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PAPER

A comparison of rural and urban Indian children's visual detection of threatening and nonthreatening animals

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Abstract

Recent studies indicate that young children preferentially attend to snakes, spiders, and lions compared with nondangerous species, but these results have yet to be replicated in populations that actually experience dangerous animals in nature. This multi-site study investigated the visual-detection biases of southern Indian children towards two potentially dangerous taxa, snakes and lions, that constituted major threats during human evolution. Three- to 8-year-old children from two distinct populations were presented with visual-search tasks containing one target image embedded in matrices of eight distractor images. Children living in Bangalore city, an urban setting in which exposure to dangerous animals would only occur occasionally during family outings to zoos and forest areas, were compared with children living in and around National Parks where exposure to dangerous species is frequent. In the first two experiments, children from both locations detected snake and lion images more rapidly than nonthreatening lizard and antelope images, respectively. Neither urban nor rural children displayed a bias for detecting horses versus cows, the latter constituting a familiar animal with strong religious significance. For all three experiments, the reaction times of urban and rural children were very similar, indicating that periodic exposure to dangerous animals early in life, coupled with adult cautioning, did not facilitate better snake and lion detection. This consistency of urban and rural children with different exposure to dangerous animals suggests that detection of some dangerous species may reflect both experience in nature and visual biases shaped by natural selection.

Research highlights

- In visual-search tasks, urban children from Bangalore and rural children from southern India living with dangerous wildlife exhibited similar patterns of locating target images of snakes and lions faster than nonthreatening lizard and antelope targets, respectively.
- Urban and rural children did not differ reliably in their speed of detecting images of horses and cows, the latter characterizing a highly revered animal in Indian culture.
- Snake and lion targets may 'pop out' in matrices of distractor lizard and antelope images, engendering faster reaction times.
- Complementary to threatening image pop out, the slower ability to detect nonthreatening target images in matrices of threatening distractors may reflect delayed disengagement while scanning through the provocative distractors.

Introduction

A growing body of literature indicates that the human visual system is selectively attentive towards animals that posed a widespread and recurrent threat to primate survival (DeLoache & LoBue, 2009; LoBue, 2010a; LoBue & DeLoache, 2008, 2010, 2011; LoBue & Larson, 2010). Through natural selection, those individuals that exhibited a propensity to quickly detect dangerous animals, such as venomous snakes, predatory pythons, and large felids, were able to survive and reproduce, further spreading this perceptual ability to subsequent generations. The long historical time frame that primates

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were exposed to predators is reflected by the various physical, social, and perceptual abilities they have evolved to cope with predatory threats (Isbell, 1994).

A variety of experimental evidence suggests that the high degree of visual acuity displayed by adults and children evolved at least partially to help detect ancient predators. Initial visual-search experiments tested whether images of threatening animals, i.e. snakes and spiders, were more easily detected in matrices of nonthreatening images than the detection of nonthreatening images in matrices of snakes or spiders (Öhman, Flykt & Esteves, 2001). The results indicated that adults do indeed preferentially detect the presence of threatening animals, but the experimental procedure used to test adults was too elaborate using multiple buttons to employ with young children. LoBue and DeLoache (2008) developed a computerized touch-screen visual-search procedure allowing children to easily complete visual-search tasks without extensive training. In their new procedure, children simply touched the target image on the screen once it was detected, eliminating the more cumbersome button pressing previously employed with adults. This child-friendly ergonomic procedure allowed for investigations into whether or not visual biases towards threatening animals are manifested prior to extensive exposure to animals early in life. The results of LoBue and DeLoache's (2008) study showed that preschool-aged children detected target images of snakes embedded in matrices of flowers, frogs, and caterpillars more rapidly than target images of flowers, frogs, and caterpillars embedded in matrices of snake images. This finding is consistent with previous results showing that adults are especially capable of detecting evolutionarily relevant animals in visual arrays of nonthreatening images (also see Öhman *et al*., 2001). The motivation for studying this phenomenon in young children was to determine whether these biases appeared early in development. Follow-up studies using this touch-screen procedure indicated that images of coiled snakes were more salient than images of snakes with extended bodies (LoBue & DeLoache, 2011), and that children and adults also preferentially detected target spiders in matrices of benign images (LoBue, 2010a).

Most recently, a new series of touch-screen visual-search tasks has replicated the original findings of LoBue and DeLoache (2008), and extended this research paradigm on several important dimensions. Penkunas and Coss (2013) first presented preschool-aged children and adults with a touch-screen visual-search task juxtaposing snakes with visually similar lizards to provide a more stringent test of the threat-superiority effect. Here, both children and adults detected the target snake images embedded in matrices of lizards more readily than target lizard images embedded in matrices of snakes. These results provide additional support to the supposition that natural selection from historical snake predation (i.e. pythons; see Headland & Greene, 2011) has shaped primate visual systems to be especially sensitive to snake images (Isbell, 2006; Öhman & Mineka, 2003).

A second class of predator, large-bodied felids, are major threats to extant primates, and leopards in particular are recognized as dangerous by some primates presented with realistic models in forest and urban settings where these felid predators are never observed (Coss & Ramakrishnan, 2000; Schel, Tranquilli & Zuberbühler, 2009). According to the fossil record, felids have constituted major threats to hominins for the past 6 million years (cf. Brain, 1970; Pickford & Senut, 2001; Coss & Moore, 2002; Treves & Palmqvist, 2007). Penkunas and Coss (2013) showed that preschool children and adults were also able to detect target images of African lions embedded in matrices of antelope faster than antelope targets in matrices of lion images. This ability likely reflects the adaptive value of detecting dangerous predators among nonthreatening animals quickly in circumstances where humans traversed open habitats in the search for food or water. Lastly, Penkunas and Coss (2013) compared the visual salience of two historically benign animals, cows and horses, that have not acted as major sources of selection on human perceptual abilities. As predicted by the threat-superiority hypothesis, the children in this visual-search experiment exhibited similar reaction times for locating cow and horse target images. On the other hand, adults showed a differential pattern of detection, with women locating the horse images reliably faster than cow images. Men exhibited no substantial difference in their speed of detecting the two animal types. The difference in reaction times (RT) for adult women, compared with men, suggests that childhood experience might contribute to the salience of certain animals. This inference is based on research showing that Norwegian girls (Bjerke, Ødegårdstuen & Kaltenborn, 1998) exhibit a greater preference for horses than boys which is likely the result of their greater horseback-riding experience (Bjerke, Kaltenborn & Ødegårdstuen, 2001).

A similar pattern of age-related change has been described for the acquisition of visual biases towards modern threats. It has been shown that guns capture the visual attention of adults to the same degree as snakes (Fox, Griggs & Mouchlianitis, 2007), but that children's attention is preferentially captured only by dangerous objects that they have had experience with, such as syringes during medical treatment (LoBue, 2010b). Together, these findings suggest that early life experience can engender perceptual biases toward objects and animals manifested later in life.

Experimental questions and predictions

Consistent with the majority of child-development studies conducted in Western countries, the children who participated in the LoBue and DeLoache (2008) and Penkunas and Coss (2013) studies were predominantly from middle-class families of European ethnicity. This relative demographic homogeneity is difficult to avoid logistically when conducting developmental research in university settings, and this phenomenon limits the generality of experimental findings to humans from other cultures.

The primary goal of the current study of urban and rural children in southern India is to determine whether differential exposure to dangerous animals affects their animal-detection ability. This study also attempts to expand the generality of the threat-superiority effect by testing two distinct populations of children whose experiences of culture, media, and education differ appreciably from those of American children. If the biases for detecting ecologically important threatening images reflect some inherent properties of the visual system, then we should find similar patterns of RTs in Indian and American children irrespective of childhood experience and cultural differences. Furthermore, American children are exposed to far fewer ecological threats than those experienced by humans living with dangerous wildlife (Thuppil & Coss, 2012).

LoBue and DeLoache (2008) showed that children with previous exposure to snakes performed no better than those who had no experience with snakes, a finding that provides an additional argument for conducting cross-national research. Nevertheless, previous research also shows that early life experiences can affect how children attend to visual information. A series of studies conducted by Pollak and colleagues (Pollak & Kistler, 2002; Pollak & Tolley-Schell, 2003; Pollak, Cicchetti, Hornung & Reed, 2000) indicate that children who have been physically abused by adult caregivers become hypervigilant towards visual cues of aggression, such as angry facial expressions. These results suggest that negative emotional experiences early in life, i.e. physical abuse, influence a child's visual attention and vigilance. In a similar vein, we can predict that those children reared in an environment where potentially dangerous wildlife is abundant will manifest increased sensitivity toward dangerous animals. Children living with a lingering risk of encountering a deadly animal may display an acute sensitivity towards dangerous animals mediated by both parental guidance and actual exposure. Alternatively, if the influence of early childhood experiences is negligible, then children living in predator-free and predator-rich settings should perform similarly on visual-search tasks for detecting dangerous animals. By testing two hypotheses simultaneously as suggested by Platt (1964), we are invoking 'strong inference' in which disconfirmation of one hypothesis enhances support for the other.

Lastly, this study examines the role of cultural significance in the development of visual biases in childhood by comparing the evocativeness of two nonpredators that are unequal in cultural meaning. We test the hypothesis that the cultural significance of one particular animal type can augment its visual salience. Over 80% of the Indian population is Hindu (Registrar General and the Census Commissioner of India, 2001), making Hinduism the predominate religion in India. The cow is a highly revered animal according to Hindu beliefs and it is illegal to slaughter cows throughout the majority of India (Heston, 1971). Indeed, if cultural significance facilitates the capture of visual attention in children, the religious significance of the cow in Hindu culture leads to the prediction that Indian children will detect cow images faster than horse images. This prediction is reasonable in light of research showing that personally relevant images are detected in visual-search tasks as fast as threatening images (Purkis, Lester & Field, 2011).

Our third experiment tests this cultural hypothesis by juxtaposing images of cows and horses in a visual-search task. We chose horses and cows for this comparison because they share similar morphological features yet exhibit a markedly different significance in Indian culture. American children in Penkunas and Coss (2013) showed no difference in their ability to locate the two benign animals, but compared with India, cows and horses in America are observed in much different contexts. This third experiment tests the hypothesis that the cultural importance of cows in Indian culture will influence children's RT irrespective of whether they live in urban or rural areas.

General method

Rural participants

For our three experiments, we selected children living in settings with a variety of dangerous snakes and large-bodied felids. One hundred and four children (45 girls, 59 boys) were chosen from a tribal community of former hunter gatherers living in the forests of Bandipur Tiger Reserve, Karnataka, and Mudumalai Tiger Reserve, Tamil Nadu. This sample included children from the small agricultural village of Bachahalli bordering Bandipur Tiger Reserve. Although Bachahalli is outside the tiger reserve, our nighttime video camera traps used for other research (see Thuppil & Coss, 2012) documented the presence of two tigers (*Panthera tigris*) and one leopard (*Panthera pardus*) about 2 km from the village school we sampled. In addition to tigers and leopards, these rural settings are home to a variety of highly venomous snake species, including the Speckled Cobra (*Naja naja*), Krait (*Bungarus caeruleus*), and Russell's viper (*Daboia russellii*). The Indian python (*Python molurus*), a large constrictor, is a potential threat to children (see Headland & Greene, 2011). In addition to these dangerous animals, rural children frequently see Asian elephants (*Elephas maximus*) that are known to kill people without provocation (Gubbi, 2012; Thuppil & Coss, 2012).

Due to the presence of these species, children in these rural schools are cautioned by teachers about how to behave during encounters with dangerous wildlife (Anjali Kumar, personal communication, 6 August 2012). These encounters can be dramatic. Coss, Fitzhugh, Schmid-Holmes, Kenyon, and Etling (2009) reported an incident about 10 km from a tribal school we sampled in which approximately 20 5 to 9-year-old girls collecting firewood surrounded a leopard that had seized their companion and beat it repeatedly with their sticks until the leopard dropped the girl and fled. In addition to word-of-mouth communication as evidenced above, newspaper articles about wildlife attacks are also posted in local eateries. Nevertheless, like other countries with dangerous animals, attacks by wildlife, especially snakes, often go unreported (see Headland & Greene, 2011). First-hand accounts of leopard attacks from Uma Ramakrishnan, a former Indian Forest Department researcher, revealed that 28 people were injured or killed in Karnataka alone during a 7-month period in 1996. In the same time frame, her personal animal tracker was killed by a tiger (personal communication, 6 August 2012).

Urban participants

One hundred and nineteen children (60 girls, 59 boys) living in Bangalore, a large metropolitan city and capital of the southern Indian state of Karnataka, were sampled. Although two venomous snakes, the Speckled Cobra and the highly venomous Russell's Viper are occasionally encountered in people's yards in Bangalore, these snakes are becoming progressively rare as the city continues to grow. As for large felids, the children in this sample are unlikely to have any first-hand experience outside of observing these animals in zoos and it must be noted that young children are not permitted on safari game drives in tiger reserves.

Apparatus and procedure

We adopted the general protocol for the touch-screen visual-search task as reported in LoBue and DeLoache (2008, 2011) and Penkunas and Coss (2013). Twenty-four representative photographic images from six animal categories (snakes, lizards, lions, antelope, cows, horses) were selected for study. For each trial, nine color photographs were presented in 3 × 3 matrices on the touch-screen monitor with one image acting as the target juxtaposed with eight distractor images. Snakes were presented with lizards, lions were presented with antelope, and cows were presented with horses. The images depicted each animal in a natural scene and none of the animals were displaying threatening postures. Photographs were collected from the following sources: (1) RGC provided original photographs of unmaned lions and antelope from the South Luangwa National Park, Zambia, (2) snake and lizard images were scanned from animal encyclopedias at 300 dpi, and (3) cow and horse images were extracted from public websites.

Image matrices were presented on a 38.1-cm (15-inch diagonal) LCD color monitor equipped with a Keytech MagicTouch touch-screen overlay. Matrices measured 32.6 × 25.7 cm when displayed on the monitor. All images were resized to 10.5 × 8.2 cm. Rows and columns in the screen image were separated by a 0.5-cm border and a 0.5-cm outside border surrounded the matrices. The rows, columns, and outside borders were a dull yellow to define the separation of the nine photographs. Each of the 24 images from the target category was presented two or three times in each of the nine possible positions in the matrix across the 24 test trials. Each of the 24 pictures from the distactor category was presented multiple times in a pseudorandomized position across trials. Each distractor image was presented approximately an equal number of times throughout the experiment. The order for the snake, antelope, and horse as target conditions was created by randomly ordering the 24 matrices. The order for the lizard, lion, and cow as target conditions was created by reversing the order of the matching comparison condition.

Children were recruited through school functions, parent groups, and science education courses offered by the Indian Institute of Science in both the rural and urban locations. The head teacher of the participating school administered the visual-search task in English for the Bangalore sample. The science extension instructor administered the visual-search task in the local language for children in the rural setting. Children were tested in a separate area of their school using a portable laptop computer and a touch-screen enabled monitor. Only nonverbal reaction time data were collected from each child. This study was approved by the Internal Review Board at the University of California, Davis, and the administrators of the participating facilities in India.

Each child was seated in front of the touch-screen monitor at a child-sized table or stood in front of a standard table when a smaller table was not available. The experimenter instructed the child to return his or her hands to the table in front of the monitor between trials, ensuring that the latency measures for each trial were reliable among trials and across participants. The experimenter sat next to the participating child to operate the computer presenting the experiment and to give instructions.

Three practice trials were first presented to familiarize the child with the procedure and the touch-screen apparatus. On the first practice trial, a single picture from the distractor category was presented and the child was instructed to touch the image. The second practice trial presented a single picture from the target category and the child was again instructed to touch the image. On the third practice trial, one target and one distractor picture were presented on the screen and the child was instructed to touch only the target image. Twenty-four test trials began after the practice trials were completed. A matrix depicting eight distractors and a single target was presented and each child was instructed to find the target animal and touch it as quickly as possible. Between each trial, the dull yellow screen was presented with a red fixation square, 3.4 × 3.4 cm, centered in the screen (see Figure 1). The experimenter advanced to the next trial manually when the child had returned his or her hands to the table in front of the touch-screen monitor.

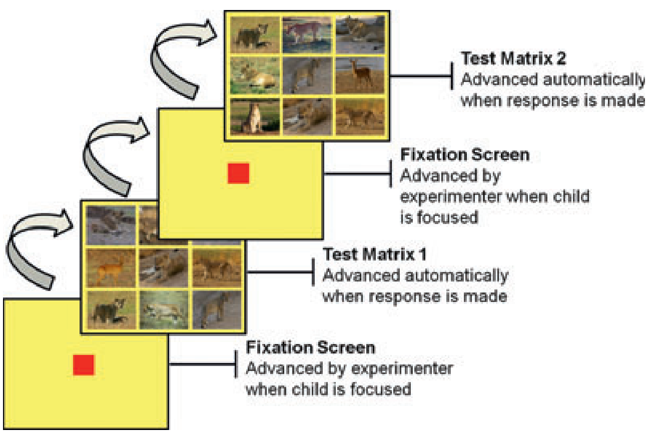

Figure 1 *An example of two trials in the touch-screen visual-search task: Children were asked to locate and touch the image of the target animal embedded in the eight distractor images. Twenty-four trials were presented and an average RT was calculated for each child.*

Statistical analyses

We excluded all trials in which a child failed to identify the correct photograph as the target (4% of trials for all experiments in the urban sample, 3% for the rural sample) or was distracted from the task (3% of trials for all experiments in the urban sample, 2% for the rural sample). An average latency to locate the target image was calculated across all valid trials for each participating child. Reaction time (RT) and age have been described as strongly related to one another (Penkunas & Coss, 2013) so multiple regression was employed to account for this association (Maccallum, Zhang, Preacher & Rucker, 2002). We calculated a centered-age variable by subtracting the age of each child in years from the average age of the entire urban and entire rural sample. The centered-age variable was entered into the model as a continuous variable and, by calculating this deviation from the mean age for each child, the beta coefficients produced by the regression analysis were interpreted more intuitively (Maxwell & Delaney, 2004). We used the estimated age of each rural child in whole years provided by parents and teachers to calculate the average age of this sample since parents could not provide the exact date of birth for over half of the children.

The same multiple regression procedure used in Penkunas and Coss (2013) was employed here. The goal of the analysis was to determine which variables reliably predicted children's RTs for locating the target image. Four independent variables were entered into the model: (1) which target condition the child was tested in for each comparison group, (2) the sex of the child, (3) the number of years the child's age deviated (±) from the average age for the sample, and (4) the interaction between the centered-age variable and target type. The goal of this analysis was to determine whether children's RTs differed when locating any of the two comparison target animals, whether boys differed from girls in their ability to locate the target animals, and whether the RTs for detecting the different target types changed as a function of age.

We also compared the latencies of the urban and rural children to determine whether the children in the two samples differed in their ability to detect any of the animal types. Two separate forward method regression models were created for each experiment, one for each target condition. The three independent variables entered in the model were: (1) the urban or rural location where each child lived, (2) the age of the child in whole years, and (3) the interaction between age and location. The goal of these analyses was to determine whether children's RTs differed reliably across the two sites while controlling for the association between age and RT. The inclusion of the interaction term allows us to see whether the detection abilities of children from one location are improving at a faster rate than those of children at the other location.

Experiment 1: snakes versus lizards

The goal of this experiment was to replicate and expand upon the previous findings of LoBue and DeLoache (2008; 2011) and Penkunas and Coss (2013) for advanced detection of snake images when presented in a visual-search task. Past studies indicate that both children and adults preferentially attend to snake images over other animals, even those that are morphologically similar to snakes. Children from the rural and urban areas were asked to find either a snake target in a matrix of lizards or a lizard image embedded within a matrix of snake images.

Participants

Fifty 3- to 8-year-old children (23 girls, 27 boys; approximate $M = 6.5$ years; one 3-year-old, four 4-year-olds, six 5-year-olds, thirteen 6-year-olds, ten 7-year-olds, sixteen 8-year-olds) from the rural community participated in this experiment. Twenty-five children were tested in each the snake as target and lizard as target conditions. Fifty-two 3- to 8-year-old urban children (32 girls, 20 boys; $M = 6.0$ years; two 3-year-olds, fifteen 4-year-olds, nine 5-year-olds, ten 6-year-olds, thirteen 7-year-olds, three 8-year-olds) participated in this experiment, 25 in the snake as target condition and 27 in the lizard as target condition.

Results

Rural sample

The RT residual for one boy tested in the snake as target condition was greater than three standard deviations away from the mean of the sample and therefore the data for this child were excluded from the analyses. A statistically significant negative correlation was evident between age in years and RT for children tested in the snake as target condition ($r\ (25) = -.70$, $p < .001$). The correlation for age and RT in the lizard condition was trending in the same direction ($r\ (25) = -.35$, $p = .09$), but this correlation was not statistically significant.

The results from the regression analysis indicated that only the centered-age variable and the target condition were reliable predictors of RT. These two predictors explained 48% of the variance in the children's average latency to locate either target animal ($R^2 = .48$, $F(2, 46) = 21.30$, $p < .001$). A child of average age, about 6.5 years old, tested in the lizard as target condition located the lizard images in 3.596 sec. A child of the same age completing the snake as target task is predicted to locate the snake targets approximately 800 ms faster ($\beta = -809.36$, $t(46) = -4.37$, $p < .001$). Second, the age of the child being tested contributed significantly in predicting his or her average latency to locate the target ($\beta = -337.52$, $t(46) = -5.01$, $p < .001$). The beta for the centered-age variable indicates that children's RTs are predicted to change 338 ms in the corresponding direction for each year above or below the average age of 6.5 years. The interaction term between the age of the child and the target type did not contribute to the regression model ($t(46) = -1.61$, $p = .11$), indicating that the intercepts for the regression lines for the two conditions are different from one another yet the slopes do not vary reliably (see Figure 2). Furthermore, boys' and girls' ability to locate either of the target animals did not differ to a statistically reliable degree ($t(46) = -0.25$, $p = .81$), demonstrating that children of both sexes were equally adept at locating the target animals.

Urban sample

The overall results from the urban sample are consistent with those from the rural sample. A statistically significant negative correlation was present between age in years and RT for lizard as target ($r\ (25) = -.74$, $p < .001$) and snake as target conditions ($r\ (22) = -.53$, $p < .01$). Only the two predictors of target condition and

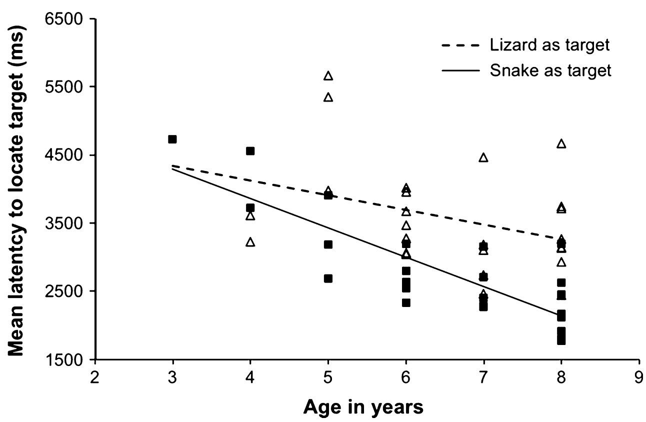

Figure 2 *Average latency to locate target lizard and snake images by age shown in corresponding lines of best fit for rural children living in and adjacent to Bandipur and Mudumalai National Parks in southern India.*

centered-age reliably contributed to the regression model and together explain 50% of the variance in the children's average latency to locate either target animal (R^2 = .50, F(2, 49) = 24.03, p < .001). Similar to the results from the rural setting, an urban child who was the average age of 6 years tested in the lizard as target condition detected the target lizard in 3.394 sec. A child of the same age completing the snake as target task is predicted to locate the snake photographs 657 ms faster (β = −657.39, t(49) = −3.66, p = .001). The centered-age variable again (see Figure 3) contributed significantly in predicating the time required to locate either target animal (β = −380.23, t(49) = −5.84, p < .001). The beta for the centered-age variable indicates that each child's RT is predicted to change 380 ms in the corresponding direction for each year above or below the average age of 6 years for these urban children. The interaction term between the age of the child and the test condition failed to contribute reliably to the regression model (t(49) = −1.15, p = .26), and there was no reliable difference in the RTs between boys and girls (t(49) = 0.44, p = .67).

Comparison of rural and urban samples

Forward method regression analysis was used to compare the RTs of rural and urban children to determine whether they differed in their latency to detect the lizard or snake targets. For the children tested in the snake as target condition, the analysis indicated that age was a statistically reliable predictor of RT (β = −345.89, t(46) = −6.06, p < .001), accounting for 44% of the variance in RT between the two samples (R^2 = .44, F(2, 46) = 36.77, p < .001). No reliable difference existed between urban and rural children in their latency to locate the target snake image (t(47) = 1.28; p = .21), and there was no reliable statistical interaction between rural and urban locations and age (t(47) = −.96; p = .33). This latter finding indicates broad similarities in the snake-detection abilities of children from both locations and that this ability changes at a similar rate as a function of age.

The analysis of children tested in the lizard as target condition indicated that age contributes significantly to predicting RT (β = −317.65, t(49) = −4.76, p < .001) and that, unlike the snake as target condition, a reliable age by location interaction exists for the lizard target (β = −68.34, t(49) = −2.08, p < .001). But, while factoring out the influence of age and the interaction between age and location, there was no reliable difference between the urban and rural children's ability to locate the target lizard (t(49) = 1.19, p = .24). The combination of age and age by location interaction accounts for 34% of the variance in children's latencies to locate the lizard target (R^2 = .34, F(2, 49) = 12.53, p < .001). This reliable interaction for the lizard target is apparent in the relatively flat slope for rural children's RTs compared with the steeper slope for urban children (compare Figures 2 and 3).

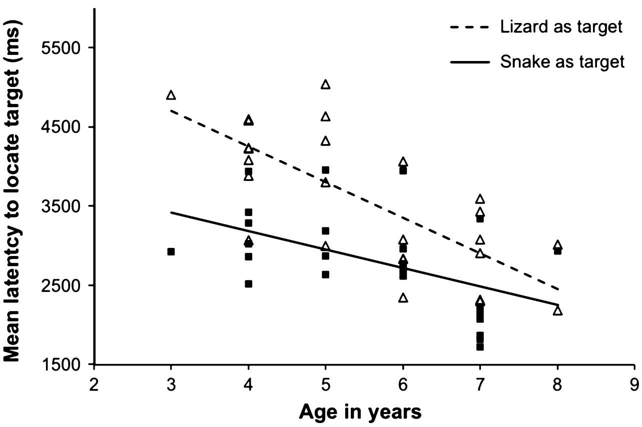

Figure 3 *Average latency to locate target lizard and snake images by age with corresponding lines of best fit for the urban children from Bangalore, India.*

Experiment 2: lions versus antelope

This experiment is a replication of the original study by Penkunas and Coss (2013) conducted with American children and will determine whether or not living in an environment where large-bodied felids are actual threats facilitates the detection of lion images in a visual-search task. Children from both the rural and urban areas were asked to find either a single lion target embedded in a matrix of antelope images or the converse.

Participants

Fifty 3- to 8-year-old children (23 girls, 27 boys; approximate M = 6.4 years; one 3-year-old, four 4-year-olds, eight 5-year-olds, thirteen 6-year-olds, nine 7-year-olds, fifteen 8-year-olds) from the rural community participated in this experiment, 25 in the lion and 25 in the antelope as target conditions. Forty-seven of these children also participated in Experiment 1. Twenty-four children who were tested in the lizard as target condition in Experiment 1 completed the lion as target task in Experiment 2. Twenty-three children who completed the snake as target task in Experiment 1 were tested in the antelope as target condition in Experiment 2. This presentation combination ensured that children were tested in one threat-relevant target condition and one nonthreatening target condition. Approximately half of the children completed Experiment 1 first and approximately half completed Experiment 2 first to eliminate any order effects. Fifty 3- to 8-year-old urban children (28 girls, 22 boys; $M = 5.7$ years; eight 3-year-olds, ten 4-year-olds, twelve 5-year-olds, seven 6-year-olds, ten 7-year-olds, three 8-year-olds) participated in this experiment, 25 in the lion as target condition and 25 in the antelope as target condition. Twenty-nine of these children also participated in Experiment 1. Fifteen children that were tested in the lizard as target condition also completed the lion as target task and 14 children that completed the snake as target task were also tested in the antelope as target condition. Again, the experimental order for those children who participated in both Experiment 1 and Experiment 2 was randomized to preclude order effects.

Results

Rural sample

A statistically significant negative correlation was evident between age in years and RT for the rural children tested in both the lion as target condition (r (25) = −.69, $p < .001$) and the antelope as target condition (r (25) = −.45, $p < .001$). The regression analysis for this sample identified the target condition and centered-age variable as reliable predictors of RT. Together, these two predictors explain 40% of the variance in the children's latency to locate either target animal ($R^2 = .40$, $F(2, 47) = 15.84$, $p < .001$). A child of average age, approximately 6.4 years old, tested in the antelope as target condition located the antelope images in 3.371 sec. Children of the same age tested in the lion as target condition located the lion targets about 400 ms faster ($\beta = -400.84$, t (47) = −2.24, $p = .03$). Second, the age of the child being tested contributed significantly in predicting his or her average latency to locate either target animal ($\beta = -327.61$, $t(47) = -5.02$, $p < .001$). The beta for the centered-age variable indicates that children's RTs are predicted to change 327 ms in the corresponding direction for each year above or below the average age of 6.4 years (Figure 4). There was no reliable difference in RTs between boys and girls ($\beta = 0.09$, $t = 0.79$, $p = .44$). The predictive ability of the interaction term between the age of the child and the test condition is approaching statistical significance ($t(47) = 1.98$, $p = .054$). This nearly reliable interaction indicates that the youngest children in this sample differed appreciably in detecting the lion and antelope targets while the oldest children were similar in their detection speeds for the two animal types (see Figure 4).

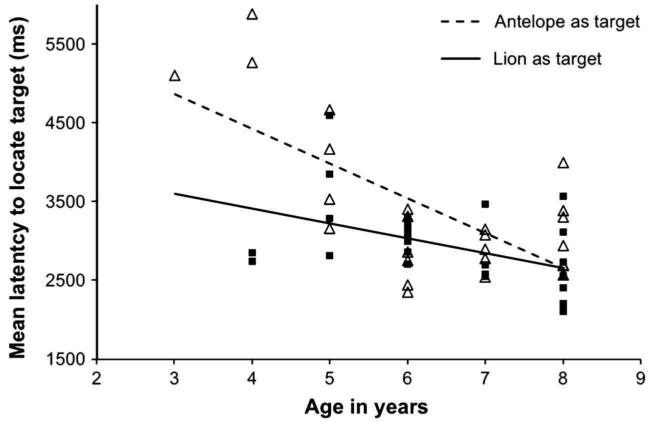

Figure 4 *Average latency to locate target antelope and lion images by age with corresponding lines of best fit for rural Indian children. The interaction between age and target-type approaches statistical significance (p = .054).*

Urban sample

A significant correlation between age and RT was present for the urban children tested in both the lion as target condition (r (25) = −.72, $p < .001$) and antelope as target condition (r (25) = −.76, $p < .001$). The regression analysis for the urban sample indicates that only the target type and centered-age variables reliably predicted RT, mirroring the results for the snake–lizard comparison (see Figure 5). The constant produced by the regression analysis indicates that a child of average age of 5.7 years in the antelope as target condition was able to locate the antelope in 3.288 sec. A child of the same age tested in the lion as target condition is predicted to locate the lion photographs 626 ms faster ($\beta = -626.63$, $t(47) = -3.78$, $p < .001$). Again, the child's age was found to be a statistically reliable predictor of RT in detecting either target animal, with a 405 ms advantage being accrued with each year of age ($\beta = -405.81$, $t(47) = -7.35$ $p < .001$). Together, the target type and centered-age variables explained 58% of the variance in the children's average latencies to locate the target photographs ($R^2 = .58$, $F(2, 47) = 32.11$, $p < .001$). For the urban sample, neither the sex of the child ($t(47) = -0.01$, $p = .99$) nor the age by target type interaction term ($t(47) = 1.35$, $p = .18$) contributed significantly to the regression model.

Comparison of rural and urban samples

As with the snake–lizard comparisons, two separate regression models were created to determine whether children exposed to dangerous wildlife were able to find either target animal faster than children living in an

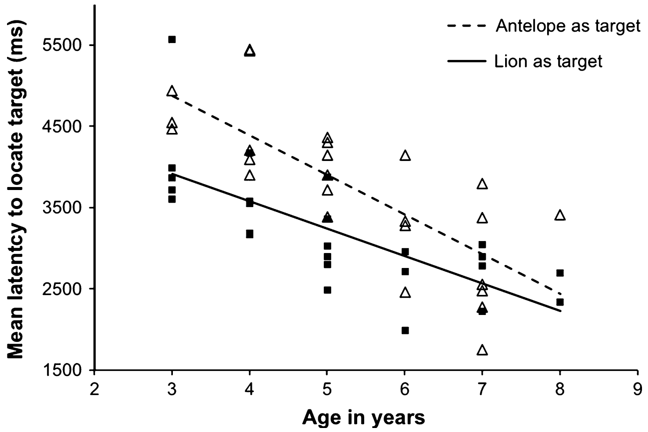

Figure 5 *Average latency to locate antelope and lion target images by age with corresponding lines of best for urban Indian children.*

urban area devoid of threatening wild animals. For the children tested in the lion as target condition, the analysis indicated that age alone reliably predicts RT (β = −262.16, $t(47) = -5.70$, $p < .001$), explaining 40% of the variance in average latency to locate the lion targets for the two samples ($R^2 = .40$, $F(2, 47) = 32.43$, $p < .001$). No reliable difference existed in the time required to locate the lion targets between children from rural and urban locations ($t(47) = -.70$, $p = .49$), and there was no statistical interaction between age and location ($t(47) = -1.05$, $p = .30$). The analysis of children tested in the antelope as target condition revealed that only age contributed significantly in predicting RT (β = −451.72, $t(47) = -7.40$, $p < .001$). Again, there was no reliable difference between the rural and urban children's ability to locate the antelope targets ($t(47) = -.579$, $p = .57$), and there was no reliable statistical interaction between location and age ($t(47) = .65$, $p = .52$). Here, age alone explained 53% of the variance in average RT for children in the antelope as target condition for the two samples ($R^2 = .53$, $F(2, 47) = 54.72$, $p < .001$).

Experiment 3: cows versus horses

Experiment 3 was designed as a robust control experiment by juxtaposing two nonthreatening animals, horses and cows, which differ greatly in their cultural significance. As discussed above, rapid detection of one animal over another may be facilitated by its cultural importance rather than evolutionary history. Because of the reverence displayed towards cows in the Hindu religion (Heston, 1971), children may display a visual bias in attending to images of cows. Our previous research has shown that adult women in America attend to horse images over cow images, yet men and American children of both genders do not (Penkunas and Coss, 2013). As in Experiments 1 and 2, children from rural and urban locations were asked to find either a single cow target embedded in matrices of horse images or a single horse target embedded in matrices of cow images.

Participants

Fifty 5- to 8-year-old children (21 girls, 29 boys; approximate $M = 6.7$ years; seven 5-year-olds, fifteen 6-year-olds, fourteen 7-year-olds, fourteen 8-year-olds) from the rural area participated in this experiment. Twenty-five children were tested in each of the cow and horse as target conditions. None of these children participated in either Experiment 1 or Experiment 2. Fifty 3- to 8-year-old children from the urban area (21 girls, 29 boys; $M = 6.0$ years; one 3-year-old, nine 4-year-olds, eighteen 5-year-olds, nine 6-year-olds, twelve 7-year-olds, one 8-year-old) participated in this experiment, 25 in the cow as target condition and 25 in the horse as target condition. Two of these urban children were also tested in the lizard as target condition in Experiment 1.

Results

Rural sample

Figure 6 illustrates the statistically significant negative correlation between age and RT for the rural children tested in the cow as target condition (r (25) = −.68, $p < .001$) and horse as target condition (r (25) = −.72, $p = .02$). The regression analysis for the rural sample indicated that only the centered-age variable was a reliable predictor of RT for both animal targets (β = −462.67, $t(48) = -4.94$, $p < .001$), accounting for 34% of the variation in performance ($R^2 = .34$, $F(1, 48) = 24.41$, $p < .001$). RT did not differ reliably by sex ($t(48) = -1.47$, $p = .15$) or target condition ($t(48) = 0.35$, $p = .73$). The interaction between age and target condition was also not statistically significant ($t(48) = 0.96$, $p = .34$).

Urban sample

For the urban children, the negative correlation between age and latency to detect the target animal was again statistically significant for children tested in both the cow as target condition (r (25) = −.69, $p < .001$) and horse as target condition (r (25) = −.55, $p = .005$). The results of the regression analysis for the urban sample reflect the findings described for the rural sample (compare Figures 6 and 7). Again, only the centered-age variable reliably predicted the average time required for children living in the urban area to find either the cow or horse targets ($\beta = -464.95$, $t(48) = -5.30$, $p < .001$). Similarly, age alone explains 37% of the variance in RT for this sample ($R^2 = .37$, $F(1, 48) = 28.06$, $p < .001$), while performance on the task did not vary by sex ($t(48) = 0.60$, $p = .55$) or target condition ($t(48) = -0.58$, $p = .57$). The age by target condition interaction term also did not contribute reliably to the regression model ($t(48) = 0.49$, $p = .63$).

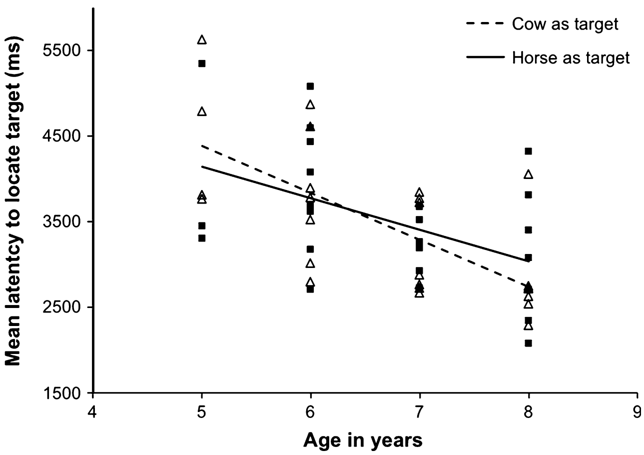

Figure 6 *Average latency to locate cow or horse target images by age with corresponding lines of best fit for rural Indian children.*

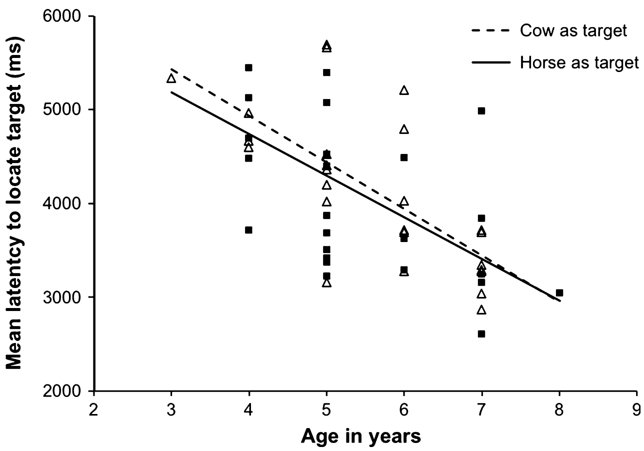

Figure 7 *Average latency to locate cow and horse target images by age with corresponding lines of best fit for urban Indian children.*

Comparison of rural and urban samples

The regression analyses comparing the children's latency to detect the cow and horse targets revealed that rural and urban children's performances were very similar. For the children tested in the cow as target condition, the analysis indicated that only age was a reliable predictor of RT ($\beta = -541.11$, $t(47) = -7.45$, $p < .001$). Age alone explained 54% the variance in average latency to locate the cow targets for the two samples ($R^2 = .54$, $F(2, 47) = 27.56$, $p < .001$). The difference in RTs between the two sites in locating the cow targets was not statistically significant ($t(47) = -.58$, $p = .57$) as was the interaction between age and location ($t(47) = -.63$, $p = .53$). The analysis of children tested in the horse as target condition also indicated that only age contributed significantly in predicting RT ($\beta = -424.28$, $t(47) = -12.24$, $p < .001$). For the two samples, age alone explained 35% of the variance in average RT for children in the horse as target condition ($R^2 = .35$, $F(2, 47) = 12.48$, $p < .001$). There was no reliable difference between the rural and urban children's ability to locate the horse targets ($t(47) = -.23$, $p = .82$), and there was no statistical interaction between age and location ($t(47) = -.15$, $p = .88$).

General discussion

The results reported here provide the first evidence for the rapid detection of evolutionarily relevant animals in children from a non-Western population. Experiments 1 and 2 demonstrated that both children in the large city of Bangalore and children living in rural areas of southern India with dangerous wildlife located threat-relevant animals (snakes and lions) faster than historically nonthreatening animals (lizards and antelope) in visual-search tasks. Experiment 3 indicated that children from neither rural nor urban sites differed reliably in their speed of detecting images of horses and cows, the latter characterizing a highly revered animal in Hindu religion. The results from the urban and rural samples in Experiment 1 support the previous findings that snake images recruit the visual attention of children rapidly (LoBue & DeLoach, 2008, 2011). Consistent with our previous research (Penkunas and Coss, 2013), Indian children who differed from American children in their experiences of media and education, detected snake images faster than lizard images that both exhibited similar-looking tessellated scale patterns, angular head shapes, and elongated bodies. In light of these similar visual features, the presence of limbs might be the conspicuous recognition cue used by children to distinguish lizards from snakes. The generality of our results from a non-Western population of children supports the argument that the salience of snakes reflects an ancient neurological property of the primate visual system (Isbell, 2006). The findings of LoBue and DeLoache (2010) add further insight to this argument because they show that snake images attract the visual attention of infants as young as 8 months of age. Nevertheless, evolutionarily 'prepared' associative learning (Seligman, 1971) may play an important role in augmenting the visual salience of snakes because prelingual infants look longer at film clips depicting snakes when they listen to recordings of a frightened human voice than when they listen to a happy voice (DeLoache & LoBue, 2009).

For the lizard as target condition, the presence of an age by location interaction for the urban and rural samples suggests that, with frequent exposure to lizards in nature, rural children showed only a slight age-related improvement in their speed of detecting lizard targets whereas urban children exhibited a much greater rate of age-related improvement (compare Figures 2 and 3). There is no statistically reliable interaction between age and location for the urban and rural children tested in the snake as target condition, indicating congruence in their rates of age-related improvement in snake-detection abilities. When controlling for age and the interaction of age and location, the lack of difference between the snake- and lizard-detection RTs for rural and urban children suggests that living in an environment where snakes are encountered frequently does not enhance snake detection in the visual-search task.

The shorter latencies for detecting snake images compared with lizard images might be explained by two possible perceptual processes. For example, the single snake target may 'pop out' rapidly from the background matrices of lizard images, engendering the rapid RTs for locating the snake targets. Öhman (1986) has suggested that snake recognition does not need to entail conscious assessment. In nature, the rapid freezing and jumping back from unexpected encounters with snakes by humans and other species (cf. Coss, 2003; Ramakrishnan, Coss, Schank, Dharawat & Kim, 2005; Zamma, 2011) is consistent with Öhman's (1986) construct of preconscious snake recognition. A second and possibly complementary explanation for the difference in snake and lizard detection speeds involves the process of delayed disengagement while scanning multiple images. In our study, each of the provocative snake distractor images might capture the child's attention briefly during the scanning process, thus slowing the speed of lizard detection (see Fox, Russo & Dutton, 2008; Lipp, 2006). The idea of delayed disengagement affecting the speed of visual search in our study is reinforced by research showing that threatening images hold attention longer than nonthreatening images (Koster, Crombez, Van Damme, Verschuere & De Houwer, 2004).

The results of Experiment 2 indicate that children in urban and rural settings perform similarly in their speed of locating lion and antelope target images. In both the rural and urban sites, children located the lion target images faster than antelope target images. This advanced detection of lions supports the theoretical notion that the ability to detect large felids rapidly has been ecologically important historically (Coss & Moore, 2002; Treves & Palmqvist, 2007). Felid recognition is unambiguously innate in some nonhuman primates as evidenced by the strong reactions of inexperienced wild and captive primates during experimental presentations of leopard models (Coss & Ramakrishnan, 2000; Davis, Parr & Gouzoules, 2003; Schel *et al*., 2009).

It is important to note in Experiment 2 that the interaction between age and target type for the rural children approaches statistical significance. This interaction is much less apparent for urban children (compare the slopes in Figures 4 and 5). The convergence of the two best-fitted lines for lions and antelope might result from progressive experiences in the older rural children who would have viewed dangerous wildlife in many more instances and have become more discriminating between animal types. Research by Pollak and colleagues (Pollak & Kistler, 2002; Pollak & Tolley-Schell, 2003; Pollak *et al*., 2000) has shown that physically abused children manifest hyper-vigilance toward threat cues. If relevant to our research, the provocative properties of lion images might be magnified by the early experiences of the youngest children with threatening wildlife, resulting in the lion distractors holding visual attention longer and slowing the speed of antelope target detection.

The results of Experiment 3 indicated that neither urban nor rural children detected cow images faster than horse images. Overall, these results failed to support our hypothesis that the religious importance of the cow in Indian culture would enhance its visual salience. Furthermore, children from the two locations performed similarly in their abilities to detect horse and cow images, both of which characterize species that have not constituted historical predatory threats. Although the children in our study did not differ appreciably in horse- and cow-detection speeds, Indian adults might differ in this ability. We found in American adults that, compared with men, women detected horses faster than cows (Penkunas and Coss, 2013), a finding that we interpreted as reflecting a greater preference toward horses by adolescent girls. Such a preference for horses has been shown for Norwegian adolescent girls (Bjerke *et al*., 1998).

This multi-site experiment provides evidence that first-hand experience with dangerous wildlife in childhood does not promote better species-detection abilities in our visual-search tasks. If viewed from a cross-cultural perspective, the similarities in age-related improvement of animal-detection speeds by American and Indian children suggest a common developmental trajectory among children independent of their level of exposure to real environmental threats. The pattern for detecting snakes and lions faster than lizards and antelope, respectively, is the same in Indian and American children. American adults also exhibit the same pattern in visual-search tasks for these two comparisons (Penkunas and Coss, 2013). Unlike the provocative snake and lion images examined in our research, American and Indian children did not differ in their pattern of detecting the two benign ungulate species which vary markedly in cultural significance. For further understanding of the development of visual biases across the lifespan, future cross-cultural studies should examine visual-search tasks in adults from a variety of populations that exhibit different attitudes toward wild and domestic animals.

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