Developmental Science

Developmental Science 12:2 (2009), pp 305–313 DOI: 10.1111/j.1467-7687.2008.00767.x

PAPER

More than just another face in the crowd: superior detection of threatening facial expressions in children and adults

Vanessa LoBue

Department of Psychology, University of Virginia, USA

Abstract

Threatening facial expressions can signal the approach of someone or something potentially dangerous. Past research has established that adults have an attentional bias for angry faces, visually detecting their presence more quickly than happy or neutral faces. Two new findings are reported here. First, evidence is presented that young children share this attentional bias. In five experiments, young children and adults were asked to find a picture of a target face among an array of eight distracter faces. Both age groups detected threat-relevant faces – angry and frightened – more rapidly than non-threat-relevant faces (happy and sad). Second, evidence is presented that both adults and children have an attentional bias for negative stimuli overall. All negative faces were detected more quickly than positive ones in both age groups. As the first evidence that young children exhibit the same superior detection of threatening facial expressions as adults, this research provides important support for the existence of an evolved attentional bias for threatening stimuli.

Introduction

In everyday social situations, emotional facial expressions serve as important sources of information. Angry, fearful, sad, and happy faces each tell us something different. Early in life, we learn to use these different facial expressions as information about what to expect from social interactions. Whereas a happy face is generally benign and indicates that a friendly interaction is likely to follow, an angry face is potentially threatening, indicating the possibility of something unpleasant or hostile (Hansen & Hansen, 1988; Ohman & Dimberg, 1978; Ohman, Lunqvist & Esteves, 2001b). Although it is not necessary to react quickly to a happy or benign face, recognizing an angry face as quickly as possible can be important to avoid harm.

Consequently, through the course of human development, our visual system may have evolved to be more efficient in detecting signals of threat, such as angry faces, than other types of stimuli. From an evolutionary perspective, humans who recognized and detected threatening facial expressions exceptionally quickly would have been more likely to escape potentially dangerous situations and hence survive to reproduce (Hansen & Hansen, 1988; Ohman *et al*., 2001b; Ohman & Mineka, 2001, 2003).

Following this logic, Hansen and Hansen (1988) proposed the 'face in the crowd hypothesis'. They suggested that 'an angry face in a crowd of benign or happy faces should be found more easily than a happy or benign face in a crowd of angry faces' (p. 917). Their claim has received substantial support from experiments using a standard visual search paradigm in which participants are presented with 3 by 3 matrices of photographs of two categories of stimuli – generally happy and angry schematic faces (i.e. very simple line drawings of faces). Each trial consists of either nine faces from one of the categories or eight faces from one category and one face from the other. Participants are generally asked to decide as quickly as possible whether a discrepant face is present in each matrix.

Using this paradigm, researchers have consistently found that participants are faster at identifying a discrepant angry schematic face than a discrepant happy schematic face (Calvo, Avero & Lundqvist, 2006; Esteves, 1999; Fox, Lester, Russo, Bowles, Pichler & Dutton, 2000; Lundqvist & Ohman, 2005; Mather & Knight, 2006; Ohman *et al*., 2001b; Schubo, Gendolla, Meinecke & Abele, 2006). Further, Lundqvist and Ohman (2005) found that speed of detection is directly related to how negatively a face is perceived. After asking participants to rate the emotional valence of each schematic face used in a visual detection experiment, they found that these ratings were directly correlated with detection latency: The more negatively participants rated the facial expressions, the faster they detected them.

Other researchers have found support for the face in the crowd hypothesis in different populations. A large body of research has found that anxious participants detect angry faces more quickly than happy ones (for a review, see Bar-Haim, Lamy, Pergamin, Bakermans-

Address for correspondence: Vanessa LoBue, Department of Psychology, University of Virginia, PO Box 400400, Charlottesville, VA 22904, USA; e-mail: vl8m@virginia.edu

Kranenburg & van Ijzendoorn, 2007). Further, Ashwin, Wheelwright and Baron-Cohen (2006) found that even adults with Autism and Asperger Syndrome (AS) – neurodevelopmental conditions that are characterized by many deficits including abnormal face processing – detect angry schematic faces more quickly than friendly ones.

Past research has also suggested that angry faces not only attract attention, but also distract from non-threatening faces as well (Eastwood, Smilek & Merikle, 2003; Fenske & Eastwood, 2003). For example, when participants were asked to identify the middle image in an array of three images of schematic faces, they were slower at detecting the target when the distracter images were of negative faces (Fenske & Eastwood, 2003). Further, when asked to count features embedded in different types of facial expressions, participants took longer to count features that were embedded on negative as opposed to positive and neutral faces (Eastwood *et al*., 2003). These findings demonstrated that negative facial expressions both capture attention and distract attention from non-threatening faces.

Although the vast majority of the research examining the detection of angry versus benign schematic facial expressions has been consistent with the face in the crowd hypothesis, experiments using pictures of real faces have not. While Horstmann and Bauland (2006) and Gilboa-Schechtman, Foa and Amir (1999) found a search advantage for angry over happy faces using photographs of real faces as the stimuli, Purcell, Stewart and Skov (1996) and Eastwood, Smilek, Oakman, Farvolden, van Ameringen, Mancini and Merikle (2005) failed to find such an advantage. Further, Juth, Lundqvist, Karlsson and Ohman (2005) reported that happy faces were consistently detected more quickly than both fearful and angry ones and Williams, Moss, Bradshaw and Mattingley (2005) found faster detection of *both* angry and happy faces than sad or fearful ones. The reason for these inconsistencies with photographs of real faces is unclear, although this issue will be addressed again in the General discussion.

All of the research discussed above examining the detection of threatening facial expressions has been conducted with adult participants. However, if humans have an evolved bias to detect threat-relevant facial expressions, angry faces should be detected more quickly than happy or neutral ones regardless of the age and experience of the participants. In fact, the *strongest* evidence for an evolved threat-detection bias would come from young children who have had little experience with threat-relevant expressions. However, the very few developmental studies of this topic all involve young adults (Mather & Knight, 2006) or older children (8- to 12-year-olds) (see Bar-Haim *et al*., 2007, for review). The primary goal of the current set of experiments was to examine the detection of threatening facial expressions from a developmental perspective, testing both adults and young children.

A second goal of the present research was to explore the basis for the well-established finding that angry faces are detected faster than happy or neutral ones. An alternative to Hansen and Hansen's position derives from the work of Cacioppo and colleagues, who propose that the human perceptual system has adapted to respond to negative stimuli more strongly than to positive stimuli (Cacioppo, Gardner & Berntson, 1999; Smith, Cacioppo, Larsen & Chartrand, 2003). They refer to this as a general negativity bias. According to their view, any negative stimulus may be detected more quickly than any positive or neutral stimulus. A large body of literature confirms that negative stimuli are generally attended to more quickly than positive stimuli. Using a variety of tasks, researchers have found that participants recognize negative people, words, and facial expressions more quickly than positive ones (for a review, see Baumeister, Bratslavsky & Finkenauer, 2001).

Although most of the visual detection results discussed above are consistent with the face in the crowd hypothesis, they could also be explained by a more general mechanism that gives priority to negative stimuli in general rather than to threat-relevant stimuli in particular. The question addressed here is whether angry faces are detected particularly quickly because they are threat-relevant or simply because they are negative. Perhaps *any* negative facial expression would be detected more quickly than *any* positive or neutral expression.

One way to resolve this issue would be to examine the visual detection of other categories of negative facial expressions, including both fearful and sad faces. While an angry face is a direct indicator of threat, a fearful face could indicate the presence of something threatening in the area (Whalen, Shin, McInerney, Fischer, Wright & Rauch, 2001). If humans are predisposed to detect threat-relevant facial expressions, fearful expressions should receive priority in visual attention, just as angry faces do. Thus, humans might detect fearful faces more quickly than happy or neutral ones as well. Past research already suggests that children and adults may detect fearful faces particularly quickly. In two experiments, both infants and adults were found to take longer to disengage from looking at a fearful face than a happy face, suggesting that fearful faces recruit more attention than happy ones (Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti & Fox, 2005; Peltola, Lappanen, Palokangas & Hietanen, 2008).

Sad faces, on the other hand, are negative, but not threat-relevant. Thus, the only reason to expect them to be detected more quickly than happy ones is if there is a general negativity bias in the detection of facial expressions. If so, sad faces, like angry ones, would be detected more quickly than happy or neutral ones.

The current set of experiments examines the detection of angry, fearful, and sad faces using a visual search paradigm. Most importantly, the detection of these facial expressions is examined not just in adults, but also in young children. As mentioned earlier, any evolved predisposition to detect threat-relevant facial expressions particularly quickly should be evident regardless of age and experience.

General method

For all the studies reported here, both preschool children and adults were presented with 3 × 3 matrices of color photographs of real threat-relevant and threat-irrelevant face stimuli. Although past research using real faces has been inconsistent, using real faces in visual search tasks is important to support real-world generalizability. The participants were asked to find the one threat-relevant target among eight non-threat-relevant distracters or the one non-threat-relevant target among eight threat-relevant distracters. Two procedural changes to the standard visual search task used with adults were instituted to make it possible to obtain reliable reaction time data from 5-year-olds (LoBue & DeLoache, 2008). First, the stimuli were presented on a touchscreen monitor, and each participant was asked to touch the target on the screen as quickly as possible. Second, only target-present matrices were presented, because the touchscreen procedure precluded the inclusion of no-target matrices. The assumption is that the latency to touch a target would be affected by any differential responsiveness to threat-relevant versus non-threat-relevant faces.

Participants

In the studies reported here, participants were 180 5-year-old children (M = 64.7 months, range = 60.2–72.0 months), half male, and half female, and their 180 accompanying parents (all but 12 parents were female). For all of the experiments, 12 children and adults were tested for each condition. In Experiments 1, 2, 3, 4a, 4b, and 4c, there were two conditions per study (for example, in Experiment 1, the two conditions were Angry Target with Happy distracters, or Happy Target with Angry distracters). Thus, there were 24 children and 24 adults for each of these studies (a total of 144 children and 144 adults). For Experiment 5, there were three conditions (Happy Target, Angry Target, or Sad Target, all with Neutral distracters). Thus there were 36 children and 36 adults in Experiment 5, for a grand total of 180 children and 180 adults across experiments.

The sample was recruited from records of birth announcements in the local community and was predominantly Caucasian and middle class. Each child was randomly assigned to one of two target conditions and one of two stimulus orders for each study. For convenience, the parent was assigned to the same condition as the child. Sixteen additional 5-year-olds were excluded for failure to follow directions.

Materials

For Experiments 1–4, the stimuli consisted of four sets of 24 color photographs of angry, fearful, happy, or sad facial expressions (96 photographs in total). All stimuli were from the NimStim face set obtained from the MacArthur Foundation Research Network on Early Experience and Brain Development. All of the photographs were adjusted to 195 × 240 pixel color (8.34 × 10.27 cm) computer images. An equal number of male and female faces were used, 67% of which were Caucasian, 22% were African American, and 11% were Asian.

A MultiSync LCD 2010X color touchscreen monitor was used to present each picture matrix on a 61 cm (24 inch) screen. The overall matrix was 39.4 cm × 39.4 cm, with 1.27 cm between rows and 0.64 cm between columns. The individual projected pictures measured 11.47 × 8.64 cm. Each of the 24 pictures in the target category served as the target exactly once, appearing in each of the nine positions in the matrix two or three times. The 24 pictures from the distracter category each appeared eight times across trials, appearing in each distracter position approximately once. One stimulus order was created by randomly selecting the target for each trial and by randomly selecting the target's position for each trial. The same was done for the distracters. This arrangement of trials was labeled as Stimulus Presentation Order 1. A second stimulus presentation (Order 2) was created by reversing the order of trials in Order 1. An outline of a child's hand-prints was located on the table immediately in front of the monitor.

Procedure

The child was seated in front of the touchscreen monitor (approximately 40 cm from the base of the screen) and told to place his or her hands on the hand-prints. This ensured that the child's hands were in the same place at the start of each trial making it possible to collect accurate latency data. The experimenter stood alongside to monitor and instruct the child throughout the procedure.

First, a set of seven practice trials was given to teach the child how to use the touchscreen. On the first two trials, a single picture appeared on the screen, and the child was asked to touch it. The first picture was from the target category and the second from the distracter category. (All pictures used in the practice trials were chosen randomly from the original sets of 24.) Next, the child was presented with two trials with one target and one distracter picture and asked to touch only the target picture. Three practice trials followed, each involving a different nine-picture matrix. The child was told to touch the target picture as quickly as possible and then return his or her hands to the hand-prints. All the children readily learned the procedure.

A series of 24 trials followed. A different picture matrix containing one target and eight distracters was presented on each trial. In between trials, a large smiley face appeared on the screen. To ensure that the child's full attention was on the screen before each matrix appeared, the experimenter pressed the face when she judged that the child was looking at it, causing the next matrix to appear. Latency was automatically recorded from the onset of the matrix to when the child touched one of the pictures on the screen.

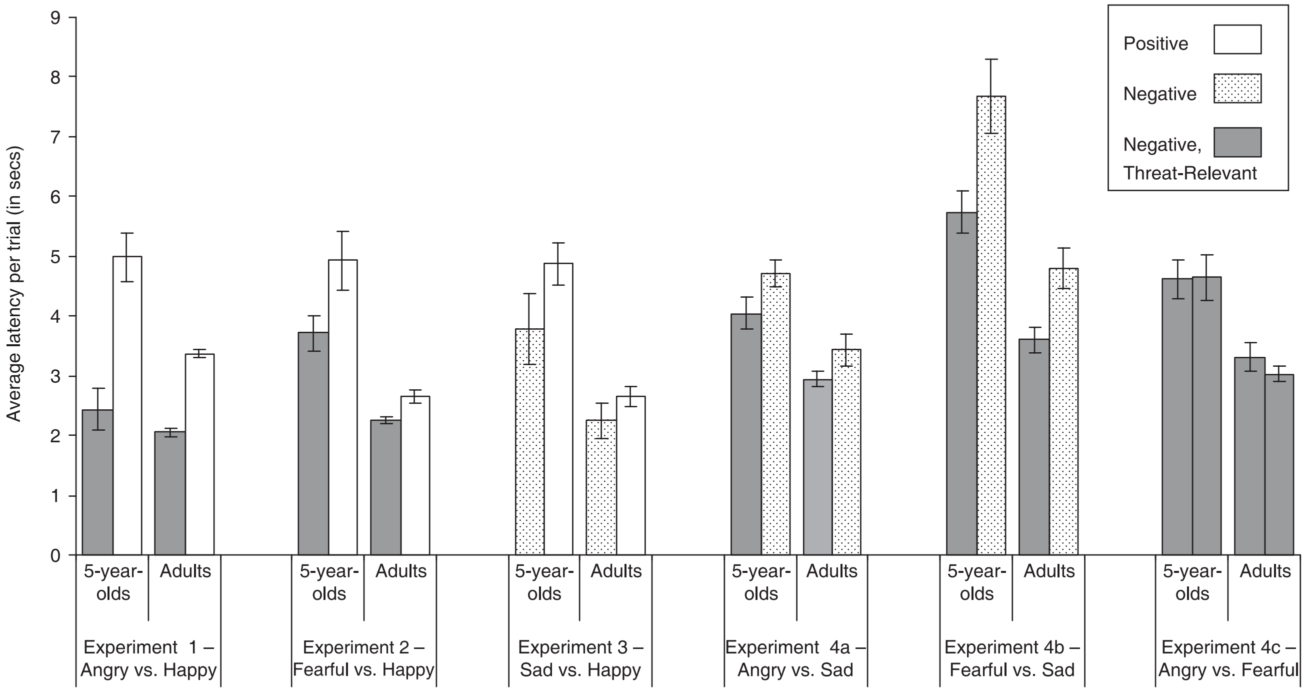

Figure 1 *Average latencies to detect the target stimulus for adult and child participants in Experiments 1 through 4. All negative facial expressions were detected more quickly than happy faces (Experiments 1, 2 and 3). Most importantly, as predicted, threat-relevant faces (angry and fearful) were detected more quickly than both happy (Experiments 1 and 2) and sad faces (Experiments 4a and 4b) with no differences in the detection of angry versus fearful faces (Experiment 4c).*

After the child had completed all 24 trials, his or her parent was tested in exactly the same manner. The parent had not been told about the experimental hypothesis and had not been present while the child was tested.

Analyses

The analyses for all of the experiments reported here were 2 (target) × 2 (age) ANOVAs on the latency to touch the target. Preliminary analyses revealed no effects of experimenter, order, or gender for any of the studies, so they were not included in the analyses. Following standard procedures for visual search tasks, only trials in which the correct target was selected were counted.[1] Results for Experiments 1–4 are presented in Figure 1, with results for Experiment 5 in Figure 3.

[1] In Experiment 1, 16 errors were made by eight 5-year-olds and no adults, leading to the exclusion of less than 2% of the 1152 data points. For Experiments 2, 3, 4a, 4c, and 5 the number of trials eliminated was 20, 42, 18, 19, and 11, respectively (less than 2% of the data). For Experiment 4b, 243 data points were eliminated (~ 21% of the data). The error rate did not differ between the two conditions in any of the studies, with the exception of Experiment 4c where both adults and children erred significantly more for fearful targets than for angry targets (Experiment 1: $t = 0.48$, *ns*; Experiment 2: $t = 1.11$, *ns*; Experiment 3: $t = 1.33$, *ns*; Experiment 4a: $t = 1.13$, *ns*; Experiment 4b: $t = 0.43$, *ns*; Experiment 4c: $t = 3.46$, $p < .01$).

Experiment 1 – angry versus happy

In Experiment 1, 5-year-old children and adults were asked to locate either a single angry target among eight happy distracters or the lone happy face among angry faces. Based on the results for these stimuli reported by previous research, the expectation was that the adults would detect angry targets more quickly than happy ones. The question of interest was whether young children would show the same pattern of performance.

Results and discussion

The ANOVA on the latency to touch the target yielded significant main effects of target stimulus, $F(1, 44) = 11.67$, $p < .01$, and age, $F(1, 44) = 29.57$, $p < .01$, with an age by condition interaction, $F(1, 44) = 11.67$, $p < .01$. Not surprisingly, the adults located the targets significantly faster than did the children. As expected, the adults who were asked to find the angry face among happy distracters did so significantly faster than those asked to locate the lone happy face among angry faces. This result was significant in a *t*-test, $t = 3.90$, $p < .01$, and establishes that our touchscreen procedure replicates the pattern of the latency data reported for adults with schematic faces (Ohman, Flykt & Esteves, 2001a).

Of most importance, the pattern of performance of the young children was the same as that of the adults: Like their parents, the children responded more rapidly

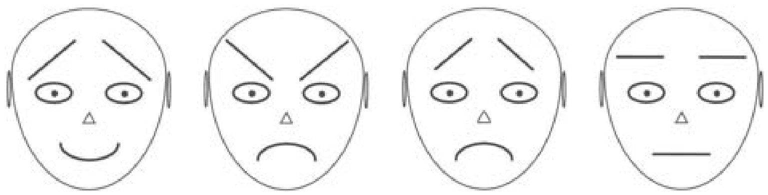

Figure 2 *Sample stimuli from Experiment 5 featuring happy, angry, sad, and neutral schematic faces.*

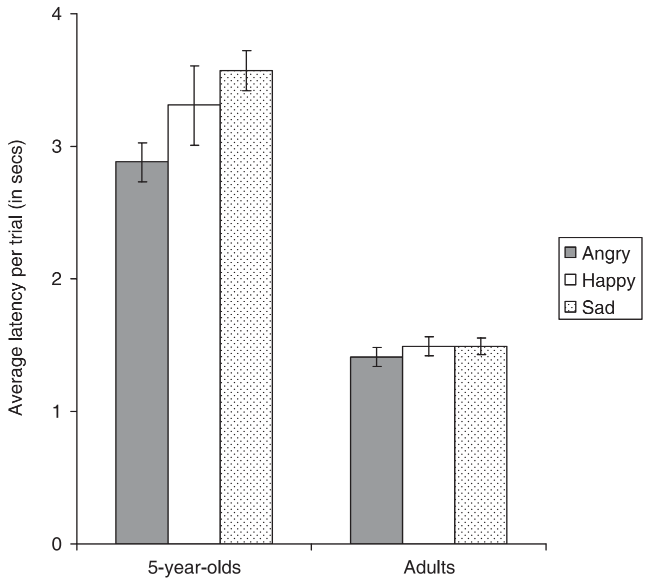

Figure 3 *Average latencies to detect the target stimulus for adult and child participants in Experiment 5. As predicted, angry faces were detected more quickly than both the sad and happy faces, although it was only statistically significant for the angry versus sad face comparison.*

to the angry targets than to the happy targets.[2] This result was also significant in a *t*-test, $t = 4.72$, $p < .01$. The interaction reflects a larger difference between the detection of angry and happy faces for the children than for the adults, but the result is significant in both age groups. These data are the first evidence that, like adults, preschool children possess a bias for the detection of angry facial expressions. Further, these developmental data are highly important to the claim that humans have a special sensitivity to certain categories of threat-relevant facial expressions (Hansen & Hansen, 1988; Ohman *et al*., 2001b).

Experiment 2 – fearful versus happy

Experiment 1 supported the idea that threatening faces are detected more quickly than non-threatening faces by both adults and young children. Experiment 2 compares the detection of happy faces to a second category of negatively valenced threat-relevant faces – fearful faces. Like angry faces, fearful faces are threat-relevant, so it is possible that they are also detected faster than happy faces.

Experiment 2 used the same method as Experiment 1, examining both adults and children. If humans are predisposed to detect faces that are threat-relevant, both adults and children should detect fearful faces more quickly than happy ones.

Results and discussion

The ANOVA on the latency to touch the target yielded significant main effects of age, $F(1, 44) = 12.53$, $p < .01$, and condition, $F(1, 44) = 8.77$, $p < .01$, with no interaction. The adults detected the targets significantly faster than did the children. The main effect of condition revealed the predicted result: both children ($t = 2.10$, $p < .05$) and adults ($t = 3.11$, $p < .01$) detected the fearful face among happy distracters more quickly than the happy target among fearful distracters (see Figure 1).

These results demonstrate that like angry faces, fearful faces are detected more quickly than happy ones. In conjunction with the results of Experiment 1, Experiment 2 provides strong support for the idea of a general bias for the detection of threat-relevant faces. This is the first evidence of which we are aware that adults and children demonstrate the same detection advantage for fearful faces that they do for angry faces in visual detection tasks. Together, these findings provide especially strong support for a bias to quickly detect threat-relevant faces, including both angry and fearful faces.

Experiment 3 – sad versus happy

Although Experiments 1 and 2 demonstrate that two categories of threat-relevant facial expressions are detected more quickly than happy faces by both adults and children, another important question concerns the basis for humans' fast detection of threat-relevant faces. Is it that, as hypothesized, humans are biased to detect angry and fearful faces particularly quickly because they are threat-relevant, or is some more general mechanism responsible? For example, both angry and fearful facial expressions are negative, while happy facial expressions are positive. Perhaps *all* negative facial expressions would be detected more quickly than positive or neutral ones, and the results of Experiments 1 and 2 and previous

[2] The detection of angry faces was also compared to the detection of neutral faces with 24 additional participants and the same results were obtained – participants detecting the angry targets did so more quickly than participants detecting the neutral targets.

research were due to a general negativity bias (Cacioppo *et al.*, 1999; Smith *et al.*, 2003).

One way to test this idea is to examine the detection of sad faces, which are negative in emotionality, but not threat-relevant. If the reason that angry and fearful faces are detected more quickly than happy faces is because of their threat-relevance, there should be no difference in the detection of sad versus happy faces. However, if angry and fearful faces are detected more quickly than happy ones simply because they are negative, then sad faces might also be detected more quickly than happy ones.

Results and discussion

The procedure for Experiment 3 was identical to that of the previous two experiments except that sad and happy faces were used. Again, both adults and children were tested. The ANOVA on the latency to touch the target yielded a significant main effect of age, $F(1, 44) = 25.75$, $p < .01$, and condition, $F(1, 44) = 13.12$, $p < .01$, with no interaction. The adults located the targets significantly faster than did the children. Of most importance, both the children ($t = 2.72$, $p < .05$) and the adults ($t = 2.79$, $p < .05$) detected the sad faces more quickly than the happy faces.

These results demonstrate that three categories of negative facial expressions are detected more quickly than happy ones in both adults and children. The data from Experiments 1–3 are consistent with the existence of a general negativity bias in processing, in that both adults and children detected angry, fearful, and sad faces more quickly than happy ones. These results are inconsistent with the face in the crowd hypothesis, because sad faces, which are negative but not threat-relevant, were detected more quickly than happy faces.

Experiments 4a and 4b – angry and fearful versus sad

The results of Experiments 1, 2, and 3 indicate that negative facial expressions in general, not just threat-relevant ones, are detected more quickly than happy expressions. However, it could be that although all negative facial expressions were detected more quickly than positive ones, negative threat-relevant faces would be detected the most quickly of all. Specifically, what is needed to assess this possibility is a comparison of the detection of negative threat-relevant faces versus negative non-threat-relevant faces. Accordingly, in Experiments 4a and 4b, the detection of sad faces (negative, non-threat-relevant) versus the detection of angry and fearful faces (both negative, threat-relevant) was examined.

Results and discussion

Both age groups in Experiment 4a detected the angry faces more quickly than the sad faces; and in Experiment 4b, both groups detected the fearful faces more quickly than the sad ones. For Experiment 4a (Angry versus Sad), the ANOVA on the latency to touch the target yielded significant main effects of age, $F(1, 44) = 11.62$, $p < .01$, and condition, $F(1, 44) = 4.29$, $p < .05$, with no interaction. For Experiment 4b (Fearful versus Sad), the ANOVA yielded significant main effects of age, $F(1, 44) = 37.78$, $p < .01$, and condition, $F(1, 44) = 14.84$, $p < .05$, with no interaction. In both studies, the adults located the targets significantly faster than did the children.

The main effect of condition indicates that both angry and fearful faces were detected more quickly than sad faces. In post-hoc *t*-tests, both the children ($t = 2.75$, $p < .05$) and the adults ($t = 2.95$, $p < .01$) detected the fearful faces significantly more quickly than the sad faces. Both the adults and children detected the angry faces more quickly than the sad faces as well, but the result in both age groups was only approaching significance in post-hoc comparisons (children: $t = 1.88$, $p < .10$; adults: $t = 1.78$, $p = .10$). However, the main effect of condition was significant in the overall ANOVA with no interaction, indicating that the effect of condition was the same for both age groups.

Although negative faces were detected more quickly than positive ones, these data suggest that negative threat-relevant faces receive the highest priority in visual detection, and are detected more quickly than both positive and negative non-threat-relevant stimuli. Together, the results of Experiments 1 through 4 support the existence of an evolved bias to detect threat in that threat-relevant facial expressions were detected more quickly than *both* positive (happy) and negative (sad) non-threat-relevant faces.

Experiment 4c – angry versus fearful

The results of the previous experiments establish that negative facial expressions are detected more quickly than positive ones and that negative threat-relevant facial expressions are detected more quickly than both positive and negative non-threat-relevant ones. There is, however, no reason to expect any difference in the detection of two negative threat-relevant facial expressions, namely angry and fearful expressions. Accordingly, Experiment 4c examined the detection of angry versus fearful faces with the expectation that no differences would be found. Although the null hypothesis was predicted here, the prediction was well grounded in theory and the previous findings reported here, so the expected result would be meaningful.

Results and discussion

The ANOVA on the latency to touch the target yielded a significant main effect of age, $F(1, 44) = 26.28$, $p < .01$; the adults located the targets significantly faster than did the children. Of most importance, there was no effect of condition, $F(1, 44) = 0.01$, *ns*, and no interaction. As

Figure 1 clearly shows, there was no difference in the detection of the angry versus fearful faces.

This predicted null result is informative in the context of the other studies reported here. In all cases in which a theory-based prediction could be made about differences in speed of detection, a difference was found. In the one case in which there was no theory-based reason to expect a difference, no difference was found. The results of Experiment 4c thus provide further support for the existence of an evolved bias for the fast detection threat-relevant facial expressions.

Experiment 5 – schematic faces

The results from Experiments 1–4 demonstrate that negative faces are detected more quickly than positive ones and that threatening faces are detected more quickly than both negative and positive non-threat-relevant ones. The stimuli in these studies consisted of photographs of real faces. Using real faces in visual search tasks is important to support real-world generalizability. However, past research using real faces has been inconsistent, and Ohman *et al.* (2001b) argued that there may be more variability among angry faces that are posed than in posed happy faces: Most people can easily produce a happy face, but it is much more difficult to pose a threatening face. For this reason, Ohman *et al.* proposed using schematic faces in visual search research. Accordingly, Experiment 5 employs schematic faces depicting angry, sad, and happy expressions to see if the same pattern of results reported in the previous four experiments would be found with schematic faces.

Further, as mentioned earlier, past research has suggested that angry faces not only attract attention, but can also distract from non-threatening targets (Eastwood *et al.*, 2003; Fenske & Eastwood, 2003). Thus, it is possible that in Experiment 1, the angry faces were detected more quickly than happy faces because the angry face distracters diverted attention from the happy targets. Accordingly, in Experiment 5, the distracter stimuli were always neutral faces.

Method

The stimuli were four simple schematic faces (angry, happy, sad, and neutral) taken from Tipples, Young, Quinlan, Broks and Ellis (2002). The faces were line drawings composed of very simple shapes. All four drawings were adjusted to 195 × 240 pixel (8.34 × 10.27 cm) computer images.

Procedure

The procedure for this study was identical to that of the preceding ones, with three exceptions. First, there were three conditions instead of two – angry versus neutral, happy versus neutral, and sad versus neutral. Second, as is typical of experiments using schematic faces (Calvo *et al.*, 2006; Esteves, 1999; Fox *et al.*, 2000; Lundqvist & Ohman, 2005; Schubo *et al.*, 2006), only one schematic representation of the four face categories (angry, sad, happy, and neutral face) was used. Finally, the distracter stimuli in every condition were the same neutral face (see Figure 2).

Results and discussion

A 3 (condition: angry, sad, happy target) by 2 (age: adult, child) ANOVA on the latency to touch the target yielded significant main effects of age, $F(1, 66) = 214.87$, $p < .01$, and condition, $F(2, 66) = 5.54$, $p < .01$, with no interaction. The adults located the targets significantly faster than the children did (see Figure 3). Although both age groups detected the angry faces more quickly than both the happy and sad faces, a series of post-hoc comparisons indicated that this result was only significant in children (sad versus angry: $t = 2.16$, $p < .05$; happy versus angry: $t = 2.10$, $p < .05$). However, the fact that the main effect of condition was significant in the overall ANOVA with no interaction indicates that the effect of condition was present in both adults and children.

These results demonstrate that the bias to detect angry faces found in the previous studies cannot be attributed to attention drawn to the distracter stimuli or to variation in posed angry versus happy faces. Even when these factors are controlled for, angry faces were still detected more quickly than happy or sad faces. These results thus provide further support for a bias to detect threat-relevant stimuli in humans.

General discussion

The results of the experiments reported here make three important contributions. First, and most important, this research is the first to examine the visual detection of threatening facial expressions in young children, and it presents the first evidence that, like adults, young children detect angry faces more quickly than happy ones. The result that even young children detect the presence of angry facial expressions particularly quickly lends important support for an evolved attentional bias for threat.

The second contribution is that these findings establish that there are *two* categories of threat-relevant stimuli that are detected particularly quickly. Just like angry faces, a fearful face signals the possible presence of threat (Whalen *et al.*, 2001). The current research is the first to show that adults detect fearful faces more quickly than happy faces in a visual search paradigm. Further, the fact that children detected the presence of fearful faces particularly quickly as well provides additional support for the existence of an evolved bias in humans to detect threat.

Finally, the third contribution made by this research is that it reveals the presence of a general negativity bias in the detection of facial expressions (Cacioppo *et al.*, 1999; Smith *et al.*, 2003). All negative facial expressions (angry, fearful, and sad) were detected more quickly than positive ones (happy), consistent with the large body of research with adults indicating that negative stimuli in general are detected more quickly than positive stimuli (for review, see Baumeister *et al.*, 2001). Further, the current research extends past findings with adults to young children, demonstrating that they too exhibit an attentional bias for negative stimuli.

As a whole, the pattern of results found here provides evidence for an important adaptation in the human visual system. On the most basic level, it would be more advantageous to quickly attend to stimuli that are *negative* than to stimuli that are *positive*, since negative stimuli can signal something adverse (Baumeister *et al.*, 2001). Further, since not all negative stimuli signal danger, it would be the most advantageous to assign the highest priority in visual attention to *negative threat-relevant* stimuli since they are the most reliable indicators of danger. Thus, the reported results provide strong evidence that the human visual system preferentially allocates attentional resources to stimuli that are generally negative, and most importantly, to stimuli that signal threat.

The same pattern of results found here for threat-relevant faces has been found for other categories of evolutionarily threat-relevant stimuli. Ohman *et al.* (2001a) were the first to report that adults detect snakes and spiders more quickly than flowers and mushrooms, and many others have replicated this result (Lipp, 2006; Lipp, Derakshan, Waters & Logies, 2004; LoBue & DeLoache, 2008; Tipples *et al.*, 2002). Further, LoBue and DeLoache (2008) found that 3-year-old children detect snakes more quickly than flowers, frogs, and caterpillars. This result with children lends support to the existence of an attentional bias to detect evolutionarily relevant threat stimuli in general, including both threat-relevant faces and threat-relevant animals, such as snakes.

The remarkable consistency between the experiments reported here is worth noting. As mentioned above, previous research using photographs of real face stimuli has been inconsistent. Yet, the experiments described here report remarkably consistent results across four experiments with two very different age groups. It is possible that the two procedural differences between the current touchscreen procedure and the standard button-press procedure used in all previous work (the full procedure is described in the Introduction) could account for these differences.

First, in all previous visual detection research, participants saw either a matrix with a single target and eight distracters or a matrix with nine distracters. In the current touchscreen procedure, only target-present matrices were presented. Second, in previous visual detection research, participants were required to decide whether or not a target was present in each matrix, and were then required to press one button if there was a target present or a second button if there was no target present. Conversely, in the current touchscreen procedure, participants already knew that each display had a target and their only task was to locate it. These differences may have made the touchscreen task easier: Instead of having to decide whether a target was present in each matrix *and* remember to press the corresponding button, participants had only to detect the location of the target and touch it on the screen. Whether these procedural differences account for the consistent findings obtained in the current research is unknown, but it is an interesting question to examine in future research.[3]

Another important question for future research is whether infants would also detect the presence of threat-relevant facial expressions more quickly than non-threat-relevant ones. Because infants have even less experience with threat-relevant facial expressions than do preschool children, this research would provide the strongest test of an inborn bias to detect threat-relevant facial expressions in humans. In a current investigation of this topic, preliminary results indicate that 9- to 12-month-old infants do indeed respond more rapidly to an angry face than a happy one.

In conclusion, the research reported here provides empirical evidence that both young children and adults detect threat-relevant faces more quickly than non-threat-relevant faces. Further, both age groups detect two categories of threat-relevant faces – angry and fearful – more quickly than non-threat-relevant ones. This research also provides support for a general negativity bias in visual detection, demonstrating that negative facial expressions are generally detected more quickly than positive ones. More broadly, these findings provide important support for the existence of an evolved predisposition to detect threat-relevant stimuli in humans.

Acknowledgements

I would like to thank Judy DeLoache for her frequent advising during the running of these studies and during the writing of the manuscript. I am also grateful to Themba Carr, Christina Danko, Joseph Romano, and Catherine Thrasher for valuable assistance conducting the research, Dennis Proffitt for help with equipment, and Evan Rappoport for programming.

References

Ashwin, C., Wheelwright, S., & Baron-Cohen, S. (2006). Finding a face in the crowd: testing the anger superiority effect in Asperger Syndrome. *Brain and Cognition*, **61**, 78–95.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M.J., & van Ijzendoorn, M.H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological Bulletin*, **133**, 1–24.

[3] I graciously thank an anonymous reviewer for pointing out these possibilities.

Baumeister, R.F., Bratslavsky, E., & Finkenauer, C. (2001). Bad is stronger than good. *Review of General Psychology*, **5**, 323–370.

Cacioppo, J.T., Gardner, W.L., & Berntson, G.G. (1999). The affect system has parallel and integrative processing for components: form follows function. *Journal of Personality and Social Psychology*, **76**, 839–855.

Calvo, M.G., Avero, P., & Lundqvist, D. (2006). Facilitated detection of angry faces: initial orienting and processing efficiency. *Cognition and Emotion*, **20**, 785–811.

Eastwood, J.D., Smilek, D., & Merikle, P.M. (2003). Negative facial expression captures attention and disrupts performance. *Perception and Psychophysics*, **65**, 352–358.

Eastwood, J.D., Smilek, D., Oakman, J.M., Farvolden, P., van Ameringen, M., Mancini, C., & Merikle, P.M. (2005). Individuals with social phobia are biased to become aware of negative faces. *Visual Cognition*, **12**, 159–179.

Esteves, F. (1999). Attentional bias to emotional facial expressions. *European Review of Applied Psychology*, **49**, 91–97.

Fenske, M.J., & Eastwood, J.D. (2003). Modulation of focused attention by faces expressing emotion: evidence from flanker tasks. *Emotion*, **3**, 327–343.

Fox, E., Lester, V., Russo, R., Bowles, R.J., Pichler, A., & Dutton, K. (2000). Facial expressions of emotion: are angry faces detected more efficiently? *Cognition and Emotion*, **14**, 61–92.

Georgiou, G.A., Bleakley, C., Hayward, J., Russo, R., Dutton, K., Eltiti, S., & Fox, E. (2005). Focusing on fear: attentional disengagement from emotional faces. *Visual Cognition*, **12**, 145–158.

Gilboa-Schechtman, E., Foa, E.B., & Amir, N. (1999). Attentional biases for facial expressions in social phobia: the face-in-the-crowd paradigm. *Cognition and Emotion*, **13**, 305–318.

Hansen, C.H., & Hansen, R.D. (1988). Finding the face in the crowd: an anger superiority effect. *Journal of Personality and Social Psychology*, **54**, 917–924.

Horstmann, G., & Bauland, A. (2006). Search asymmetries with real faces: testing the anger-superiority effect. *Emotion*, **6**, 193–207.

Juth, P., Lundqvist, D., Karlsson, A., & Ohman, A. (2005). Looking for foes and friends: perceptual and emotional factors when finding a face in the crowd. *Emotion*, **5**, 379–395.

Lipp, O. (2006). Of snakes and flowers: does preferential detection of pictures of fear-relevant animals in visual search reflect on fear-relevance? *Emotion*, **6**, 296–308.

Lipp, O., Derakshan, N., Waters, A.M., & Logies, S. (2004). Snakes and cats in the flower bed: fast detection is not specific to pictures of fear-relevant animals. *Emotion*, **4**, 233–250.

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

Lundqvist, D., & Ohman, A. (2005). Emotion regulates attention: the relation between facial configurations, facial emotion, and visual attention. *Visual Cognition*, **12**, 51–84.

MacArthur Face Stimulus Set. (n.d.). Retrieved 17 March 2004, from http://www.macbrain.org/stim/faces.htm

Mather, M., & Knight, M.R. (2006). Angry faces get noticed quickly: threat detection is not impaired among older adults. *Journal of Gerontology: Psychology Sciences*, **61B**, P54–P57.

Ohman, A., & Dimberg, U. (1976). Facial expressions as conditioned stimuli for electrodermal responses: a case of 'preparedness'? *Journal of Personality and Social Psychology*, **36**, 1251–1258.

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

Ohman, A., Lundqvist, D., & Esteves, F. (2001b). The face in the crowd revisited: an anger superiority effect with schematic faces. *Journal of Personality and Social Psychology*, **80**, 381–396.

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

Ohman, 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.

Peltola, M.J., Leppanen, J.M., Palokangas, T., & Heitanen, J.K. (2008). Fearful faces modulate looking duration and attention disengagement in 7-month-old infants. *Developmental Science*, **11**, 60–68.

Purcell, D.G., Stewart, A.L., & Skov, R.B. (1996). It takes a confounded face to pop out of a crowd. *Perception*, **25**, 1091–1108.

Schubo, A., Gendolla, G.H.E., Meinecke, C., & Abele, A.E. (2006). Detecting emotional faces and features in a visual search paradigm: are faces special? *Emotion*, **6**, 246–256.

Smith, N.K., Cacioppo, J.T., Larsen, J.T., & Chartrand, T.L., (2003). May I have your attention, please: electrocortical responses to positive and negative stimuli. *Neuropsychologia*, **41**, 171–183.

Tipples, J., Young, A.W., Quinlan, P., Broks, P., & Ellis, A.W. (2002). Searching for threat. *The Quarterly Journal of Experimental Psychology*, **55A**, 1007–1026.

Whalen, P.J., Shin, L.M., McInerney, S.C., Fischer, H., Wright, C.I., & Rauch, S.L. (2001). A functional MRI study of human amygdala responses to facial expressions of fear and anger. *Emotion*, **1**, 70–83.

Williams, M.A., Moss, S.A., Bradshaw, J.L, & Mattingley, J.B. (2005). Look at me, I'm smiling: visual search for threatening and nonthreatening facial expressions. *Visual Cognition*, **12**, 29–50.

Received: 18 December 2007
Accepted: 21 March 2008