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Brief article

Do infants possess an evolved spider-detection mechanism?

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Abstract

Previous studies with various non-human animals have revealed that they possess an evolved predator recognition mechanism that specifies the appearance of recurring threats. We used the preferential looking and habituation paradigms in three experiments to investigate whether 5-month-old human infants have a perceptual template for spiders that generalizes to real-world images of spiders. A fourth experiment assessed whether 5-month-olds have a perceptual template for a non-threatening biological stimulus (i.e., a flower). The results supported the hypothesis that humans, like other species, may possess a cognitive mechanism for detecting specific animals that were potentially harmful throughout evolutionary history.

Keywords: Infancy; Perception; Cognition; Evolution; Fear; Spiders; Adaptations

1. Introduction

From an evolutionary perspective, failing to survive past childhood posed a grave adaptive problem: those who died before puberty failed to become ancestors. As a

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result, there would have been powerful selection pressure for the evolution of psychological adaptations that helped infants and children to avoid recurrent threats to survival. Of all the non-human animals that were potentially harmful to hominids over evolutionary history, in all likelihood none were more recurring than spiders and snakes. Today they are among the most common object-related phobias in adults in North America, and both are strongly represented in the mythologies of Greece, India and Africa, and South America (Nesse, 1990). One adaptive solution for learning that snakes and spiders, in particular, are potentially harmful is for a cognitive mechanism to specify their appearance so that they may be attended to and the appropriate response learned. Has evolution provided humans with a means to identify these animals so that a fear response for them can be quickly acquired?

There is considerable evidence that human infants develop fears for various stimuli other than snakes and spiders that were recurring hazards throughout evolutionary history. For example, infants develop an apprehension of heights around the time they start to crawl (Campos et al., 2000; Gibson & Walk, 1960), and during the same period they also start to fear one of the most recurring physical threats, namely, male humans (Ainsworth, Blehar, Waters, & Wall, 1978). Öhman and Mineka (2001) hypothesized that humans and non-human primates also possess an evolved fear mechanism for snakes and other fear-relevant stimuli (e.g., spiders) that is selectively sensitive to, and is activated by such stimuli. This mechanism causes individuals rapidly to attend to snakes and spiders when they are present and facilitates rapid learning of an association of fear with such stimuli. In support of this view it has been found that adult humans detect fear-relevant stimuli such as snakes against a background of non-fear-relevant stimuli (such as flowers and mushrooms) more quickly than they detect fear-irrelevant stimuli hidden amongst fear-relevant stimuli (Öhman, Flykt, & Esteves, 2001). In addition, young lab-raised rhesus monkeys more rapidly learn to associate snakes with a fearful response – as emitted by another monkey – than learn to associate flowers with a fearful response (Cook & Mineka, 1990).

We hypothesized that if humans possess an evolved fear module, then early in life they should have a perceptual template for snakes and spiders that specifies their basic shape and configuration (Rakison, 2005). That is, a mechanism that causes an individual selectively to attend to specific stimuli must incorporate an initial representation of those stimuli that can be matched with their real-world counterpart. Evidence of such a perceptual template in human infants has been found in the domain of face recognition such that newborns and young infants preferentially track a face-like schematic image longer than a linear or scrambled version of the image (Johnson, Dziurawiec, Ellis, & Morton, 1991; Johnson & Morton, 1991). However, despite considerable research on a fear mechanism in adults, to date no research has examined whether human infants possess a perceptual template for snakes or spiders. In the four experiments outlined here, we examined whether 5-month-old infants show evidence that they have a basic perceptual representation of spiders. We also investigated whether a similar representation exists for a non-threatening biologically plausible stimulus, namely, a flower.

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2. Experiment I

In this experiment we used a version of the preferential looking paradigm, which has been used extensively to investigate the stimuli and stimulus features to which young infants attend (Fantz, 1963). In the adaptation of the procedure used here, we measured infants' visual fixation to a stimulus that was presented individually on a computer screen. There were three stimuli in Experiment 1 (see Fig. 1a): One was an image of 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. In line with previous work on face tracking in young infants (Johnson & Morton, 1991), we 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. In contrast, if no such template exists infants were expected to look equally long at all three stimuli.

2.1. Methods

2.1.1. Participants

Participants were 16 health-term infants with a mean age of 5 months 4 days (range: 4 months, 20 days to 5 months, 16 days). There were 9 females and 7 males. An addi-

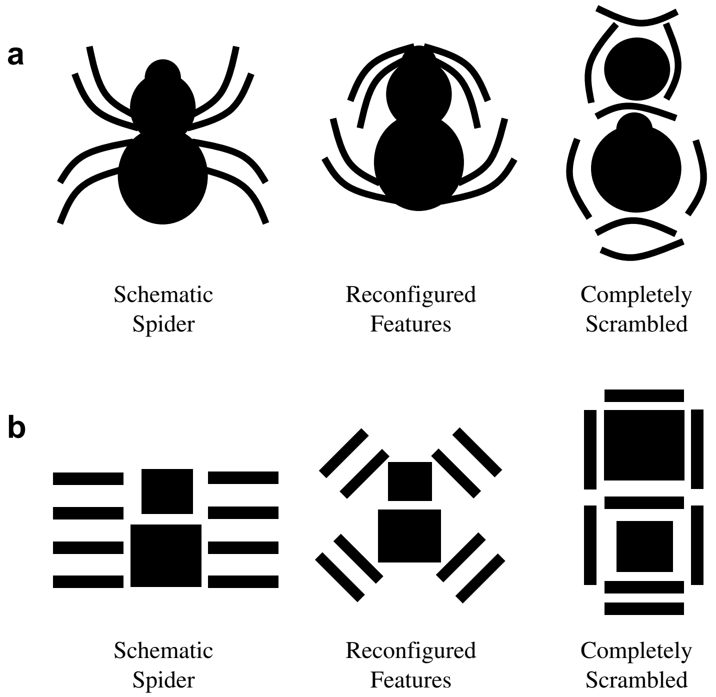

Fig. 1. Schematic images of spiders used as test stimuli in Experiments 1–3: (a) test stimuli used in Experiments 1 and 3; (b) test stimuli used in Experiment 2.

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tional eight infants were tested but excluded from the final analysis because of fussiness (3), experimenter error (3), or looking more than 3 SD beyond the condition mean (2). Parents were asked if their infant had been often exposed to images of spiders (e.g., in books, videos, toys); however, no parents reported frequent exposure to spiders.

2.1.2. Materials

Infants were shown three stimuli of geometric images moving back and forth across a computer screen. Each stimulus took 5 s to cross the screen and return to its original position. As shown in Fig. 1a, one image was a schematic representation of a spider while the other two had the same number and types of parts, but arranged in nonsensical geometric formations. All images were black on a grey background and were bilaterally symmetrical. Each stimulus was presented twice, and the order of stimulus presentation was counterbalanced across infants.

2.1.3. 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 14×24 in. (35.6×61 cm) computer monitor that was approximately 24 in. (61 cm) from the infant's face. Stimuli appeared on the monitor for a maximum of 2 min or until the infant looked away from the monitor for 5 s. A green expanding and contracting circle on a dark background and a synchronous bell sound was presented on the screen prior to the first trial and between each test trial 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 from 25% of the participants from a videotape of the session. Interrater reliability in all of the experiments reported here was >95%.

2.2. Results

Infants' looking times were averaged across the two presentations of the same stimulus (Fig. 2), and then examined by means of a repeated-measures analysis of variance (ANOVA). The analysis revealed that infants' looking times to the three stimuli were reliably different, $F(2,30) = 6.18$, $p < .006$. Planned comparisons indicated that infants looked longer at the schematic spider ($M = 24.12$; $SD = 16.99$) than at the spider with reconfigured features ($M = 15.52$; $SD = 12.04$), $F(1,15)=10.35$, $p < .006$, and the totally scrambled spider ($M = 17.33$; $SD = 11.91$, $F(1,15) = 6.83$, $p < .02$. Infants looked equally long at the spider with reconfigured features and the totally scrambled spider, $F(1,15) = 0.53$, $p > .4$.

2.3. Discussion

These data show that 5-month-olds look longer at an image of a schematic spider than at scrambled versions of the same image. In line with the reasoning used in early

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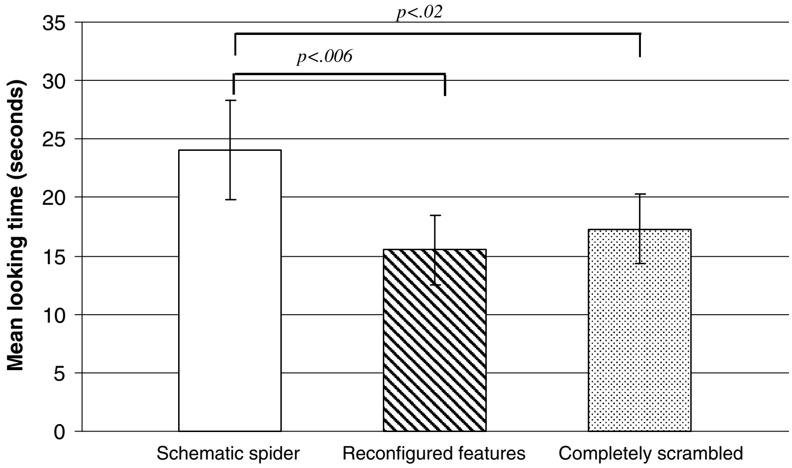

Fig. 2. Infant looking times to the three spider-like images in Experiment 1. Five-month-olds visually fixate to the schematic spider significantly longer than to the spider with reconfigured features and the totally scrambled spider. Visual fixation to the spider with reconfigured features and the totally scrambled spider was not significantly different. Error bars represent standard error.

face-recognition research, this suggests that infants may possess a representation for spiders that incorporates their basic structure and configuration. It remains to be seen, however, in what way infants' template specifies the shape and features of spiders. For instance, would the same attentional mechanism be triggered by an image with the same structure as a spider but that lacks the curvilinear features typical of arachnids? We addressed this question in the second experiment.

3. Experiment 2

In the current experiment, infants at 5 months of age were presented with three images that matched those used in Experiment 1 except that the body and legs of the stimuli were rectangular rather than curved. It was predicted that 5-month-olds would look longer at the schematic spider than the other two test images if their perceptual template does not encapsulate a curvilinear body and leg shape typical of spiders; however, it was expected that infants would look equally long at the three images if their perceptual template specifies this information.

3.1. Methods

3.1.1. Participants

Sixteen healthy full-term infants with a mean age of 4 months 29 days (range: 4 months, 14 days to 5 months, 17 days) participated in this experiment. There were 9 males and 7 females. Three additional infants were tested but eliminated from the final analysis because of fussiness (1) and experimenter error (2).

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3.1.2. Materials and procedure

The stimuli in the experiment were similar to those in Experiment 1 except that the geometric figures consisted of rectilinear rather than curvilinear shapes (see Fig. 1b). All other aspects of the design and procedure were the same as Experiment 1.

3.2. Results and discussion

As in the first experiment, infants' looking times were averaged across the two presentations of the same stimuli. A repeated-measures ANOVA revealed that, in contrast to the findings of the first experiment, there was no significant difference in visual fixation to the three stimuli, $F(2, 30) = 0.28$, $p > .75$ (see Fig. 3). This pattern of looking, when compared to that found in Experiment 1, suggests that infants' perceptual template incorporates the structure of spiders as well as the curved shape of the legs and body of spiders.

4. Experiment 3

The first two experiments show that infants may possess a perceptual template for spiders; however, it is important to demonstrate that this template facilitates learning for real spiders. Perhaps 5-month-olds have a preference for particular shapes – specifically, the schematic spider shape in Experiment 1 – but this preference might be unrelated to an evolved fear mechanism for learning about spiders. To address this question, we conducted a third experiment in which 5-month-old infants were habituated to four static color images of different real

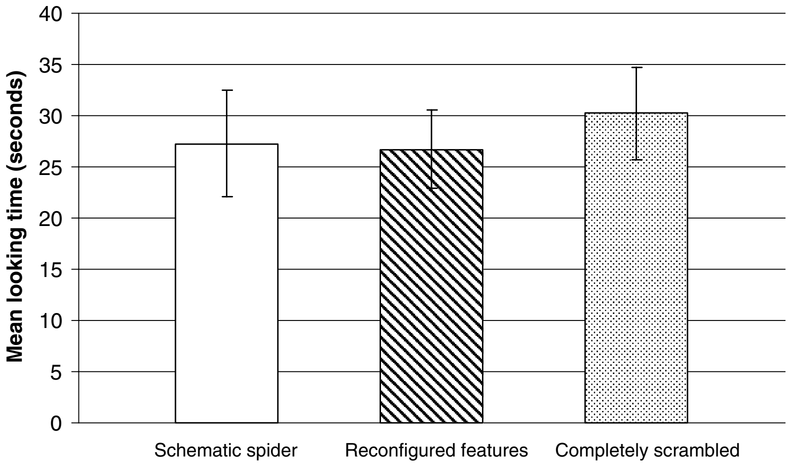

Fig. 3. Infant looking times to the three rectangular spider-like images in Experiment 2. Visual fixation times to the three images were not significantly different. Error bars represent standard error.

spiders and then tested with the same stimuli used in Experiment 1. The rationale for this design was that if infants' perceptual template is used to learn about spiders in their environment, then following habituation to real images of spiders the schematic image should be familiar to them; that is, infants should look longer at the reconfigured and completely scrambled spider than the schematic spider. In contrast, if 5-month-olds do not have a perceptual template specifically for spiders, then following habituation to images of real spiders they should behave similarly to infants in Experiment 1.

4.1. Methods

4.1.1. Participants

Twenty healthy full-term infants with a mean age of 5 months 2 days (range: 4 months, 11 days to 5 months, 21 days) acted as participants. There were 8 males and 12 females. Thirteen additional infants were tested but eliminated from the final analysis because of failure to habituate (10), experimenter error (2), and looking more than 3 SD beyond the condition mean (1).

4.1.2. Materials and procedure

The habituation stimuli were four color images of different kinds of spiders (see Fig. 4). During the habituation phase, each spider stimulus was presented until the infant looked away from the monitor for over 1 s or until 30 s of continuous looking had elapsed. The habituation phase stopped when an infant's looking time

Fig. 4. Habituation stimuli used in Experiment 3.

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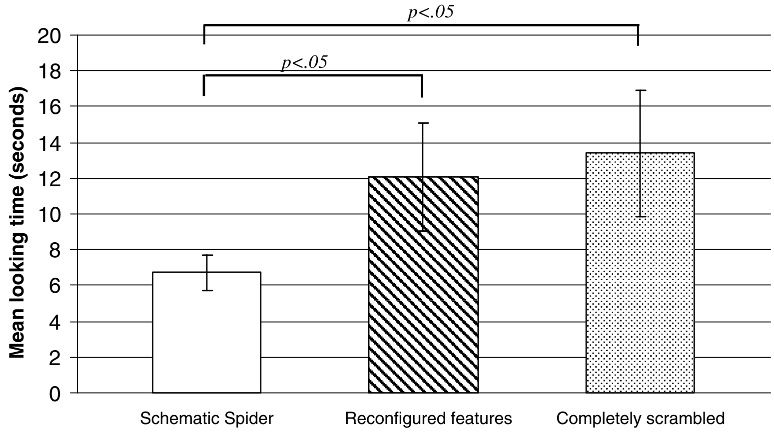

Fig. 5. Infant looking times to the three spider-like images following habituation to real images of spiders. In contrast to Experiment 1, infants' visual fixation to the spider with reconfigured features and the totally scrambled spider were longer than to the schematic spider. Infants' visual fixations to the spider with reconfigured features and the totally scrambled spider were not significantly different.

decreased to a set criterion level (a block of three trials in which total looking was 50% of that in the first three trials) or until 16 trials were presented. The test trials were identical to those in Experiment 1. A green expanding and contracting circle on a dark background and a synchronous bell sound was presented on the screen prior to the first habituation trial and between each habituation and test trial. All other aspects of the procedure were identical to Experiments 1 and 2.

4.2. Results

Infants' looking times were averaged across the two presentations of the same stimuli. The looking times are presented in Fig. 5. As in Experiments 1 and 2, we used 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 reliably different, $F(2,38) = 3.51$, $p < .05$. Planned comparisons showed that infants looked significantly longer at the spider with reconfigured features ($M = 12.05$; $SD = 13.57$), $F(1,19) = 4.45$, $p < .05$, and the totally scrambled spider ($M = 13.40$; $SD = 15.89$), $F(1,19) = 4.39$, $p < .05$, than at the schematic spider ($M = 6.73$; $SD = 4.43$). Infants looked equally long at the spider with reconfigured features and the totally scrambled spider, $F(1,19) = 0.39$, $p > .5$.

4.3. Discussion

The results of Experiment 3 show that 5-month-olds respond to a schematic spider as familiar following habituation to images of real-world spiders. Infants generalized from the real spiders they observed during the habituation to the schematic spider but not to the other images presented during the test phase. This implies that infants' preferential looking to the schematic spider in Experiment 1 was not a consequence of a simple perceptual preference for that shape that was unrelated to a template for spiders.

It could be argued that the effects of the current experiment were simply the result of a spider prototype formed during the habituation phase (Quinn, Eimas, & Rosenkrantz, 1993). However, in contrast to previous studies on prototype formation, infants in the present studies showed an initial visual preference for the schematic stimulus (Experiment 1) and generalized from a real to a schematic image (Experiment 3). Furthermore, given the various positions of the legs of the spiders used in habituation, a prototype effect would have been predicted to generalize to the scrambled spider in addition to the schematic one.

5. Experiment 4

One potential interpretation of the experiments presented thus far is that infants orient to biologically plausible stimuli regardless of whether they are recurrent threatening or non-threatening stimuli. For instance, it may be the case that infants would look longer at any biologically plausible stimulus than at a scrambled version of the same stimulus. To address this issue, in this experiment we presented 5-month-old with three flower-like images – one a schematic flower, one with reconfigured features, and one that was completely scrambled – to determine whether infants would exhibit the same pattern of looking as that found in Experiment 1. A flower was chosen as the control stimulus because flowers have been used as control stimuli by Öhman, Mineka, and colleagues in a number of studies with human adults and non-human primates (e.g., Cook & Mineka, 1990; Öhman & Mineka, 2001).

5.1. Methods

5.1.1. Participants

Participants were 16 health-term infants with a mean age of 4 months 25 days (range: 4 months, 5 days to 5 months, 15 days). There were 10 females and 6 males in the final sample. Two additional infants were excluded from the final analysis, one because of fussiness and one because of experimenter error.

5.1.2. Materials and procedure

The stimuli for this study were comparable to those in Experiment 1 except that infants were shown three flower-like geometric stimuli that moved back and forth across a computer screen. The stimuli, which are illustrated in Fig. 6, included a schematic representation of a flower along with two versions of the same image for which the features were partially (reconfigured features) or totally (completely scrambled) rearranged. All other aspects of the procedure and design of the study were identical to Experiments 1 and 2.

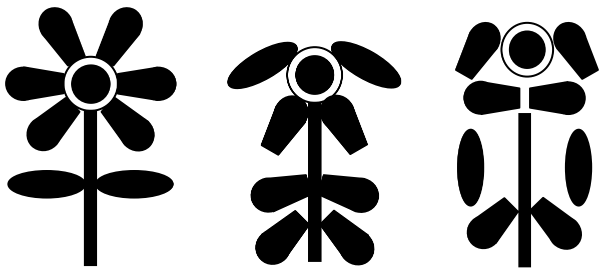

Fig. 6. Schematic images of flowers used as test stimuli in Experiment 4.

5.2. Results and discussion

Infants' looking times were averaged across the two presentations of the same stimuli and analyzed with a repeated-measures ANOVA. The analysis revealed that 5-month-olds looked equally long at all three stimuli, $F(2, 30) = 0.93$, $p > .4$ (see Fig. 7). Planned comparisons similarly showed that the differences in visual fixation across stimulus type did not approach significance (all p's $> .25$).

The results of this experiment suggest that infants' behavior in Experiment 1 did not result from a general bias to attend to biologically plausible stimuli. If infants possessed such a tendency they would have been expected to look longer at the schematic flower than the other two stimuli; the results show that this was not the case. The current experiment, in conjunction with the others reported here, provides further support for the notion that infants may have a perceptual template for specific stimuli that were recurrent threats over evolutionary time.

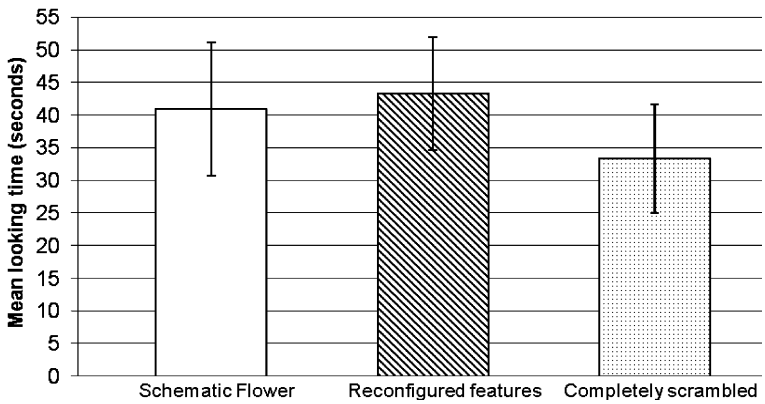

Fig. 7. Infant looking times to the three flower-like images in Experiment 4. Visual fixation times to the three images were not reliably different. Error bars represent standard error.

6. General discussion

These experiments are the first to show that infants may possess a mental template for an animal that was a recurrent, but avoidable, threat during evolutionary history. The experiments reveal that this mental template specifies not only the structure of spiders but their curvilinear body and legs. More impressive perhaps, the data show that infants' learning about images of real spiders can be generalized to this perceptual template, which suggests that the effect found in Experiment 1 was not an artifact of some simple perceptual bias for the schematic spider image. The data from Experiment 4 suggest that the visual preference in Experiment 1 did not result from prior experience with spiders; that is, 5-month-old infants in all likelihood have greater exposure to flowers than to spiders but nonetheless they did not look longer at a schematic flower than at scrambled versions of the same stimulus. The extant literature confirms the existence of similar templates in non-human animals. For example, toad tadpoles and young salamanders reared in the laboratory display predator aversion responses to a variety of predatory species that commonly prey on them but not to non-predatory animals that inhabit the same environment (Kats, Petranka, & Sih, 1988; Kiesecker, Chivers, & Blaustein, 1996; see also Griffin, Evans, & Blumstein, 2001).

We, along with other theorists (e.g., Öhman & Mineka, 2001, 2003), propose that humans' perceptual template serves two purposes, one in infancy and early childhood and one throughout the lifespan. First, it facilitates learning early in life such that fear responses can be rapidly associated with the stimulus in question when conspecifics' behavior is observed. Research on conditioning adult human and non-human primates to snakes supports this idea (Cook & Mineka, 1990). Second, in childhood and beyond it allows for rapid identification of a potential threat. This automatic "attention-grabbing" characteristic of fear-relevant stimuli could engender quicker reaction to threatening situations. Work on adult humans' ability to detect quickly fear-relevant stimuli supports this view (Öhman et al., 2001).

The current data are also consistent with previous studies that showed that infants prefer a schematic image of a face than images with similar geometric forms arranged in nonsense patterns (Johnson & Morton, 1991). At the same time, the results of Experiment 2 diverge with those found in experiments on early face tracking in which neonates preferentially oriented to a simplified face that consisted of two square shapes for eyes and one square shape for a mouth. In our view, these results are not contradictory. An adaptation for face orienting needs to operate within the first months of life – when visual acuity is poor and does not allow details to be parsed from the world – so that infants can build an emotional and social bond with their parents. An adaptation for spider recognition, in contrast, is not necessary until later in life when infants begin to locomote and may become exposed to potentially dangerous creatures. To address this issue, ongoing research in the first author's laboratory is examining whether infants younger than 5 months of age also look longer at schematic images of spiders than to scrambled versions of the same image.

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To our knowledge these data, along with work on early face recognition, are the first to show that infants may possess a perceptual template for evolutionarily relevant stimuli. In all likelihood, infants possess perceptual templates for other stimuli for which they are ‘‘prepared’’ by evolution to learn. It is possible, for example, that infants also have a perceptual template for male humans that facilitates the anxiety toward men but not women that appears around 7 months of age. The current data also help to address a long-standing criticism of evolutionary psychology; namely, what is the basis for the cognitive biases observed in adulthood and how are they implemented? The findings reported here imply that an innate perceptual template can account, in principle, for many (but almost certainly not all) such biases. It is quite plausible that many of the cognitive biases found in adults by evolutionary psychologists (e.g., that for a specific range of waist-to-hip ratios, Singh, 1993) may have their basis in infancy. Future research could employ the techniques used here to elucidate the presence and content of such templates.

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References

Ainsworth, M. D. S., Blehar, M., Waters, E., & Wall, S. (1978). *Patterns of attachment*. Hillsdale, NJ: Erlbaum.

Griffin, A. S., Evans, C. S., & Blumstein, D. T. (2001). Learning specificity in antipredator training. *Animal Behavior, 62*, 577–589.

Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. (2000). Travel broadens the mind. *Infancy, 1*, 149–219.

Cook, M., & Mineka, S. (1990). Selective associations in the observational conditioning of fear in rhesus monkeys. *Journal of Experimental Psychology: Animal Behavior Processes, 16*, 372–389.

Fantz, R. (1963). Pattern vision in newborn infants. *Science, 140*, 296–297.

Gibson, E. J., & Walk, R. D. (1960). The ‘‘visual cliff’’. *Scientific American, 202*, 64–71.

Johnson, M. H., & Morton, J. (1991). *Biology and cognitive development: The case of face recognition*. Oxford: Blackwell.

Johnson, M. H., Dziurawiec, S., Ellis, H. D., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition, 40*, 1–19.

Kats, L. B., Petranka, J. W., & Sih, A. (1988). Antipredator defenses and the persistence of amphibian larvae with fishes. *Ecology, 69*, 1865–1870.

Kiesecker, J. M., Chivers, D. P., & Blaustein, A. R. (1996). The use of chemical cues in predator recognition by western toad tadpoles. *Animal Behavior, 52*, 1237–1245.

Nesse, R. M. (1990). Evolutionary explanations of emotions. *Human Nature, 1*, 261–289.

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

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

Öhman, A., & Mineka, S. (2003). The malicious serpent: Snakes as a prototypical stimulus for an evolved module of fear. *Current Directions in Psychological Science, 12*, 5–8.

Quinn, P. C., Eimas, P. D., & Rosenkrantz, S. L. (1993). Evidence for representations of perceptually similar natural categories by 3-month-old and 4-month-old infants. *Perception, 22*, 463–475.

Rakison, D. H. (2005). Infant perception and cognition: An evolutionary perspective on early learning. In D. Bjorkland & B. Ellis (Eds.). *Origins of the social mind: Evolutionary psychology and child development*. New York: Wiley.

Singh, D. (1993). Adaptive significance of female physical attractiveness: Role of waist-to-hit ratio. *Journal of Personality and Social Psychology, 65*, 293–307.

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