

Abstract Stimuli Associated With Threat Through Conditioning Cannot Be Detected Preattentively

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Studies of anxiety suggest that threat stimuli can be identified preattentively, but this conclusion is questionable because of possible low-level perceptual confounds. Two experiments used visual search tasks in which abstract shapes were conditioned to carry neutral or negative valence. Experiment 1 found generally faster responses to threat-associated abstract stimuli but no evidence that they were detected preattentively, irrespective of trait anxiety level. A similar pattern was found in Experiment 2, in which individuals high in snake or spider fear showed no evidence of preattentive detection of abstract stimuli associated with their feared object. In contrast, implicit behavioral measures showed significant effects of conditioning, demonstrating that targets associated with threat were negatively evaluated in these experiments.

Keywords: anxiety, attention, Implicit Association Test, visual search, threat

An attentional bias toward threat is central to a number of cognitive models of anxiety (e.g., Eysenck, 1992; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1988, 1997). This bias has been reliably demonstrated both in clinical populations (e.g., MacLeod, Mathews, & Tata, 1986) and in individuals with high levels of state (e.g., Fox, Russo, Bowles, & Dutton, 2001) and trait anxiety (e.g., Mogg & Bradley, 1999). Although these findings have been relatively consistent despite differences in the methodology (generally, emotional Stroop, dot-probe, or visual search tasks), the stage of processing at which this bias is thought to occur is more controversial.

From an evolutionary perspective, potentially harmful stimuli must be detected quickly to facilitate avoidance or escape. Neurobiological evidence (e.g., LeDoux, 1996, 2000) suggests that the thalamo-amygdala pathway may mediate this function by providing a “quick and dirty” route for the transmission of information alerting of potential dangers. Conditioned stimuli associated with threat caused fear responses mediated by the amygdala even after destruction of cortical pathways. Hence, gross physical characteristics associated with danger presu-

ably are detected subcortically at a very early stage of visual processing.

Fear-relevant (FR) stimuli (e.g., snakes, spiders, and angry faces) are undoubtedly a potent source of threat that evoke unique emotional responses (Öhman & Mineka, 2001). Their significance is evidenced both at the neural level (e.g., Morris, Frith, Perrett, Rowland, Young, Calder, & Dolan, 1996) and in differential responses to conditioned masked FR stimuli (e.g., Öhman, Esteves, & Soares, 1995). However, although these studies demonstrate selection without conscious awareness, it is not clear whether they are examples of preattentive detection, in which a threat stimulus in the presence of physically similar competing stimuli is detected and triggers a response or draws attention to itself before it is ever selected. In addition, we must consider two competing hypotheses: Does negative valence allow for preattentive detection of stimuli that would require attentional processing to be identified without the emotional link, or does negative valence increase attentional capture of stimuli that can always be detected preattentively on the basis of low-level sensory properties? LeDoux’s (1996) findings are more consistent with the latter hypothesis; FR stimuli will activate the amygdalae preattentively through the “quick and dirty” route, and the amygdalae will modify attentional processes through pathways to the cortex. Under this hypothesis, threat stimuli can be found quickly in visual search only when they are distinguished from nonthreat distractors by simple visual properties that can be detected without attention.

One of the first experiments providing evidence of preattentive (i.e., without focused attention) detection of threat was a study by Hansen and Hansen (1988) in which participants searched arrays of faces for a discrepant stimulus. Hansen and Hansen found a search asymmetry, whereby participants were faster to detect angry faces (FR stimuli) among happy faces than vice versa. More important, as there was no additional cost to find the angry faces when the number of distractors (the set size) was increased (Experiment 3), this was taken as evidence

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that an angry face was so easily detected among happy faces that it would seem to “pop out” of the display, similar to the way that a red stimulus pops out from among green stimuli (Treisman & Gelade, 1980; Treisman & Souther, 1985). However, a number of alternative explanations for these findings have since been posited, including the possibility that friendly faces may be processed more efficiently than threatening faces because of their familiarity (Öhman, Lundqvist, & Esteves, 2001). This possibility is supported by the fact that response times (RTs) to detect the absence of discrepant targets in “friendly” arrays were faster than RTs to detect the absence of discrepant targets in “threatening” arrays of faces. More important, however, was the discovery of a low-level perceptual confound in the specific stimuli used in this study. The more rapid responses to identify the threatening faces were attributable to low-level features (conspicuous dark areas apparent in the area around the neck and chin in the threatening faces), rather than affective expression per se. Subsequent replications controlling for this effect (e.g., Purcell, Stewart, & Skov, 1996) were unable to replicate Hansen and Hansen’s original findings.

To extrapolate whether preattentive detection of threat is a fundamental characteristic of anxiety (as advocated by a number of theoretical models, e.g., Mogg & Bradley, 1998; Williams et al., 1988, 1997), Öhman, Flykt, and Esteves (2001) carried out a series of experiments in which participants searched through matrices of color photographs. For each stimulus display, participants decided as quickly as possible whether all items came from a single category (e.g., all flowers) or whether one item belonged to a different category (e.g., a spider among mushrooms). Displays were composed of FR targets (snakes or spiders) among fear-irrelevant (FI) distractors (flowers and mushrooms), FI targets among FR distractors (i.e., a flower or mushroom among snakes or spiders), or all items from one category (all snake or spider photos or all flower or mushroom photos). Participants were faster to detect FR stimuli among FI distractors than vice versa. Furthermore, when the size of the matrix was increased from 2×2 to 3×3 (increasing the number of distractors from three to eight), there was no significant increase in RTs to detect FR targets. In a final experiment, Öhman et al. selected participants on the basis of high snake or spider fear or low snake/spider fear (control group) and carried out the same experiment. Most important, fearful participants were faster to detect their feared than their nonfeared FR target (i.e., high spider fear participants were faster to locate spider targets than snake targets, whereas high snake fear participants were faster to detect snakes than spiders), and the faster RTs were not at the expense of a speed-accuracy trade-off.

Although these findings are persuasive, the evidence that threat stimuli are detected preattentively is equivocal. In a recent series of experiments using visual search with pictures (Tipples, Young, Quinlan, Broks, & Ellis, 2002), participants found threatening animals (snakes, bears, and dogs poised to attack) more quickly than plants. However, data from subsequent searches for “pleasant” animals among plants again showed a significant advantage in favor of animals. Furthermore, when neutral distractors were incorporated into the search matrices, the search asymmetry remained, with faster detection to both threatening and pleasant animals than plants. In a final experiment, pictures of fruit were

added to the search matrices, and participants were instructed to search for animals (both threatening and pleasant), flowers, and fruit as a unified category. RTs to threatening and pleasant animals and fruit were roughly the same, whereas detection of flowers was significantly slower. The pattern of results found by Tipples et al. suggests that threat stimuli have no special advantage in preattentive processing and that whenever search can be done quickly, it is because of simple visual properties that distinguish targets from distractors.

To avoid the problems with controlling these basic visual properties in photographic stimuli, some visual search studies have used schematic faces, which can be more carefully controlled (e.g., Eastwood, Smilek, & Merikle, 2001; Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Öhman, Lundqvist, & Esteves, 2001). However, these studies showed no evidence of pop-out of angry faces. Furthermore, despite the efforts of these researchers to control for basic featural differences, the results from Purcell and Stewart (2002) suggest that the search advantages that do appear for angry faces may be due to shape configurations in the angry faces independent of their emotional connotation.

These findings undermine the notion that classes of stimuli defined by complex attributes such as threat are detected more efficiently than other stimuli as an evolutionary advantage and are consistent with models of visual attention built on the assumption that search efficiency is determined by the number of simple visual features shared by targets and distractors (e.g., Cave, 1999; Treisman & Gelade, 1980; Wolfe, 1994; Wolfe, Cave, & Franzel, 1989). In these models, high-level properties such as the affect conveyed by a stimulus would be identified only by higher level mechanisms that would not be able to guide visual search (Cave & Batty, in press). Threat stimuli could be found easily in search, according to these models, only if there were simple visual features that appeared more often in threat targets than in nonthreat distractors.

Taken together, the evidence that complex threat stimuli are detected very early in visual processing and without focused attention is equivocal. Both photographic and schematic stimuli may contain unique features, and their rapid detection might be possible because subjects learn to search for those specific low-level features, rather than identifying the objects as threats. In an attempt to reconcile these findings, we have developed a novel paradigm that affords the advantages of photo and schematic stimuli without the weaknesses inherent in either method.

Experiment 1

This experiment was designed to test whether threat-associated stimuli can be detected preattentively. To control for low-level stimulus properties, target letters were conditioned to carry affective valence using evaluative conditioning (De Houwer, Thomas, & Baeyens, 2001). Evaluative conditioning is essentially a form of classical conditioning in which neutral stimuli are repeatedly paired with biologically salient stimuli or events (the unconditioned stimulus; UCS). In this experiment, each UCS is a photograph of a negative stimulus, such as a mutilated body. Over time, the subject learns to associate the neutral event (the conditioned stimulus; CS) with the UCS, and the affective valence from the UCS is transferred to the CS. In

the current experiment, target letters (CS) were hidden among distractors composed of different arrangements of the same shape components in a visual search task, and the RTs to find neutral and negative targets were measured. To ensure that the conditioning procedure was effective, the search task was followed by an explicit (ratings) and implicit (Implicit Association Test [IAT]; Greenwald, McGee, & Schwartz, 1998) assessment of valence of conditioned stimuli. Because participants were aware of the contingency between CS and UCS stimuli, the implicit measure was considered to be most important to indicate effective conditioning.

Method

Participants

Forty-six students (20 male, 26 female) from the University of Southampton participated in the experiment in return for course credits or £5 (approximately U.S. \$9) payment. Participant age ranged from 19 to 45 years. Mean age was 25.46 years ($SD = 5.78$). All participants gave written informed consent and reported normal or corrected-to-normal vision, including normal color perception. Trait anxiety scores were measured using the Spielberger State–Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), and participants were split into three equally sized groups on the basis of these scores. STAI scores can range from 20 to 80, with cutoff points as follows: 40 and below for low anxiety, 41 to 49 for medium anxiety, and 50 and above for high anxiety. Ten male and 6 female participants constituted the low-anxiety group (STAI: $M = 28.20$ state, 33.10 trait); 7 male and 8 female participants the medium-anxiety group (STAI: $M = 37.13$ state, 44.47 trait); and 3 male and 12 female participants the high-anxiety group (STAI: $M = 48.87$ state, 56.73 trait). There were no significant differences between groups in age and gender distribution.

Design

A mixed design was used. The between-subjects factor was the trait anxiety level. Each participant was required to search for two targets, a *T* and an *F* (the within-subject factor). For half the participants in each group, the letter *T* was paired with negative valence images taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997), and the letter *F* with neutral valence images. The remaining half experienced the reversed pairing (i.e., *T* was neutral and *F* negative). On each trial, one of the two targets was present. All conditions were counterbalanced across each group so that 50% of participants were required to press the left-hand button of the button box if a *T* was present and the right-hand button if an *F* was present. The remaining half used the opposite mappings.

Stimuli

Two types of picture sets were relevant for this study: 24 negative valence pictures (e.g., mutilated bodies) and 24 neutral valence pictures (e.g., an office block) from the IAPS (Lang et al., 1997), a standardized set of normative emotional stimuli. Selection was made on the basis of mean ratings of valence and arousal taken from the IAPS technical manual. Each scale ranges from 1 to 9, where 9 represents a high rating for the particular dimension (e.g., positive valence or high arousal) and 1 represents a low rating (e.g., negative valence or low arousal). Mean valence and arousal values for the negative images were 1.77 and 6.63, respectively. For the neutral images, mean valence was 4.92 and mean arousal was 2.87. To simplify proceedings, images were selected on the basis of having appropriate scores for both male and female participants, thus eliminating the need for a separate set of pictures for each group. As the IAPS images

varied in size, they were aligned onto a black background and centered for fixation. The display size of each image, along with the black background, was $1,152 \times 870$ pixels and occupied the entire screen.

Stimuli used in the visual search task were arrays of target letters (*T* and *F*) and distractors, a *T–F* hybrid similar to that used by Shiffrin and Gardner (1972; see Figure 1). Both targets and distractors were presented at one of four orientations (0° , 90° , 180° , or 270°), and their presentation was randomized. In a single trial there could be only one target present. However, the number of distractors varied across trials (either none, 2, 5, or 11). Target and distractor letters were black and 10 mm tall and 10 mm wide. Throughout all trials the background was white. Target and distractor letters were spaced around an imaginary circle with a diameter of 100 mm around fixation. Throughout the course of the experiment, target and distractors could appear at any of 12 equally spaced locations around this imaginary circle. A black fixation cross was displayed in the center of the screen both before and throughout stimulus presentation.

IAT stimuli were either positive words (e.g., *lucky*, *ecstasy*) or negative words (e.g., *vomit*, *scar*) and the letters *T* and *F* (presented at the same four orientations used in the visual search task). Stimuli were presented just below the center of the monitor and appeared at the same location on each trial. All stimuli were black on a white background. Letters making up words were 10 mm tall and 10 mm wide, and the letters *T* and *F* were 25 mm tall and 25 mm wide.

Apparatus

The experiment was conducted on Apple Macintosh Power PC 400 MHz G4 computers with Formac ProNitron 19/600 19-in. color monitors. Participants responded with their dominant hand on a Superlab button box (Cedrus Corporation, San Pedro, CA) interfaced with the computer via a serial port adapter connected to a USB port.

Procedure

Visual search task. Upon entering the laboratory, participants were asked to complete the STAI and were presented with cards on which the letters *T* or *F* were displayed at four orientations (0° , 90° , 180° , and 270°). Participants were asked to rate the letters for valence on a 7-point scale,

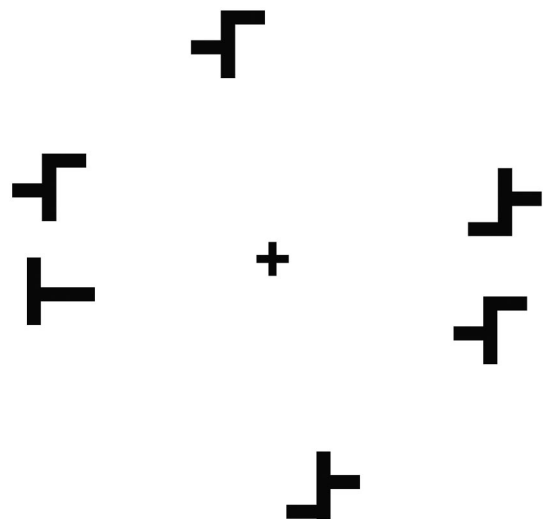


Figure 1. Example stimuli used in the visual search task in Experiment 1. The target was either the letter *T* or the letter *F*. Set size varied between 1, 3, 6, and 12 items. This example shows *T* as the target with five distractors.

with 1 representing low (negative) valence and 7 representing high (positive) valence.

Participants were seated approximately 60 cm in front of the computer monitor. Verbal instructions were given, and the contingency between the CS (*T* or *F*) and picture type (negative or neutral) was explicitly stated. In example trials, negative and neutral IAPS images were presented after the appropriate targets, and participants were informed that *T*s or *F*s (depending on the participant's group) would be paired with similar images for the duration of the experiment. A practice block of 24 randomized trials (12 negative, 12 neutral) with 6 presentations of each set size (i.e., 0, 2, 5, and 11 distractors) served as a practice and conditioning block.

Data were recorded from two blocks of 96 trials, with prompts for a break every 24 trials. The number of *T* and *F* trials was equal in each block. The procedure was identical to that used in the practice block. At the beginning of each trial, a fixation cross was displayed in the center of the monitor for 1,200 ms, followed by a randomized search array of 1, 3, 6, or 12 items arranged around an imaginary circle. The stimulus display remained until a response was made. Presentation was randomized, with equal numbers of each set size over the two blocks. Participants responded (via the button box) as quickly and accurately as possible to which target was present by pressing the corresponding button. If an incorrect response was made, feedback was given via a "negative" auditory tone. In all trials (including error trials), an IAPS image appropriate for the letter was displayed (e.g., a negative picture followed the letter *T* and a neutral picture followed *F*, or vice versa). The stimulus onset asynchrony between the initial fixation cross and IAPS image varied depending on the speed of the participant's response. However, the display duration of the IAPS image was always 5 s.

At the end of the visual search task, participants were again presented with cards showing the letters *T* and *F* at each of the four orientations and were asked to rate them for valence using the same 7-point scale as before.

IAT procedure. The second half of the experiment consisted of the IAT (Greenwald et al., 1998), used to measure whether targets had been successfully conditioned to carry affective valence. Briefly, the premise behind the IAT is that responses to a shared key will be faster when the mapping is congruent than when the mapping is incongruent. Stimuli were presented one at a time and were of two types: words (positive and negative) and letters (*T* and *F*). In each phase of the IAT, a word or letter was presented that had to be classified into one of two categories by pressing the left or right button. In critical trial blocks, word trials and letter trials were randomly intermixed. Thus, participants classified a word or letter as belonging to one of two combined categories (e.g., *T* and *Bad* or *F* and *Good*). If conditioning has been successful, participants who had the letter *T* paired with negative pictures should evidence faster RTs if *T* and negative words require the same response (response congruity) than if *T* and positive words require the same response (response incongruity); similarly, RTs to *F* (which was paired with neutral pictures) should be less affected by response congruity with bad or good words. Thus, the IAT should effectively discriminate valence between the conditioned letters from the visual search task. The five stages of the IAT are described below.

Phase 1 (attribute discrimination task). The words *Bad* and *Good* were displayed in the top left and top right of the monitor, respectively. Written instructions were displayed on screen at the beginning of this and all subsequent phases until the participant depressed a key on the button box to start the trials. The instructions detailed the format and the correct key responses and emphasized the need to respond as quickly and accurately as possible. Only words appeared in each trial in this phase (*T* and *F* were never present), and each word remained visible until a response was given. Participants were instructed to press the left key whenever an unpleasant word (e.g., *vomit*) was presented and the right key when a pleasant word (e.g., *laughter*) was displayed. Words appeared in the same location (slightly below center) throughout each experimental stage, and as in all stages, their order of presentation was randomized. Feedback was given

whenever participants made an error. Participants completed 32 trials in this initial stage (16 positive and 16 negative words).

Phase 2 (associated target discrimination). The letters *T* and *F* were displayed in the top left and top right of the monitor, respectively. Participants followed exactly the same procedure as in Phase 1, except that target stimuli were the letters *T* and *F* (25 mm tall and 25 mm wide). Presentation was randomized so that stimuli appeared at any of the four orientations seen in the previous visual search task. Participants were instructed to press the left key for *T* at any orientation and the right key for *F* at any orientation. Again, participants completed 32 trials (16 *T* and 16 *F*).

Phase 3 (initial combined task). The word *Bad* and letter *T* and the word *Good* and letter *F* were displayed in the top left and top right of the monitor, respectively. Participants responded to these combined categories by pressing the left key for the letter *T* and unpleasant words and the right key for the letter *F* and pleasant words. Participants completed 128 trials in this phase (32 *F*, 32 *T*, 32 positive words, and 32 negative words).

Phase 4 (reversed attribute discrimination). The procedure was exactly the same as in Phase 1, except that target categories (and their displays) were swapped—that is, participants pressed the left key for words that could be classified as "good" and the right key for words that could be considered "bad." As in Phase 1, participants completed 32 trials.

Phase 5 (reversed combined task). This phase was identical to Phase 3, but *Bad* and *Good* were reversed so that the letter *F* and *Bad* appeared to the upper right side of the monitor and the letter *T* and *Good* appeared to the upper left side of the monitor.

The positions of the letters *T* and *F* in the IAT corresponded to the buttons that they were associated with in the earlier visual search task. The evaluative attributes (positive and negative), though, switched sides over the course of the IAT. To contend with any potential order effect, the order of presentation of Phases 3 and 5 was counterbalanced across participants. The order of presentation for the IAT was P1, P2, P3, P4, and P5 for half the participants who pressed the left-hand button for *T* in the visual search experiment and for half the participants who pressed the left-hand button for *F* in the attention experiment, and P4, P2, P5, P1, and P3 for the remainder. Data were compared from Phases 3 and 5 so that each participant provided data from a total of 256 trials. These data were analyzed by a series of analyses of variance (ANOVAs).

Results

Visual Search

Data were analyzed by a $4 \times 2 \times 2 \times 3$ mixed ANOVA, with the within-subject factors set size (1, 3, 6, and 12), target valence (negative vs. neutral pictures) and block (1 vs. 2) and the between-subjects factor anxiety level (low, medium, or high). In searches for letters as similar as *T*s and *F*s, but with no emotional associations, the response time generally increases with the set size, reflecting the role of attention in locating and identifying the target (Treisman & Gelade, 1980). However, if the threat associated with the target letter allows it to be detected preattentively, then it should be detected rapidly regardless of the set size, or at least the set size effect should be less with the threat target than with the nonthreat target. Thus, preattentive threat detection will be reflected in a significant Target Valence \times Set Size interaction.

RTs of less than 100 ms and error trials were removed prior to analysis. Owing to the large variation in RTs at larger set sizes, there was no upper cutoff point. A similar analysis was conducted on the error rates. If necessary, Greenhouse–Geisser adjustments to correct for any violations of sphericity were performed, and only corrected significance levels are reported.

The main RT effects of the visual search task are summarized in Table 1. Search slopes indicated very inefficient search for all

Table 1
Mean Response Times (in ms) and Errors (%) to Abstract Targets Associated With Negative or Neutral Pictures Differentiated by Set Size and Trait Anxiety Level

Anxiety level and target	Set size											
	1			3			6			12		
	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors
Block 1												
Low anxiety												
Negative target	628.6	141.1	2.6	809.4	203.1	1.0	1,001.1	292.9	2.6	1,381.7	434.0	0.0
Neutral target	629.8	217.1	1.0	768.9	196.2	1.0	966.3	250.0	1.6	1,252.5	445.9	0.5
Medium anxiety												
Negative target	648.4	141.1	4.4	879.2	203.1	2.2	1,033.5	292.9	2.7	1,345.1	434.0	4.4
Neutral target	638.8	217.1	4.0	809.2	196.2	3.9	948.4	250.0	0.5	1,355.3	445.9	3.9
High anxiety												
Negative target	565.9	141.1	1.1	719.6	203.1	1.1	903.0	292.9	5.0	1,237.3	434.0	5.5
Neutral target	721.5	217.1	2.8	771.5	196.2	2.2	955.6	250.0	2.8	1,365.5	445.9	3.9
Block 2												
Low anxiety												
Negative target	602.6	140.7	0.5	751.7	165.5	1.0	929.1	250.1	1.0	1,180.4	363.3	1.0
Neutral target	595.3	182.4	0.5	750.8	187.6	0.5	932.8	253.5	0.5	1,161.5	356.9	0.5
Medium anxiety												
Negative target	608.9	140.8	2.2	752.7	165.5	3.9	892.6	250.1	1.1	1,257.1	363.3	1.7
Neutral target	665.2	182.4	1.6	776.4	187.6	3.3	948.4	250.0	2.2	1,213.5	356.9	4.4
High anxiety												
Negative target	557.3	140.8	1.1	690.5	165.5	2.2	827.6	250.1	3.9	1,016.3	363.3	5.1
Neutral target	691.9	182.4	2.2	754.5	187.6	1.1	924.7	253.5	3.3	1,183.8	356.9	3.3

groups, with target-trial rates of about 60 ms/item for both negative and neutral associated targets. The ANOVA returned significant main effects of block, $F(1, 43) = 41.90, p < .001$, and of set size, $F(3, 129) = 189.82, p < .001$, indicating that RTs were slower in the first block relative to the second block (931 ms vs. 859 ms) and that RTs increased with set size. The Block \times Set Size interaction, $F(3, 129) = 11.80, p < .001$, reflected a greater RT speedup from Block 1 to Block 2 for larger compared with smaller set sizes. Finally, there was no significant target valence main effect, but there was an interaction of Block \times Target Valence, $F(1, 43) = 4.69, p < .05$. Although there was no target valence effect for the first block (932 ms vs. 929 ms), RTs in the second block were faster to the negatively conditioned targets than to the neutral targets (839 ms vs. 880 ms), perhaps reflecting a general alerting triggered by the negative stimuli (Posner, Nissen, & Ogden, 1978). No other main or interaction effect reached significance.

Table 1 also summarizes the mean error effects. Errors were analyzed in the same way as response times. A main effect of block, $F(1, 43) = 7.41, p < .01$, evidenced more errors in the first block compared with the second block. In addition, a main effect of anxiety level, $F(2, 43) = 3.26, p < .05$, revealed that the low-anxiety group had lower error rates than the moderate- and high-anxiety groups (1.0%, 2.8%, and 3.0% respectively). Finally, a significant interaction between set size and anxiety level, $F(6, 129) = 69.20, p < .001$, indicated that the increase of error rates with corresponding increases in set size was evident only in the high-anxiety group (see Table 1). However, error rates were low across all groups and set sizes, with a maximum error rate of 5% for the high-anxiety group in the largest set size (11 distractors).

IAT

A three-way ANOVA with the between-subjects factors negative target shape (whether the negative target was *F* or *T*) and order (congruent first or incongruent first) and the within-subject factor response congruity (congruent or incongruent) was performed. If the letter *F* had been paired with negative pictures in the visual search task, then the pairing of *F* and "bad" words was considered to be congruent response pairing. Similarly, if *F* was paired with "good" words following a negative association in the visual search task, this was termed incongruent. Trials with errors or with RTs below 100 or above 2,000 ms were excluded from the analysis.

The effectiveness of conditioning is verified by a significant main effect of response congruity, $F(1, 42) = 6.53, p < .05$. Participants were faster to associate the negatively paired target with bad words and the neutral paired target with good words than vice versa (732 ms for congruent vs. 770 ms for incongruent). In addition there was a marginally significant interaction of Response Congruity \times Negative Target Shape, $F(1, 42) = 3.17, p = .08$. Participants were somewhat faster to associate *F* with bad words and *T* with good words than vice versa.

Valence Ratings

Ratings of valences of *T* and *F* on the 7-point scale were used to produce change scores (the difference between the pre- and post-test scores for neutral and negative conditioned targets), which were tested with a 3×2 repeated measures ANOVA with the factors anxiety level (low, medium, and high) and target valence

(negative or neutral). There was a main effect of target valence, $F(1, 43) = 3.82, p = .057$, on the cusp of significance, suggesting that valence for letters paired with negative pictures dropped during testing whereas valence for letters paired with neutral pictures may have risen (4.18 pretest vs. 4.31 posttest neutral and 4.52 pretest vs. 4.11 posttest negative). The main effect of anxiety level and the interaction of Target Valence \times Anxiety Level, $F(2, 43) = 1.13, p > .05$, were not significant.

Correlations

Perhaps visual searches for threat-associated targets were more efficient, but this efficiency was not reflected in the results owing to individual differences in conditioning (i.e., some participants evidenced little or no conditioning, whereas for others, the conditioning was very strong). To rule out this possibility, correlations between the strength of conditioning (measured by the IAT) and efficiency of search for negative targets (measured by visual search RT slopes) were calculated. If conditioning was successful, then subtracting the congruent RT from the incongruent RT in the IAT should give a positive value. Similarly, if threat targets are detected more efficiently than neutral targets, then subtracting negative from neutral slope RTs (ms/item) should give a positive value. No significant correlations were found between the two difference measures for all three levels of trait anxiety combined ($r = .018, n = 46, p > .05$) or for low ($r = .085, n = 16, p > .05$), medium ($r = -.059, n = 15, p > .05$), and high anxiety ($r = -.024, n = 15, p > .05$) when considered separately. Strength of conditioning was not correlated with the efficiency of visual search.

Two additional analyses examined whether there was any correlation between visual search differences and valence ratings. In the first, the difference between negative and neutral slopes was correlated against the valence ratings, and no significant correlation was found ($r = .041, n = 46$). In the second, the difference between the valence ratings for negative and neutral stimuli was calculated and correlated with the slope differences used before. Again, there was no significant correlation ($r = .028, n = 46$). Finally, a regression analysis with efficiency of visual search as dependent variable and efficiency of conditioning and anxiety level as predictors returned no significant effects ($R^2 = .005$).

Discussion

The first finding is that search RTs overall increased with the number of distractors. This finding is in line with previous studies (e.g., Treisman & Gelade, 1980) and validates the experimental procedure. Second, search RTs and number of errors decreased from the first to the second experimental block, showing faster performance with practice. Third, conditioning was successful. Explicit and implicit measures both indicated the expected valence difference between the negative and neutral conditioned stimuli. Fourth, and most important, the search RT for negative conditioned stimuli was affected by the number of distractors, and the effect was comparable to that for neutrally conditioned stimuli. Search slopes for negatively conditioned and neutral stimuli were similar and in both cases indicated inefficient search processes. These data offer no support for the suggestion that attention to negatively conditioned stimuli can be captured preattentively or at

a very early stage of visual processing, independently of focused attention.

Finally, overall RTs were *lower* for negatively conditioned stimuli than for neutral stimuli in the second experimental block but not in the first. It seems that the conditioning processes caused an overall speeding of responses to negatively valenced targets. However, this effect was independent of the set size; it was apparently not affecting the search process but some other aspect of the task. One possibility is that the emotional impact of the negative photos caused the shape stimuli that preceded them to be recorded more effectively in memory, which allowed the same shape to be identified more quickly when it was selected by the search. Another possibility is that the negative associations with the shape led participants to respond more quickly to remove it from the display, or to get the presentation of the negative photo over with more quickly. In both cases, these effects may be linked to attentional processes: Once attention has moved to a stimulus item, the link to threat might strengthen attention so that it speeds the identification process and the response. Whatever the explanation, the effects developed over the course of the experiment, presumably because the conditioning underlying the effects took time to develop. Although previous experimental work (e.g., Öhman & Dimberg, 1978) has shown that some conditioning effects are quickly established, the speed with which attentional biases are evidenced might be rather slow, and evaluative conditioning effects may take longer to become apparent.

Trait anxiety level did not affect search RTs. Response times were generally slower to neutral valenced targets relative to negative valenced targets in Block 2, whereas they showed no difference in Block 1.

Perhaps preattentive detection of FR does occur but the conditioning of the target (*T* or *F*) stimuli was too weak or ineffective. This possibility is doubtful for several reasons: First, an explicit measure, the valence ratings of targets before and after conditioning, indicated that conditioning was successful; second, an implicit measure, the IAT, indicated that target letters were associated with valence characteristics in accordance with conditioning; third, the effect of negative valence on overall RT in Block 2 shows that the threat-associated target is being treated differently from the neutral target, at least during Block 2.

Finally, an alternative explanation is that the conditioning procedure caused threat to be associated with one of the response buttons rather than one of the visual search targets. If *T* was paired with negative pictures and assigned the left-hand button in both tasks, then conditioning might actually have affected the valence of the button rather than the letter.¹ However, conditioning of a response button could not have affected the valence ratings, which also indicated effective conditioning. Nonetheless, an amended response method was used in the next experiment to redress this potential ambiguity.

In summary, Experiment 1 produced no evidence of preattentive detection of threat-associated targets (although association with threat did speed responses). However, it is possible that the evaluative conditioning procedure was not strong enough to enable any real effects of preattentive threat detection to surface immediately. The fact that threat affected RT in Block 2 but not in Block 1

¹ We are grateful to Karin Mogg for this suggestion.

suggests that the conditioning may have taken time to develop. The procedure was changed in the next experiment to enable conditioning effects to accrue more quickly. In addition, the examination of phobic individuals and the use of prepared threat stimuli (pictures of snakes or spiders) were expected to cause stronger conditioning as well as greater attentional effects.

Experiment 2

Experiment 1 offered no evidence that threat-associated stimuli are detected preattentively (at least in the general population). However, while IAPS pictures are undoubtedly a potent source of threat, evidence suggests that stimuli that have provided a recurrent source of threat in our ancestral history (i.e., spiders and snakes) are particularly effective in the capture of attention (Öhman, 1996; Öhman et al., 1995; Öhman, Flykt, & Esteves, 2001; Öhman & Mineka, 2001; Seligman, 1970). Therefore, the current experiment used participants with high and low levels of self-reported snake and spider fear. Their task, as in the previous experiment, was to search for a neutral or a negative target, both of which were abstract shapes paired with neutral and snake or spider pictures, respectively. If theories of anxiety presented by Mogg and Bradley (1998) and by Williams et al. (1988, 1997) are correct, then visual search for the FR targets should be more efficient than searches for neutral targets. Furthermore, as this effect is likely to be mediated by fear level, participants high in snake or spider fear should be faster still to detect shapes paired with snakes and spiders, respectively, than individuals low in snake or spider fear. According to models of visual search in which search performance depends only on the presence of low-level visual features and not on emotional content (e.g., Cave, 1999; Treisman & Gelade, 1980; Wolfe, 1994; Wolfe et al., 1989), there should be no differences in search rates regardless of participants' fear level, as only features shared between targets and distractors determine search efficiency.

In addition, the response method was amended to readdress any issues regarding the ambiguity of what was being conditioned, and a conditioning block before the visual search task was added to enable conditioning effects to accrue more quickly.

Method

Participants

Two hundred fifty students from the University of Southampton were screened for snake and spider fear using the validated Snake Fear Questionnaire (SNAQ) and Spider Fear Questionnaire (SPQ; Klorman, Weerts, Hastings, Melamed, & Lang, 1974). From the screening procedure, 63 participants were selected for inclusion in the study, separated into four groups: high spider fear (14 men, 2 women, mean age 25.5 years, $SD = 9.03$; SPQ: $M = 20.63$, $SD = 3.32$); low spider fear (4 men and 12 women, mean age 23.25 years, $SD = 6.44$; SPQ: $M = 2.00$, $SD = 1.46$); high snake fear (2 men and 13 women, mean age 23.53 years, $SD = 8.03$; SNAQ: $M = 20.40$, $SD = 3.5$); and low snake fear (1 man and 15 women, mean age 23.19 years, $SD = 7.59$; SNAQ: $M = 1.81$, $SD = 1.17$). Participant age ranged from 18 to 50 years. All participants gave written informed consent and reported normal or corrected-to-normal vision, including normal color perception. Participants selected for the study scored in the top or bottom 10% for snake and spider fears. Only participants with reliable SPQ scores (confirmed in a second assessment) were included in the study. As expected, the high snake fear group evidenced significantly higher scores on the SNAQ than the low snake fear group, $t(14) = 18.8$, $p < .001$. Similarly,

the high spider fear group scored higher than the low spider fear group on the SPQ, $t(15) = 19.6$, $p < .001$. All participants received either course credit or £5 (approximately U.S. \$9) payment.

Design

A mixed design was used. Each participant was required to search for either of two targets (although only one target was ever present on any given trial): a "swirl" or a "diamond" (see Figure 2). For half the participants in each group, the swirl was paired with the negatively valenced UCS (a snake or a spider picture, depending on the participant's fear) using a procedure similar to that detailed in Experiment 1, and the diamond was paired with neutral pictures. For the remaining half the pairing was reversed. The number of diamond and swirl trials and the number of trials with each set size were equal across each block.

Stimuli

Stimuli used in the visual search task were complex abstract shapes (a swirl and a diamond), both being different arrangements of four white and four black triangles. In one target they were configured into a diamond pattern; in the other they were configured into a swirl. A third configuration of the same eight triangles was used for all the distractors (see Figure 2).² Targets were always presented upright (0°). However, distractors were randomly presented at four orientations (0° , 90° , 180° , and 270°). Target and distractor shapes were black and white, and each was enclosed by a black outline square. Each shape was 10 mm tall and 10 mm wide. Throughout all trials the background was white. As in the previous experiment, target and distractor shapes were evenly spaced around an imaginary circle with a diameter of 100 mm around fixation. Throughout the course of the experiment, target and distractors could appear at any location around this imaginary circle. A black cross was presented in the center of the screen 1,000 ms before stimulus onset and remained visible for the duration of each trial. The number of pictures used as the UCS was increased from 24 to 48 for each picture set. Neutral images were again taken from the IAPS. As there were not sufficient snake and spider images in the IAPS alone, additional pictures were selected from various Internet sites. As in Experiment 1, pictures were scaled appropriately and centered for fixation on a black background.

Apparatus

The experiment was conducted with the same computers and response boxes used in Experiment 1.

Procedure

Visual search task. Upon entering the laboratory, participants were asked to complete either the SNAQ or the SPQ (Klorman et al., 1974), depending on their score from the earlier screening procedure. Any participants with scores deviating ± 5 (2 cases) from their initial screening score were excluded from the study, and recorded scores were taken from the second administration of the questionnaires.

Following completion of the questionnaires, participants were given written and verbal instructions regarding the experimental protocol. A sample FR image was shown, and participants were explicitly informed of the contingency between targets and pictures and given the opportunity to withdraw from the study. A conditioning block ensued prior to the practice trials to strengthen conditioned responses (Glautier, De Houwer, & Red-

² Abstract shapes were used in the present experiment, because the IAT showed that the letters used in Experiment 1 were somewhat biased in valence.

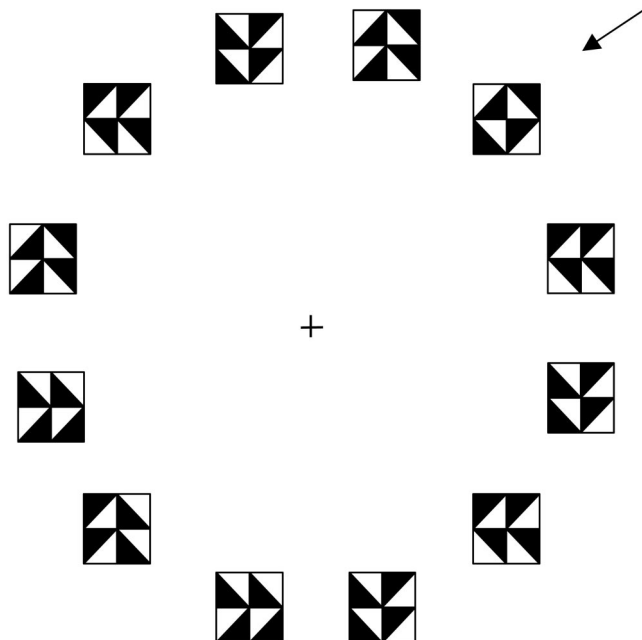


Figure 2. Example stimuli used in the visual search task in Experiment 2. The target was either a diamond or a swirl. Set size varied between 1, 3, 6, and 12 items. This example shows a diamond as the target (marked by an arrow that was not present in the stimulus) with 11 distractors.

head, 2001). This conditioning block consisted of 24 trials, 12 FR (spiders or snakes, depending on the participant's SNAQ/SPQ score) and 12 neutral. Each trial began with a target shape (swirl or diamond, 50 mm \times 50 mm, centered on a white background) for 2 s, immediately followed by an appropriate photo (i.e., a snake, spider, or neutral picture), again 2 s in duration. As in Experiment 1, photos were centered on a black background and occupied the entire screen. After an intertrial interval of 2 s (during which time the monitor display was black), the next trial was automatically initiated. Target presentation was randomized, with an equal number of snake/spider and neutral pictures shown in the conditioning block. During the conditioning phase, participants were instructed to look at the screen and learn the contingencies between targets and picture type.

Following the conditioning block, participants were given verbal instructions for the visual search task and a practice block of 8 trials. During the practice block, each set size was randomly presented twice, and there were equal numbers of FR and neutral targets. The paradigm used was similar to that of Experiment 1. Participants sat approximately 60 cm in front of the monitor and were instructed to make a response upon locating a target as quickly and accurately as possible. A small cross was presented in the center of the monitor at the start of each trial, and, following a stimulus onset asynchrony of 1,000 ms, a search array of between 1 and 12 items was displayed until a response was initiated. Participants completed two blocks of 96 trials. In each block there was an equal number of neutral and FR pictures. Each set size was displayed 12 times, with the order of display randomized across each block. Prompts for breaks were displayed after every 24 trials. However, the method of response was different: Participants were required to press the center button of the button box as quickly as possible upon locating either target using their nondominant hand (ascertained at the beginning of the experiment).

As soon as the center button was pressed, the search display disappeared and was replaced by the two targets, presented vertically in the center of the monitor and separated by a gap of 35 mm. Their display size was identical to those used in the visual search (i.e., 10 mm \times 10 mm), and target

location was randomized from trial to trial; hence, the top target was equally likely to be a swirl or a diamond. Participants were required to select which target had been present in the previous display by clicking over the appropriate target with the mouse, using their dominant hand. RTs to the mouse responses were not included in the data analysis, and it was stressed to participants that speed was important in only the initial target response (pressing the center button on the button box). Following the selection of the target, a larger (50 mm \times 50 mm) version of the target was displayed for 750 ms, followed immediately by an appropriate image (snake, spider, or neutral picture) for 2 s.

IAT procedure. Following the visual search task, participants completed the IAT as before. The number of trials and the procedure used in the IAT were identical to that implemented for the IAT phase in Experiment 1 (with the exception of the stimuli used: swirl and diamond shapes replaced the exemplars *T* and *F*). The 32 negative and positive words were the same as those used previously. The side of presentation of the targets and their order of presentation (i.e., congruent or incongruent response pairing first) were counterbalanced. It is important to note that the target shapes described here as diamonds and swirls were never given labels during the experiment, so that participants would be able to form their own mental labels of these abstract shapes.

Results

Visual Search

Data were analyzed by a 4 \times 2 \times 2 \times 2 \times 2 mixed ANOVA, with the within-subjects variables set size (1, 3, 6, and 12), target valence (negative vs. neutral, i.e., paired with a spider or snake vs. neutral picture), and block (1 vs. 2). Between-subjects variables were fear level (high or low) and fear content (snake or spider). As in Experiment 1, RTs below 100 ms and errors were removed prior to analysis. Table 2 and Figures 3 and 4 depict the mean visual search RTs differentiated for set sizes, target valence, and fear level.

As expected, there were main effects of set size, $F(3, 177) = 343.42, p < .001$, and block, $F(1, 59) = 23.75, p < .001$. As in Experiment 1, participants' RTs increased with corresponding increases in set size, and RTs in Block 1 (1,381.1 ms) were slower than in Block 2 (1,228.8 ms). Most important, there was also a significant main effect of target valence, $F(1, 59) = 6.43, p < .05$, whereby the detection of negatively valenced targets (1,275 ms) was overall faster than the detection of neutral targets (1,339 ms).

Errors were entered into an ANOVA, using the same factors as in the visual search analysis. Again, there were main effects of set size, $F(3, 177) = 7.95, p < .001$, and block, $F(1, 59) = 6.02, p < .01$, indicating that errors increased with set size (1.6%, 2.9%, 4.3%, and 4.7%) and decreased in the second block (3.98% vs. 2.79%). The marginally significant effect of target valence, $F(1, 59) = 3.78, p = .06$, was evidenced by higher error rates to negative than neutral targets (3.7% vs. 2.9%). In this experiment, the general alerting effect triggered by the negative stimuli appears to have speeded responses at the expense of accuracy. In addition, there was a significant interaction of Block \times Fear, $F(1, 59) = 4.16, p < .05$; high-fear participants made fewer errors in Block 2 than in Block 1 (1.9% vs. 4.1%), whereas this was not the case for low-fear participants (3.7% vs. 3.8%). However, as in Experiment 1 error rates were low across all groups and set sizes.

IAT

The results indicated that conditioning was successful. RTs of high-fear participants (with fear of snakes or spiders) to targets

Table 2
Mean Response Times (in ms) and Errors (%) to Abstract Targets Associated With Snake, Spider, or Neutral Pictures Differentiated by Set Size and Fear Level

Fear level and target	Set size											
	1			3			6			12		
	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors	<i>M</i>	<i>SD</i>	Errors
Block 1												
Low snake fear												
Negative target	710.30	208.9	1.0	1,048.63	459.2	1.0	1,305.21	388.6	4.2	2,033.71	813.4	2.6
Neutral target	769.67	336.2	0.0	965.41	207.5	2.1	1,321.47	370.3	3.1	2,098.49	918.7	2.6
High snake fear												
Negative target	778.04	251.7	2.8	1,080.31	402.6	5.6	1,541.22	581.5	5.6	2,354.25	1,117.7	9.4
Neutral target	921.33	730.9	1.1	1,161.05	414.9	2.2	1,553.28	524.8	4.4	2,473.87	1,236.8	9.4
Low spider fear												
Negative target	835.34	334.6	3.6	1,171.94	420.5	4.7	1,560.53	658.2	7.3	2,208.97	1,035.2	8.3
Neutral target	876.22	259.7	4.2	1,249.84	405.0	3.1	1,773.95	754.1	6.8	2,312.15	1,244.1	6.8
High spider fear												
Negative target	719.54	231.9	2.6	975.78	388.0	5.2	1,337.16	409.6	3.6	2,068.45	951.5	2.1
Neutral target	807.37	507.9	3.1	969.92	287.0	1.6	1,364.58	417.9	2.6	2,059.23	859.0	3.1
Block 2												
Low snake fear												
Negative target	629.99	174.5	1.0	877.69	290.9	2.6	1,175.07	407.6	2.1	1,964.84	922.3	3.6
Neutral target	669.59	232.0	0.5	918.97	277.0	2.1	1,286.73	427.0	2.1	1,996.38	1,128.3	2.6
High snake fear												
Negative target	723.60	299.7	1.7	1,015.58	349.3	1.7	1,375.46	503.7	5.0	2,246.68	1,043.8	3.3
Neutral target	734.93	322.0	0.0	1,030.67	352.0	0.6	1,424.70	440.1	0.6	2,367.95	1,081.0	1.1
Low spider fear												
Negative target	645.25	235.3	1.0	914.11	357.8	4.2	1,276.24	486.8	7.8	1,777.72	811.6	8.3
Neutral target	734.65	285.7	0.5	922.73	278.3	5.8	1,511.43	731.1	7.8	1,888.75	834.9	7.3
High spider fear												
Negative target	633.26	225.5	0.5	850.14	205.3	2.6	1,159.87	396.3	3.6	1,873.75	799.1	1.6
Neutral target	646.38	208.8	1.6	865.82	209.3	1.6	1,254.16	354.1	1.6	1,947.72	798.8	3.1

Note. Negative target refers to snake or spider associated shapes.

associated with FR (i.e., snake or spider) pictures were lower when paired with bad words (655 ms) than good words (704 ms). However, participants with low levels of fear given the same pairing showed no difference (706 ms for both pairings).

These conclusions were confirmed by analyzing the data from the two high-fear groups and the two low-fear groups with a $2 \times 2 \times 2$ repeated measures ANOVA. The analysis included one within-subjects factor, response congruity (congruent or incongruent) and the between-subjects factors fear level (high vs. low), fear content (whether the shape was associated with snake or spider pictures), and order (congruent or incongruent first). As in Experiment 1, errors and RTs below 100 ms and above 2,000 ms were excluded from the analysis. As predicted, a main effect of response congruity, $F(1, 55) = 4.32, p < .05$, and a significant interaction of Response Congruity \times Fear Level, $F(1, 55) = 4.38, p < .05$, were found. Follow-up t tests revealed that high-fear participants were significantly faster to the congruent than to the incongruent response pairing, $t(30) = -2.82, p < .01$. Low-fear participants, however, showed no significant difference between congruent and incongruent response pairings, $t(31) = 0.009, p > .05$. Finally, there was a significant interaction of Response Congruity \times Order, $F(1, 55) = 10.18, p < .01$, suggesting a weakening of conditioning effects during the IAT; that is, response congruity effects related to

the combination of bad words and abstract shapes associated with fear slides were stronger during the first data phase of the IAT compared with the second data phase.

Correlations

Correlations of the strength of conditioning and visual search RT slopes were calculated as before. Again, there were no significant correlations for low or high snake fear participants ($r = -.123, n = 16, p > .05$; $r = .002, n = 15, p > .05$, respectively) or low or high spider fear participants ($r = .288, n = 16, p > .05$; $r = .363, n = 16, p > .05$, respectively).

Discussion

As in Experiment 1, there were significant main effects of set size and block for RTs and errors, whereby performance deteriorated as the number of distractors increased and performance improved with practice. A main effect of target valence for visual search RTs indicated that participants in all groups were significantly faster to detect negatively conditioned targets than neutral conditioned targets. In contrast to Experiment 1, this effect was already apparent in the first visual search block, suggesting that the

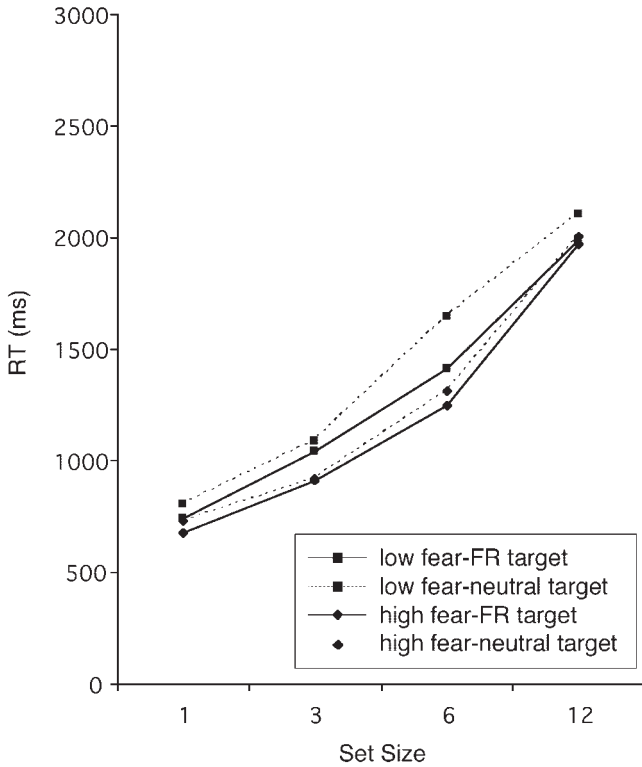


Figure 3. Mean visual search response times (RTs) for high (diamond) and low (square) spider fear participants differentiated by set size and target valence. Spider-associated targets (negative valence) are denoted by solid lines; neutral valenced targets are denoted by dashed lines. FR = fear relevant.

conditioning block before the visual search task was effective. As discussed in Experiment 1, there are a number of possible explanations for this effect. The marginally significant target valence effect for errors indicated more errors in response to negatively valenced target stimuli. Although RT findings were based only on correct responses, these findings may indicate a speed-accuracy trade-off, in which participants responded more quickly but made more errors for threat-associated stimuli. This biased response pattern may be explained by an “adaptive conservatism” (Mineka, 1992; Öhman & Mineka, 2001). Fast responses to potentially threatening stimuli have an evolutionary advantage, whereas false alarms to stimuli that are harmless have little evolutionary cost. Simultaneously, not responding to threat stimuli decreases the likelihood of survival.

As in Experiment 1, no evidence for preattentive detection of threat-associated stimuli was found. First, search rates for both neutral and FR targets were well above the 30 ms/item threshold used to describe “very inefficient” search (Wolfe, 1998). Second, search RTs for threat-associated stimuli did increase with the number of simultaneously presented distractors, and RT slopes were comparable for negatively conditioned and neutral targets. Finally, there were no significant correlations between the strength of conditioning as reflected in the IAT and search efficiency for the FR targets in the visual search task as indicated by search slopes, indicating that both measures reflect unrelated processes.

These results are consistent with the assumption that searches for conjunctions of features require effortful, focused attention (e.g., Cave, 1999; Treisman & Gelade, 1980; Wolfe, 1994, 1998; Wolfe et al., 1989). As such, the present experiment offers evidence against the preattentive detection of conditioned abstract FR stimuli.

However, as in Experiment 1, we have to consider whether conditioning might have been strong enough to elicit prioritized attentional capture without being strong enough to cause preattentive detection. Conditioning was validated by the IAT, which indicated that for high-fear participants, the shape associated with snake or spider pictures in the visual search task was negatively evaluated, whereas for low-fear participants, there were no differences in valence between the neutral and FR shapes.

Both low-fear and high-fear participants produced faster responses to threat-associated stimuli in the preceding visual search task. This pattern suggests that the main effect of target valence on visual search RT was not due to the association with threat, because it occurred even with participants for whom the snake or spider pictures were not threatening. Instead, it suggests that participants learned shapes more quickly when they were associated with more arousing or interesting pictures, regardless of the valence that the participant assigned to those pictures.

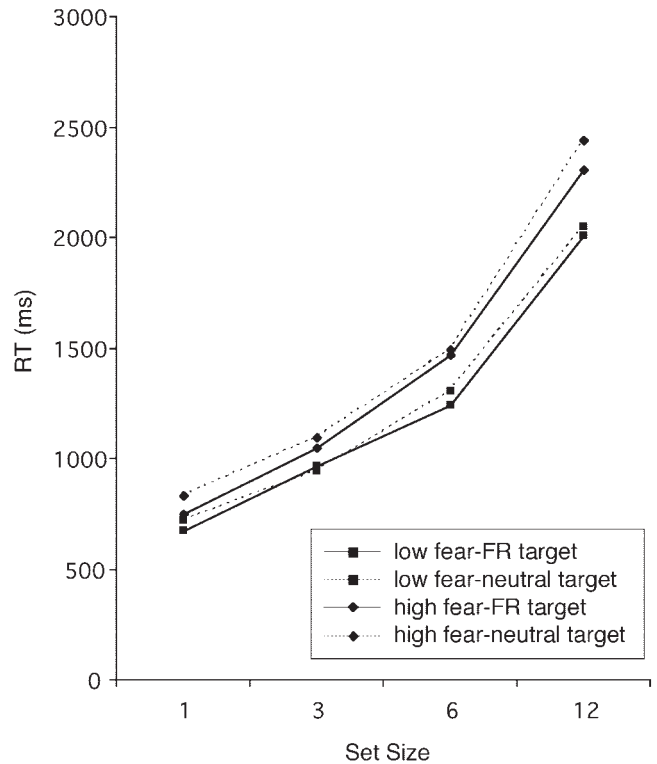


Figure 4. Mean visual search response times (RTs) for high (diamond) and low (square) snake fear participants differentiated by set size and target valence. Snake-associated targets (negative valence) are denoted by solid lines; neutral valenced targets are denoted by dashed lines. FR = fear relevant.

General Discussion

The present experiments were designed to test whether threat stimuli can be detected preattentively. To examine these questions, previous studies used visual search tasks with either photographs (e.g., Hansen & Hansen, 1988; Öhman, Flykt, & Esteves, 2001) or schematic faces (e.g., Eastwood et al., 2001; Fox et al., 2000; Öhman, Lundqvist, & Esteves, 2001) as threat stimuli to be detected. The problem with these paradigms is the lack of control over the perceptual features distinguishing target from distractors. Various control conditions for perceptual features were developed, especially for schematic faces (e.g., Eastwood et al., 2001; Fox et al., 2000), although complete control of perceptual features is hard to accomplish (e.g., Purcell & Stewart, 2002). Therefore, the present studies used a new paradigm, which maintains perceptual control while still using realistic threat stimuli. Evaluative conditioning (De Houwer et al., 2001) was used to transfer the valence of ecologically valid threat stimuli to abstract stimuli with defined and controlled perceptual features. These abstract stimuli were then used in visual search tasks to examine attentional biases. The efficacy of conditioning was assessed with the IAT, an implicit measure of affective valence of stimuli.

No evidence for preattentive detection (pop-out) of threat stimuli, either for stimuli associated with general threat or for stimuli associated with evolutionarily relevant threat, was found. Most important, participants with high fear of spiders or snakes revealed no evidence for preattentive detection of stimuli associated with their feared objects. Search rates were, in all conditions and for all participants, well above the established threshold used to describe “very inefficient” search (Wolfe, 1998). These findings are in accord with attention models claiming that searches for conjunctions of features require effortful, focused attention independent of emotional associations (e.g., Cave, 1999; Treisman & Gelade, 1980; Wolfe, 1994, 1998; Wolfe et al., 1989).

The present studies are in line with several previous reports that also question pop-out for threat or affective stimuli. Although the findings of Öhman, Flykt, and Esteves (2001) regarding stimuli depicting threatening animals (snakes and spiders) are persuasive (see introduction), recent studies (e.g., Tipples, Atkinson, & Young, 2002) have failed to show differences in visual attention for threatening animals versus nonthreatening targets. Of the few studies in which pop-out has been demonstrated, most have been later shown to be either flawed or ambiguous in their findings (see introduction). The majority of studies (e.g., Eastwood et al., 2001; Fox et al., 2000; Öhman, Lundqvist, & Esteves, 2001) have provided no evidence of pop-out, even if they have shown some search advantage for negative or threatening stimuli.

On the basis of the present findings, it remains unlikely that negatively valenced stimuli can be detected preattentively if other salient stimuli compete for attentional resources, unless there is some simple visual feature that distinguishes negative targets from neutral distractors. Indeed, recent findings from a study by Pessoa, Kastner, and Ungerleider (2002) using functional magnetic resonance imaging on the processing of facial expression showed no activation of the amygdala to angry faces presented in peripheral regions when participants undertook a cognitive task that imposed an attentional load. This study illustrates the importance of attention in detecting threat, as it is known that focused attention on angry faces will cause amygdala activation (Morris, deBonis, &

Dolan, 2002; Morris et al., 1996). It seems that affective stimuli can elicit very rapid processing without awareness (e.g., Öhman et al., 1995) and are computed independently from identity (Humphreys, Donnelly, & Riddoch, 1993). It may be possible that a visual feature can be used more effectively to guide search when it is associated with a strong affective valence. Nonetheless, the experiments presented here and those preceding them indicate that threat cannot be identified before a stimulus is selected for high-level visual processing if there is not some simple visual feature or simple configuration of features associated with threat in the stimulus set.

The conclusion that stimuli associated with threat cannot be detected preattentively requires arguing from the null hypothesis. Thus, it becomes important to explore every other possible explanation for the lack of an effect. One possibility is that the conditioning procedure was ineffective or not strong enough. However, the lack of correlation between the speed of visual search for threat-associated stimuli and strength of conditioning, as measured with the IAT (with the exception of the low-fear participants in Experiment 1), speaks against the latter argument. In addition, the valence ratings for target stimuli in Experiment 1 and the consistent IAT findings in both experiments demonstrated that conditioning was effective and did influence behavior of participants. The IAT, an implicit and behavioral measure, seems to be a preferable and reliable measure of the affective valence of stimuli (de Jong, Pasman, Kindt, & van der Hout, 2001) and is less open to demand characteristics than self-report measures (Hermans, Vansteenweg, Crombez, Baeyens, & Eelen, 2002). Finally, the finding that threat stimuli produce faster RTs demonstrates that participants are learning to associate the two different target stimuli with the two different sets of photographs.

In support of the validity of the realized evaluative conditioning procedure and the implicit measures used as a manipulation check, Hermans et al. (2002) carried out a study in which participants undertook two conditioning procedures: classical conditioning and evaluative conditioning. Using valence ratings and an affective priming task, the authors found significant conditioning across both paradigms, with the magnitude of this effect roughly equivalent across the two measures. More important, the data showed that in each case this effect was due to the CS+ being perceived as more negative rather than the CS- becoming more positive. In line with this finding, the effect of target valence in the IAT in Experiment 2 was significant only for high-fear participants, as would be expected if any change is primarily the result of decreased valence for targets associated with the feared object. Nevertheless, because it remains a matter of debate whether evaluative and classical conditioning are based on similar learning mechanisms, it will be informative to see whether future studies replicate our findings with classical conditioning.

Further evidence for the efficacy of implicit tests in general, and the IAT in particular, comes from a study by Phelps, O'Connor, Cunningham, Funayama, Gatenby, Gore, & Banaji (2001). The effects of picture stimuli on amygdala activation, IAT, and startle potentiation were significantly correlated. As the role of the amygdala and startle potentiation in the activation and expression of fear is well documented (see introduction), these findings indicate that the IAT may be suitable to measure the effects of fear conditioning.

One could argue that the present study is weighted in favor of a null result because of the search paradigm used. Much of the evidence for attentional biases to threat has come from visual search tasks using an “odd one out” paradigm, in which participants must search for a stimulus that differs from its distractors, typically by affective valence (e.g., Hansen & Hansen, 1988; Öhman, Flykt, & Esteves, 2001). Rinck, Becker, Kellerman, and Roth (2003) have argued that prior knowledge of a target can disrupt the attentional advantage of threat targets while still preserving distraction effects. They claim that because of this disruption, threat effects are more likely to be found in odd-one-out searches than in searches in which the target is known in advance. In considering Rinck et al.’s argument, one should bear in mind two important points. The first is that the search task used in the experiments presented here is not the standard visual search task considered by Rinck et al. In the standard task, participants are told to expect a threat target on some trials. During those trials, participants work to keep the target in memory, and the activation of these memories can generate anxiety. No such anxiety arises when they are expecting neutral targets, and thus performance is hindered for threat targets relative to neutral targets. In the current experiments, participants know both targets in advance, but at the beginning of each trial, they do not know which target will appear. Thus, there will be no more anxiety at the beginning of threat-target trials than at the beginning of neutral-target trials, and performance on the threat-target trials should not be subject to any more interference than the other trials.

The second point to consider relates to the evolutionary significance of threat detection. One of the main motivations for expecting preattentive detection of threat is that it would improve chances for quick reaction and survival. This mechanism would be much less useful if it is rendered inoperable in those situations in which a threat is expected. Learning theory (e.g., Seligman, 1970) and some models of anxiety (e.g., Mogg & Bradley, 1998) emphasize the evolutionary advantage afforded by preferentially attending to threat stimuli; in an environment populated by snakes it is advantageous to be aware of their potential danger and to have rapid access to mental templates of the basic features inherent in snakes (see Öhman, Flykt, & Esteves, 2001). Thus, it seems unlikely that a mechanism could have evolved to detect threat preattentively but that this same mechanism is effectively disabled at the times that threat is most likely to appear.

With respect to the conditioning procedure, the interaction of Block \times Target Valence suggests that conditioning effects took time to accrue in Experiment 1. It is difficult to ascertain whether this was attributable to the IAPS images lacking sufficient impact to afford rapid conditioning, or whether the effect was due to the visual search task and evaluative conditioning procedure occurring simultaneously. However, in Experiment 2 when the conditioning block preceded the visual search task and snake and spider pictures were used in the evaluative conditioning procedure, there was no interaction of Block \times Target Valence. By including a conditioning procedure prior to rather than during the search task in Experiment 2, it is most likely that conditioned responses were in place at the start of the experiment. This methodological change also redresses, to some extent, the potential problem that the evaluative data were collected after the visual search task. Future work using similar paradigms might benefit from including evaluative tests

prior to the search task, as these conclusions are dependent on a conditioned response being in place for the majority of trials.

In sum, two experiments were designed to test whether attentional biases occur for threat stimuli and whether these stimuli can be detected preattentively. To rigorously control perceptual features of stimuli to be detected, evaluative conditioning was used to transfer the valence of threat stimuli to abstract stimuli. The efficacy of conditioning was confirmed with implicit association tests. However, no evidence was found for a pop-out of threat-associated stimuli or for any preattentive detection that could improve the rate of visual search. As such, these findings are in keeping with visual attention models that claim that search efficacy is governed by the number of features shared among targets and distractors (e.g., Cave, 1999; Treisman & Gelade, 1980; Wolfe, 1994, 1998; Wolfe et al., 1989). Threat association or affective valences of stimuli seem to be irrelevant for preattentive detection. However, threat-associated stimuli do appear to be able to speed responses once the stimuli are attended. Future experiments manipulating the intensity of the conditioned stimulus might further elucidate the mechanisms underlying attentional control and whether threat-associated stimuli are capable of eliciting preattentive detection. On the basis of the present studies, however, threat cannot be considered a special category that enables preattentive processing without low-level features that distinguish threats from nonthreats.

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