to different versions of a shark or rodent. This finding suggests that infants may not possess perceptual templates for nonhuman animals that are often perceived as dangerous to humans but were not recurrent evolutionary threats (Burgess, 1991). The results of Experiments 2 and 3 also imply that infants' longer looking to the schematic snake in Experiment 1 was not because it represented a better Gestalt image than the other two stimuli; if it were the case, then infants would have also been expected to look longer at the schematic shark and rodent than the scrambled versions of those animals. The data also indicated that infants in Experiment 1 and in Rakison and Derringer (2008) did not preferentially orient to the schematic images merely because they represented animate agents (cf. New, Cosmides, & Tooby, 2007).

The fact that infants looked longer at the schematic snake relative to the two other images would have been predicted only if infants had an evolved bias—presumably via a mental template—to attend to snakes. In other words, no traditional theories of learning (e.g., Rescorla & Wagner, 1972) including the general learning model have predicted that infants without previous exposure to snakes would look longer at a snakelike image than at scrambled versions of that image. It is also somewhat impressive that infants generalized from real snakes to the schematic snake but not to the reconfigured snake that maintained many of the configural properties of a snake. In other words, the reconfigured-features snake had the same curvilinear body as the schematic snake and differed from it only in relation to the head and tail. This finding suggests that infants' perceptual template for snakes may include information about the shape and location of these features.

The fact that infants may possess such a template for snakes—as well as spiders—but not sharks and rodents is consistent with the fact that snakes and spiders are among the top 5 phobias for men and women and that sharks and rodents have rarely ranked in the top 10 phobias in multiple polls (Brewer, 2001; Fredrikson et al., 1996). There is considerable evidence that nonhuman animals have evolved mechanisms that specify the identity of potential predators (Griffin, Evans, & Blumstein, 2001; Kats et al., 1988): The present experiments—in conjunction with previous research (Rakison & Derringer, 2008)—demonstrated that infants may have perceptual templates for specific nonhuman animals that were recurrent threats over evolutionary time but not for other nonhuman animals. The goal of Experiments 2 and 3 was to determine whether infants possess such templates for sharks and rodents, both of which are currently viewed as dangerous (Burgess, 1991) but may not have represented recurrent evolutionary threats. As highlighted earlier, it is important to be cautious about the interpretation of the null results from Experiments 2 and 3. However, the fact that the same pattern was found for snakes and spiders (Experiment 1; Rakison & Derringer, 2008) but not for rodents and sharks suggests infants may have failed to show a preference for the latter two nonhuman animals because they do not possess a perceptual template for them. This suggestion does not exclude the possibility that infants have other specialized adaptations or mechanisms to learn about sharks or rodents—as predicted by the nonassociative model—but the current experiments found no evidence for a perceptual template for these nonhuman animals. Thus, it remains to be seen whether humans possess a mental perceptual template for recurrent threats other than snakes or spiders.

The current data, in conjunction with previous work with infants' ability to detect and learn about recurrent threats (e.g., LoBue & DeLoache, 2008; Rakison, 2009; Rakison & Derringer, 2008), add to the growing support that human infants possess an evolved fear mechanism to learn about specific nonhuman threats. It has been suggested that this mechanism is composed of two components. The first component is a perceptual template that directs attention to recurrent threats such as snakes and spiders when they are in the surrounding environment. The second component allows infants to more readily associate the recurrent threat with the appropriate emotional response exhibited by conspecifics during an encounter with the threat or from a personal negative experience. Although to date only a small handful of studies have tested this second component in infants (LoBue & DeLoache, 2008; LoBue et al., 2010; Rakison, 2009), evidence from snake conditioning studies with adult humans and nonhuman primates has provided additional support for its existence (Cook & Mineka, 1990).

The fact that infants in the current experiments showed a preference for the schematic snake but not for the schematic rodent or shark provides important information that helps to inform and extend the current theory about humans' specialized two-part fear mechanism. First, the current data, in conjunction with previous work (Rakison & Derringer, 2008), suggest that selection pressure during evolution may have been particularly intense for specific nonhuman animals that were common threats to humans—namely, snakes and spiders—and that it may have led to the evolution of a perceptual template for these threats. Second, the present work—and that of Rakison and Derringer (2008, Experiment 2), in which infants did not look longer at a schematic rectangular spider than at a scrambled version of that spider—suggests that perceptual templates are initially highly specified in terms of their content. In other words, infants showed a preference only for a schematic spider or snake when those images respectively were curvilinear and when their features were placed appropriately (e.g., the head and tail of the snake in the correct orientation). In a similar vein, Morton and Johnson (1991; Johnson et al., 1991) found that newborn infants preferentially tracked facelike stimuli—with two upper "blobs" and one lower "blob"—relative to inverted versions of those stimuli. These findings, in conjunction with the work of Rakison and Derringer, provide converging evidence that perceptual templates for snakes and spiders (as well as faces) are relatively well specified and that object features and orientation are present in the initial representation. Moreover, the finding that adults and 3-year-old children rapidly attend to coiled items (that are not snakes) relative to frogs and flowers (LoBue & DeLoache, 2011) suggests that the initial perceptual template may act as a representational foundation that changes over developmental time following experience with real-world instances of snake and spiders. Alternatively, it may be that humans learn to react to input that merely closely resembles a recurrent threat because it is "better to be safe than sorry" (see Nesse's [1990] smoke-detector principle for a similar argument).

Although the current experiments tested only 5-month-olds, it is predicted that younger infants would exhibit the same pattern of looking found here and in Rakison and Derringer (2008). Morton and Johnson (1991; Johnson et al., 1991), for example, reported evidence to suggest that newborns possess a perceptual template for faces, and there is no reason why infants' perceptual template for recurrent threats would not also be online at birth or shortly thereafter. A more developmental approach to the study of fear mechanisms in infants was recently applied by LoBue et al. (2017, Experiment 1) who examined 4- to 24-month-olds' looking patterns to snakes relative to frogs. The study showed that infants attended more to snakes than to frogs, but there was no effect of age, which suggests that the attentional bias found here for schematic snakes likely does not change during the 1st years of life. Additional work could also use larger samples with additional trials, which would provide greater chances to examine more complex relations using within-participants designs (see Oakes, 2017).

The increasing evidence in support of a two-part fear mechanism provides new insight into how phobias may be acquired during the life span. Although it is known that many phobias emerge through fear conditioning, such as in the classic case of Little Hans reported by Freud, the origin of other phobias remains unknown. For example, many people develop phobias for animals or places that they have not experienced directly (Öhman & Mineka, 2001, 2003). The current studies partially explain such phobic responses by positing that humans and nonhuman animals are particularly susceptible—or prepared (Seligman, 1971)—to orient to, and presumably develop fear responses for, nonhuman animals that were potentially harmful during our evolutionary history. This explanation is presumably why many of the most common phobias among humans in the modern world are for evolutionarily relevant threats such as people, open spaces, heights, snakes, and spiders (Buss, 2008).

In sum, the current experiments extended previous work on humans' evolved fear mechanism by showing that 5-month-old infants possess a perceptual template for snakes but not for rodents or sharks. This template causes infants to orient to snakes when they are in the surrounding environment and presumably facilitates the process by which the appropriate response is learned for these recurrent threats (Rakison, 2009). These data, in combination with previous research, suggest that evolution has prepared human infants to learn about the appropriate response for specific threat-relevant stimuli such as snakes and spiders. The growing focus on evolutionary developmental (see, e.g., Ellis & Bjorklund, 2005) suggests it is only a matter of time before researchers start to discover the full range of threat-related adaptations that emerged during human evolutionary history.

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