Published in final edited form as:
Emotion. 2007 November ; 7(4): 691–696. doi:10.1037/1528-3542.7.4.691.

The Detection of Fear-Relevant Stimuli: Are Guns Noticed as Quickly as Snakes?

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Abstract

Potentially dangerous stimuli are important contenders for the capture of visual–spatial attention, and it has been suggested that an evolved fear module is preferentially activated by stimuli that are fear relevant in a phylogenetic sense (e.g., snakes, spiders, angry faces). In this study, a visual search task was used to test this hypothesis by directly contrasting phylogenetically (snakes) and ontogenetically (guns) fear-relevant stimuli. Results showed that the modern threat was detected as efficiently as the more ancient threat. Thus, both guns and snakes attracted attention more effectively than neutral stimuli (flowers, mushrooms, and toasters). These results support a threat superiority effect but not one that is preferentially accessed by threat-related stimuli of phylogenetic origin. The results are consistent with the view that faster detection of threat in visual search tasks may be more accurately characterized as *relevance superiority effects* rather than as *threat superiority effects*.

Keywords

fear; threat detection; basic emotions; visual search; appraisal

The detection of threat-relevant stimuli is controlled by a complex network of neural structures that allow for the rapid perception of potential danger and support a variety of coping strategies such as fighting, freezing, or rapid escape (e.g., Armony & LeDoux, 2000; Calder, Lawrence, & Young, 2001; LeDoux, 1996). The amygdala is a crucial structure within this network and plays an important role in coordinating responses to threatening stimuli (Aggleton, 2000). One theoretical view is that the amygdala operates primarily as a rapid-response "fear module" in the brain that enables both the perception of fear in others and the experience of fear within the individual. Such an evolved fear module is assumed to have been shaped and constrained by evolutionary contingencies so that it is preferentially activated within aversive contexts by stimuli that are relevant in a phylogenetic sense (Öhman, 1993;Öhman & Mineka, 2001). This perspective is compatible with discrete emotions theories (e.g., Ekman, 1984; Tomkins, 1962), in which emotions are considered to be specific response patterns that are elicited most strongly by prototypical eliciting stimuli. Thus, biologically relevant stimuli related to threat would preferentially activate such a system with relatively little computational processing required (LeDoux, 1996). If this view is correct, the fear module should be activated more effectively by phylogenetic threats that are common to all mammals, such as snakes and reptiles.

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Several strands of evidence support this view. Specific phobias, for example, are more likely to develop in reaction to situations that posed a threat to the survival of our ancestors, (e.g., predators and heights) than to potentially deadly objects that are more commonly encountered in our contemporary environment (e.g., weapons or motorcycles; De Silva, Rachman, & Seligman, 1977). Seligman (1971) outlined a preparedness theory to account for this type of data, which proposed that preferential associations are formed between certain classes of “biologically prepared” stimuli (e.g., snakes or spiders) and negative outcomes, and these “selective associations” are thought to underlie the development of specific phobias. Support for preparedness theory comes from conditioning experiments using skin conductance responses (SCRs), which have consistently shown enhanced resistance to extinction of responses conditioned to such “prepared” stimuli (McNally, 1987;Öhman & Mineka, 2001). Moreover, naive monkeys who have been reared under laboratory conditions can rapidly acquire a fear of snakes by means of simply viewing a video of another adult monkey displaying fear to a toy snake. Monkeys who had watched the video showed a strong fear response when they were presented with a live snake after conditioning. However, when the video was spliced so that the monkey’s fear display on video now appeared to be in response to a bunch of flowers, the monkeys who had watched the video did *not* demonstrate a fear response when similar flowers were subsequently presented (Cook & Mineka, 1989). These results demonstrate that a selective association developed for a fear of snakes but not flowers, supporting the notion that the fear module is especially responsive to phylogenetically fear-relevant stimuli.

It is important to note that the evolved fear module theory does not dispute the fact that threat-related *ontogenetic* stimuli (guns, electric outlets etc.) can and do activate the fear system. Öhman & Mineka (2001) made it clear that threat-relevant stimuli with a strong ontogenetic history (e.g., guns) can also gain access to the fear module. Nevertheless, the main point is that phylogenetic stimuli should be able to activate this system with more degraded input so that only mildly aversive “prepared” stimuli may evoke a strong fear response (Öhman & Mineka, 2001). In other words, the fear module, with the amygdala at its center, is considered to be more easily accessed by threat-related stimuli that have a fear-relevant evolutionary history. An alternative view, however, is that the amygdala and related structures represent a more general system that has evolved to detect *relevance* rather than being dedicated specifically to fear relevance and threat (Sander, Grafman, & Zalla, 2003). Although fear-relevant stimuli with phylogenetic origins are likely to be automatically appraised as “relevant,” this would not be expected to differ from the degree of relevance appraisals accrued for more contemporary fear-relevant stimuli. Indeed, if anything, a recent threat stimulus such as a gun may be appraised as more relevant than a more ancient threat (e.g., a spider). Thus, these two perspectives make different predictions in terms of the ability of different classes of stimuli to activate the brain’s fear system. If fear is indeed a basic emotion with a dedicated evolved fear module (Öhman & Mineka, 2001), then fear-relevant stimuli with a phylogenetic origin (e.g., snakes, spiders) should preferentially activate this system. In contrast, if the proposed fear module is better characterized as a relevance detection system that has a wider role in the processing of emotionally relevant stimuli, then we would predict that any stimuli that are appraised as being relevant for current goals would preferentially activate this system (Sander et al., 2003). This proposal allows for a more flexible system without any assumption that the brain is organized in a modular way, with separate circuits for stimuli relevant for different basic emotions such as fear, anger, happiness, and so forth (see Feldman-Barrett & Wager, 2006; and Murphy, Nimmo-Smith, & Lawrence, 2003, for detailed discussion of this issue). We should note that a detailed contrast between the evolved threat detection and the evolved relevance detection hypotheses would need to include both threatening and nonthreatening stimuli that are appraised as relevant, and this is not done in the present experiments. However, as a first step, we contrast stimuli that are matched in terms of threat value (which may be seen as an index of relevance) but that differ in terms of phylogenetic origin. The relevance detection hypothesis would predict a general threat superiority effect that should not differ between ancient and new stimuli, whereas the evolved threat detection hypothesis would predict faster detection of the more ancient stimuli.

Appraisal theories of emotion have suggested that an early evaluation process is responsible for determining the extent to which particular events and objects become relevant in the current hierarchy of goals and needs of the individual. The proposal is that appraisal of high relevance would tend to enhance and modulate the degree of attentional processing dedicated to those particular stimuli (Sander, Grandjean, & Scherer, 2005). This type of model therefore predicts that stimuli that have been appraised as highly relevant will get noticed more quickly than less relevant stimuli. On many occasions, of course, these stimuli will tend be threat relevant, but at other times, threatening stimuli may be relatively less relevant than other (e.g., appetitive) stimuli. Neuroimaging studies have provided some evidence that the neural structures involved in threat detection may indeed play a wider role and may be more accurately described as detecting *relevance* rather than having a primary role in detecting *threat* (see Sander et al., 2005, for a comprehensive review). A difficulty for appraisal models, however, is finding ways of independently establishing the relevance of stimuli. It is, of course, circular to categorize relevant stimuli as those that are detected more quickly. One means of achieving this is to ask people to rate stimuli on some dimensions of relevance (e.g., threat value) before using these stimuli in attentional tasks.

The foregoing research has important implications for the interpretation of the growing literature on the so-called threat-superiority effect. To illustrate, a common behavioral method of probing the characteristics of the proposed fear module is to assess the efficiency with which threatening stimuli can be detected in a visual search task. Typically, an array of items is presented, and the participant is required to indicate whether all of the items are from the same category (same trials) or whether there is a discrepant item in the display (discrepant trials). Öhman, Flykt, and Esteves (2001) found that a discrepant picture of a snake (or spider) embedded in a background of flowers (or mushrooms) was detected more quickly than a discrepant picture of a mushroom (or flower) in a background of snakes or spiders. Moreover, when the display size was manipulated, it was found that the time to detect fear-relevant stimuli was not affected by the display size, whereas detection times for fear-irrelevant stimuli did increase significantly when the display size increased. This pattern of results has also been found for aggressive facial expressions relative to neutral or friendly facial expressions. To illustrate, when asked to make same different judgments to displays of schematic faces, participants were faster in responding to displays containing a single angry expression in a background of neutral faces relative to a single happy expression in a background of neutral expressions (Fox et al., 2000). Other research has found a similar pattern of results with displays of schematic faces (Eastwood, Smilek, & Merikle, 2001; Öhman, Lundqvist, & Esteves, 2001), photographs of real faces (Hansen & Hansen, 1988), and photographs of just the eye regions of faces (Fox & Damjanovic, 2006). These results are widely characterized as *threat superiority effects*, because they show that negative and threat-related expressions are detected more quickly than other positive (happy) or negative (sad) facial expressions.

The results from the visual search paradigm are compatible with the basic emotions approach, which assumes that an evolved fear module is preferentially activated by phylogenetic threat-related stimuli. However, if the proposed fear module actually plays a wider role of a relevance detector (Sander et al., 2003), then these previous experiments are not particularly informative as only phylogenetic (and threat-related stimuli) were examined. When threat-related (angry expressions or snakes) and positively valenced items (happy faces or flowers) are contrasted with each other, it is likely that the stimuli indicating potential danger are appraised as more relevant. A better test would be to contrast stimuli that are of equal threat relevance but differ in terms of phylogenetic origin. Phylogenetic and ontogenetic fear-relevant stimuli have been compared with each other in studies examining associative conditioning. Although this research generally supports the evolutionary theory, there is some evidence that highly potent ontogenetic threat stimuli (pointed guns) are comparable with potent phylogenetic threat stimuli (pointed snakes) in terms of the resistance to extinction (Hugdahl & Johnsen, 1989). However, Öhman & Mineka (2001) have pointed out a number of problems with this study, and the results may have been due to selective sensitization to the pointed gun stimuli rather than to associative conditioning (see Öhman & Mineka, 2001, for detailed discussion).

A primary aim of the present experiments was to investigate whether threat stimuli that are evolutionarily significant (snakes) are more likely to capture attention than threat stimuli that are relevant in only an ontogenetic sense (guns). Thus, we compared response latencies for snakes, guns, and neutral items in a visual search task. When our experiments were completed we became aware of two other recent studies that also contrasted threat-related stimuli that differed in terms of phylogenetic history (Blanchette, 2006; Brosch & Sharma, 2005). In both cases, it was found that the threat superiority effect was equivalent for phylogenetic (e.g., snakes, spiders) and for ontogenetic (e.g., guns, syringes) stimuli, which does not support the fear module theory. In both of these previous studies, however, there was no reported rating of the threat value of the various photographs. This leaves open the possibility that the ontogenetic stimuli (guns, knifes, syringes) may actually have been more threatening than the phylogenetic stimuli (snakes and spiders). As pointed out by Öhman & Mineka (2001), guns are stimuli that are strongly associated with danger in industrialized societies and also represent a deadly threat that can operate at a distance. In contrast, snakes and spiders can generally be avoided by withdrawing from the immediate danger zone. Thus, if the ontogenetic pictures used in the two previous studies (Blanchette, 2006; Brosch & Sharma, 2005) were subjectively more threatening than the phylogenetic stimuli, then the results may be masking easier detection of the phylogenetic fear-relevant stimuli. In the present experiments, care was taken to ensure that the phylogenetic and ontogenetic stimuli were matched in terms of ratings for threat value in an initial pilot study. If the fear module were particularly finely tuned for phylogenetic threat-relevant stimuli, then we would expect to find a detection advantage for snakes, but not guns, relative to neutral stimuli. However, if the evolved fear module is flexible and operates as a relevance detector rather than a specific fear detector, we would expect to find detection advantages for both snakes and guns, as we ensured that these were matched for overall threat value.

Experiment 1

Experiment 1 directly compared the detection of fear-relevant (snakes and guns) with fear-irrelevant (flowers and mushrooms) stimuli in a well-established visual search task. An important feature of the present experiment is that the fear-relevant stimuli differed in terms of phylogenetic origin, allowing us to investigate the specificity of the proposed fear module.

Method

Participants—Thirty participants (19 female, 11 male), aged 18 to 55 years (*M* = 25 years), took part in the experiment.

Apparatus and stimuli—Participants were tested in a quiet testing cubicle. The experiment was conducted on a Macintosh Power PC running SuperLab Pro 1.75 software.

The stimuli used were photographs selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1996). Four different categories of pictures were selected (snakes, guns, flowers, and mushrooms), with five exemplars of each. Three of the five exemplars for the snakes and guns showed images in which the snake or gun was pointing toward the viewer. All of the pictures were changed to grayscale to reduce the possibility of color variations affecting visual search latencies, and they were also equated for luminance. In an initial pilot study, each of the 20 photographs were rated by 15 independent judges (undergraduate students) on a 7-point scale ranging from 1 (*not at all threatening*) to 7 (*extremely threatening*). As expected, the snakes ($M = 5.6$, $SD = 0.55$) and guns ($M = 5.4$, $SD = 0.89$) were rated as being more threatening than flowers ($M = 1.0$, $SD = 0.0$) and mushrooms ($M = 1.0$, $SD = 0.0$). It is important to note that the ratings of threat between the snakes and the guns did not differ from each other, $t(19) < 1.0$.

Each of the pictures had a vertical visual angle of 3.3° and a horizontal visual angle of 2.9° at a viewing distance of 60 cm from the computer screen. Stimulus arrays were constructed containing five pictures with a distance of 5.3° of visual angle from fixation to each of the pictures. The “same” displays consisted of five exemplars from the same category (all snakes, all guns, all flowers, and all mushrooms). The “discrepant” displays consisted of four different exemplars from the same category and one exemplar from a different category (e.g., four different pictures of flowers and a single picture of a snake). The position of the target on discrepant trials was systematically balanced over the five possible locations across all trials. The fear-relevant targets (snakes and guns) were always embedded in fear-irrelevant distractors (flowers or mushrooms), whereas the fear-irrelevant targets always appeared in displays of either guns or snakes. Each of the resulting eight discrepant displays was presented 15 times each, resulting in 120 trials. There were also 120 “same” trials, with each of the four target-absent trials being presented 30 times.

Procedure—Each trial started with a fixation cross (+) presented at the center of the computer screen for 500 ms, followed immediately by a stimulus display that remained on the screen for 1000 ms. After the participant’s response, there was a blank field for 1500 ms and then the fixation display for the next trial was presented. If the participant did not respond, then the next trial followed 1500 ms after offset of the stimulus display. Participants were told that if all pictures belonged to the same category (snakes, guns, flowers, or mushrooms) they should press the “A” or the “L” key on the computer keyboard, whereas if there was one discrepant item in the display (e.g., a flower among snakes) then they should press the other key “A” or “L.” Participants were told that half of the displays would contain a discrepant target, and the response mappings were counterbalanced across participants. Each session started with 32 practice trials, including 16 target-absent and 16 target-present displays. These were followed by the 240 experimental trials (120 target-absent and 120 target-present displays).

Results

All trials (7.64%) in which incorrect responses were made were excluded from the main reaction time analysis. Trials in which reaction times were less than 100 ms or greater than 1,500 ms (<2%) were also excluded from the analysis. For the analysis, errors and mean reaction times for target-present trials only are reported since these are the theoretically interesting trials. The errors occurring on these discrepant trials did not differ among snake, gun, flower, or mushroom targets, $F(3, 87) = 1.11$, $p < .35$ (see Table 1). A one-way analysis of variance (ANOVA) on the mean reaction times (see Table 1) showed that there was a main effect for target type (snake, gun, flowers, mushrooms), $F(3, 87) = 12.9$, $p < .001$. Further analysis by means of paired t tests revealed that, as predicted, reaction times to snake targets were faster when compared when flower targets, $t(29) = 2.7$, $p < .006$; or mushroom targets, $t(29) = 5.0$, $p < .001$. However, the detection of snakes was not any faster than the detection of gun targets, $t(29) < 1.0$). Moreover, the detection of gun targets was faster when compared with both flower targets, $t(29) = 3.3$, $p < .001$; and mushroom targets, $t(29) = 7.7$, $p < .001$. All of these comparisons are significant when taking account of the Bonferroni correction ($p < .008$).

Discussion

Results from this study support the threat superiority effect in demonstrating that fear-relevant stimuli were detected more quickly than fear-irrelevant stimuli. However, the new information gained from the present experiment is the demonstration that there was no difference in detection time between fear-relevant stimuli that were matched for threat value but that differed in terms of phylogenetic origin. The phylogenetically relevant stimuli (snakes) were not detected any faster than the evolutionary more recent fear-relevant stimuli (guns). These results confirm those reported in two recent studies (Blanchette, 2006; Brosch & Sharma, 2005) and suggest that threat relevance may be more important than phylogenetic origin, in terms of determining how quickly stimuli can be detected.

Experiment 2

The first experiment demonstrates that guns are detected as quickly as snakes and, therefore, are presumably as effective in drawing visual attention to their location. Similar results have been reported with a wider range of stimuli (snakes, spiders, syringes, guns, knives, etc.; Blanchette, 2006; Brosch & Sharma, 2005). However, there is a potential problem with all of these previous experiments in that participants searched for targets (e.g., snakes, guns, flowers, mushrooms) against other stimuli that were also used as targets in the experiment. Under these conditions, it is always possible that the apparent faster detection of fear-relevant stimuli (snakes and guns) may actually have been due to the faster rejection of fear-irrelevant distractors. Also, in our first experiment, the display size was not manipulated; therefore, potential differences in the efficiency of processing between evolutionarily significant and nonsignificant stimuli (snakes vs. guns, respectively) may have been missed. To further investigate the hypothesis, in Experiment 2, we presented fear-relevant (snakes, guns) and fear-irrelevant (mushroom, toasters) targets among backgrounds of mixtures of various exemplars of flowers and electric kettles. This design ensured that any speeding of response on the fear-relevant target trials could not be attributed to faster rejection of distractors. A further advantage of this design is that the potential influence of the evolutionary significance of the stimuli can be examined for both fear-relevant (snakes vs. guns) as well as fear-irrelevant (mushrooms vs. toasters) targets. The background contained a mixture of both evolutionarily ancient (flowers) and recent (kettles) neutral items on all trials.

We also manipulated display size in Experiment 2 to assess the efficiency of search. Although there is no absolute criterion for judging whether a search function is serial or automatic, one principle that is widely accepted is that search functions with slopes under 10 ms could be considered to reflect automatic search, whereas over 10 ms per item could be considered to necessitate a serial item-by-item search (Treisman & Souther, 1985).

Method

Participants—Twenty participants (12 female, 8 male) aged 19 to 34 years (*M* = 22 years) took part in the experiment.

Apparatus and stimuli—The same apparatus and stimuli as presented in Experiment 1 were used in Experiment 2, in addition to extra pictures selected from a variety of sources.

This enabled us to present four target categories—snakes, guns, mushrooms, and toasters—with nine exemplars of each of these target types. We also selected two categories of distractors to ensure that there was no overlap between the target and the distractor sets. The distractors consisted of nine exemplars each of flowers (evolutionarily ancient) and kettles (evolutionarily recent). Each of these 54 photographs were rated by 10 independent judges (undergraduate students) on a 7-point scale ranging from 1 (*not at all threatening*) to 7 (*extremely threatening*). As before, the snakes ($M = 5.5$, $SD = 0.69$) and guns ($M = 5.6$, $SD = 0.72$) were rated as being more threatening than mushrooms ($M = 1.0$, $SD = 0.0$) and toasters ($M = 1.2$, $SD = 0.16$). It is important to note that the ratings of threat between the snakes and the guns did not differ, $t(19) < 1.0$. The distractor sets of flowers ($M = 1.0$, $SD = 0.0$) and kettles ($M = 1.0$, $SD = 0.0$) were also rated as low on threat value.

Stimulus arrays were constructed for both the small (four-item) and the large (nine- item) displays. The “target-absent” or “same” displays consisted of four (or nine) different exemplars from the same background category (all flowers, all kettles). The “target-present” or “discrepant” displays consisted of three (or eight) different exemplars from one of the distractor categories (flowers or kettles) and one exemplar from one of the target categories (e.g., four different pictures of flowers and a single picture of a gun; eight different pictures of kettles and a single picture of a gun). The position of the target on discrepant trials was systematically balanced over all of the nine possible locations across all trials. These nine locations formed a circle and were equidistant (4.9°) from fixation. Participants were presented with arrays containing either four or nine pictures, and half of these were discrepant trials (2 set sizes × 2 backgrounds × 4 targets × 9 positions = 144 trials), which were randomly intermixed with 144 same trials. The 288 experimental trials were presented in a different random order for each participant.

Results

All trials (7.94%) on which incorrect responses were made were excluded from the main reaction time analysis. Trials in which reaction times were less than 100 ms or greater than 1500 ms (<3%) were also excluded from the analysis. The data shown in Table 2 were analyzed by means of a 2 (evolutionary significance: significant, nonsignificant) × 2 (fear relevance: fear-related, neutral) × 2 (display size: small, large) repeated measures ANOVA. Analysis of the mean error rates revealed that there was a main effect for display size, $F(1, 19) = 11.3$, $p < .003$, so that errors increased for the large displays (10.3%), relative to the small displays (4.8%). There was also a significant main effect for fear relevance, $F(1, 19) = 7.9$, $p < .011$, so that fewer errors occurred on the fear-relevant trials (5.3%), relative to the neutral (9.8%) trials. There were no significant interactions. For reaction times, there was a main effect for display size, $F(1, 19) = 56.1$, $p < .001$, so that latencies increased an average of 56 ms from the small (four-item) to the large (nine-item) displays. The fear relevance of targets also exerted a main effect with fear-relevant targets (snakes and guns) being detected faster (572 ms) than the fear-irrelevant (mushrooms and toasters) targets (684 ms), $F(1, 19) = 28.5$, $p < .001$. Display size and fear relevance interacted significantly, $F(1, 19) = 19.2$, $p < .001$; and this interaction was *not* qualified by the evolutionary significance of the stimuli, $F(1, 19) = 1.3$, $p = .28$. To break down this interaction, the mean slope for the fear-relevant and neutral stimuli was calculated (see Table 2). A series of planned comparisons revealed that the slope for snakes was significantly less when compared with mushrooms, $t(19) = 4.3$, $p < .001$; and toasters, $t(19) = 3.9$, $p < .001$. Likewise, the slope for guns was significantly less than that observed for mushrooms, $t(19) = 2.9$, $p < .008$; whereas the trend for a smaller slope compared with toasters, $t(19) = 2.5$, $p < .01$; did not survive the Bonferroni comparison ($p < .008$). It is of theoretical interest to note that there was a trend for the slope for snake targets to be less than that of gun targets, $t(19) = 2.5$, $p < .012$, whereas the slopes for mushrooms and toasters did not differ from each other.

Discussion

The results of Experiment 2 extend the results of Experiment 1 in a number of ways. First, the finding that detection time for snake and gun targets did not differ from each other in small display sizes was replicated, and this finding was also extended to larger display sizes (nine items). This threat superiority effect for fear-relevant stimuli (regardless of evolutionary significance) must be due to faster detection of threat stimuli rather than possible differences in the speed of rejection of distractor stimuli, as distractor stimuli were equivalent across target categories. Although there was an interaction between the size of the display and the fear relevance of the stimuli as expected, the evolutionary significance of the target did not make a difference. Thus, there was no statistical evidence that searching for snakes was any more efficient than searching for guns in similar backgrounds. Although there was a tendency for snake stimuli to be detected more efficiently than gun stimuli, both were detected very efficiently (slope <10 ms). Thus, we can be fairly sure that fear relevance was an important factor in driving the search results.

General Discussion

The present results demonstrate that the efficient detection of threat was not restricted to phylogenetic stimuli in a visual search task. Although participants rated ontogenetic stimuli (guns) as being comparable in threat value to phylogenetic stimuli (snakes), it was not the case that the snake stimuli were detected faster than guns, as would be expected by the hypothesis that an evolved fear module can be preferentially accessed by phylogenetic stimuli (Öhman, 1993; Öhman & Mineka, 2001, 2003). These results are consistent with earlier reports that phylogenetic stimuli do not have any advantage over ontogenetic stimuli in visual search tasks (Blanchette, 2006; Brosch & Sharma, 2005). Taken together, the general pattern of results is inconsistent with a strong view that an evolved fear module is triggered primarily by threat existing at the time of mammalian evolution. Instead it seems that, if a fear module does indeed exist, it may be flexible and can be triggered by threat-related stimuli of both ancient and recent origin. Although the evolved fear module hypothesis does not predict this finding, Öhman & Mineka (2001) did acknowledge that ontogenetic stimuli can also trigger the fear module. Using a computational model of fear conditioning (Armony & LeDoux, 2000), they argued that biologically “prepared” stimuli may gain access to a fear module by means of stronger preexisting connections between units representing features of certain stimulus–outcome combinations. Thus, phylogenetic stimulus combinations can more rapidly gain strength in the competition to control the next layer in the model. Although this proposition explains phylogenetic effects on fear conditioning it can also provide a mechanism by which similar effects may develop from ontogenetic experience. Thus, given “extensive and consistent experience (literature, lore, media) with particular stimuli (e.g., guns) in aversive contexts, the weights connecting them to fear may have gained weight to an extent that make them function like evolutionary prepared associations.” (Öhman & Mineka, 2001, p. 513). The visual search results are entirely consistent with this proposition (present experiments; Blanchette, 2006; Brosch & Sharma, 2005).

Although the present results cannot be taken as evidence against the notion of an evolved fear module, they are broadly consistent with the notion that stimuli that are appraised as relevant are detected more efficiently. In other words, it may not be threat value per se that predicts speed of detection, but rather the degree to which a stimulus is appraised as subjectively relevant (Sander et al., 2005). As we discussed earlier, there is growing evidence that the neural networks involved in threat detection may actually play a much wider role and are possibly better characterized as being involved in relevance detection (Sander et al., 2003, 2005). It is critical for emotion science to determine whether the attentional effects, as reported in the present article, are a reflection of a specific threat superiority effect or whether these effects can be generalized to other kinds of signals that are highly relevant for the organism. As pointed out earlier, we cannot answer this question completely in the present study, as we did not include nonthreatening stimuli that may be appraised as subjectively relevant. Nevertheless, the present results, in combination with those reported by Blanchette (2006) and Brosch and Sharma (2005), are consistent with the notion that highly relevant stimuli (e.g., stimuli indicating potential danger) are likely to capture attentional processes and gain priority in terms of speed of processing. Future research is needed to directly compare both positively and negatively valenced stimuli that vary in terms of appraised relevance to directly compare the two competing explanations outlined earlier. If the evolved fear module hypothesis is correct, then threat-related stimuli should always be prioritized over other categories of stimuli, even if they are appraised as highly relevant. In contrast, if the relevance detection hypothesis is correct, then stimuli that are appraised as highly relevant should always be prioritized over less relevant stimuli regardless of threat value. Such studies are currently ongoing in our laboratory.

Acknowledgments

Thanks are due to Roger Grace for help with computer programming. The data reported in Experiment 1 were collected as part of a final year undergraduate project by Laura Griggs. The study was supported by a Wellcome Trust project grant awarded to Elaine Fox (ref: 076701/z/05/z).

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Table 1

Mean Reaction Times in Milliseconds and Percentage Error (With Standard Deviations) for Each Type of Target on Discrepant Trials in Experiment 1

Measure	Guns	Snakes	Flowers	Mushrooms
% error	4.1 (3.8)	6.2 (5.1)	5.4 (5.7)	4.9 (5.5)
Reaction time	608 (61)	615 (81)	704 (142)	717 (88)

Table 2

Mean Reaction Times (RTs) and Percentage Errors as a Function of the Evolutionary Significance and Fear Relevance of Targets on Discrepant Displays for Both Small (Four Items) and Large (Nine Items) Displays in Experiment 2

Measure	Evolutionary significance			
	High		Low	
	Fear (snake)	Non-fear (mushroom)	Fear (guns)	Non-fear (toaster)
RT (in milliseconds)				
Small display	553 (65)	644 (82)	554 (56)	650 (99)
Large display	583 (66)	718 (114)	600 (65)	724 (94)
Slope	6.0	14.9	9.1	14.8
% Error				
Small display	4.0 (6.3)	5.0 (5.7)	4.0 (5.9)	6.3 (8.2)
Large display	6.0 (4.8)	17.2 (28.6)	7.3 (6.5)	10.7 (6.6)

Note. Standard deviations are given in parentheses.