Speeded Detection and Increased Distraction in Fear of Spiders: Evidence From Eye Movements

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Anxiety patients exhibit attentional biases toward threat, which have often been demonstrated as increased distractibility by threatening stimuli. In contrast, speeded detection of threat has rarely been shown. Therefore, the authors studied both phenomena in 3 versions of a visual search task while eye movements were recorded continuously. Spider-fearful individuals and nonanxious control participants participated in a target search task, an odd-one-out search task, and a category search task. Evidence for disorder-specific increased distraction by threat was found in all tasks, whereas speeded threat detection did not occur in the target search task. The implications of these findings for cognitive theories of anxiety are discussed, particularly in relation to the concept of disengagement from threat.

Keywords: fear of spiders, speeded detection, threat, attentional biases, anxiety

Cognitive theories of anxiety postulate that cognitive processes are highly relevant for the etiology and maintenance of anxiety disorders (e.g., Barlow, 1988; Beck, Emery, & Greenberg, 1985; Clark & Wells, 1995; Eysenck, 1992; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams, Watts, MacLeod, & Mathews, 1997). According to these theories, the attention of individuals suffering from anxiety disorders should be biased selectively toward threatening stimuli. Indeed, anxiety-related attentional biases have been observed in a large number of empirical studies using a variety of experimental tasks (for reviews, see Becker & Rinck, 2004; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; or Williams et al., 1997). Most researchers have assumed that these tasks reveal an anxiety-related bias in the initial orienting of attention toward threat stimuli. For instance, spider-phobic individuals' attention should be drawn selectively toward spiders, such that spiders are easily detected and interfere strongly with the allocation of attention to other stimuli.

Recently, however, these assumptions have been challenged by experimental results reported by Fox and her colleagues (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002). They pointed out that the most popular paradigms used in attentional bias research do not allow differentiation between alterna-

tive accounts of attentional biases. In particular, Fox et al. (2001, 2002) used a model of visual-spatial attention proposed by Posner and Peterson (1990) to distinguish between the attentional processes of shifting, engagement, and disengagement. Fox et al. argued that threat stimuli do not necessarily draw attention (i.e., speeded shifting or accelerated engagement as an explanation of attentional biases) but that they hold attention (i.e., decelerated disengagement from threat). For instance, spider-phobic individuals should not necessarily be faster to shift attention to spiders, but they should find it harder to remove attention from them. Indeed, by developing an experimental design that allows researchers to study disengagement of attention separately from other components of the attentional process, Fox et al. (2001) showed that participants with high state anxiety scores showed slower disengagement from threat words and angry faces but not faster engagement of attention. Fox et al. (2001, 2002) studied healthy participants who were high versus low in state or trait anxiety, and it is not clear whether their results may be generalized to anxiety disorders. In fact, Fox et al. (2001, p. 697) cautioned that "it is possible that differences in both the shift and disengage component of visual attention when threat stimuli are presented may occur for clinically anxious people." In contrast, Fox and her colleagues are correct in stating that attentional biases in anxiety disorders have been studied mostly with tasks that do not allow for a separation of shifting, engagement, and disengagement. Therefore, their conclusions may indeed generalize to anxiety patients.

There is one set of empirical results, however, that was not reviewed by Fox and her colleagues (Fox et al., 2001, 2002), and that seems to contradict their conclusions. These results were observed in studies using a particular visual search task. It may be called the *odd-one-out search task*, which was introduced by Hansen and Hansen (1988) and later modified by other researchers. In this task, a group of stimuli are simultaneously presented to the participants—for instance, a 3 × 3 matrix of pictures— and the participants are asked to indicate (by pressing one or the other key on the computer keyboard) whether one of the stimuli is different from others on a predefined dimension (the

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odd-one-out stimulus). For example, the matrix might contain a single spider among eight flowers. In this case, the participants would have to react to the spider. Öhman, Flykt, and Esteves (2001) used the odd-one-out search task by presenting a fear-relevant target stimulus (a picture of a spider or a snake) among a number of fear-irrelevant distractors (pictures of flowers or mushrooms) or vice versa in 2 × 2 and 3 × 3 matrices. In general, threatening targets among neutral distractors were detected more quickly than neutral targets among fear-relevant distractors. This difference in itself is ambiguous: It may be explained by speeded detection of threat targets (engagement), by slowed disengagement from threat distractors, or both. However, the advantage for threat targets was most pronounced in the presence of anxiety: Spider pictures among neutral distractors were detected particularly quickly by spider-fearful individuals and snake pictures among neutral distractors were detected by snake-fearful individuals. These between-groups differences are very hard to explain by differences in disengagement, unless one assumes that fear affects attention to neutral items rather than attention to the feared stimuli. Moreover, no effect of matrix size on reaction times was reported for trials involving threatening targets, suggesting "pop-out" of threatening stimuli. Thus, Öhman et al. (2001) concluded that a preattentive and automatic bias toward threatening stimuli exists because of their evolutionary relevance, with a particular enhancement of the bias in fearful participants. Byrne and Eysenck (1995) as well as Gilboa-Schechtman, Foa, and Amir (1999) also used the odd-one-out search task. They presented human faces to their participants (e.g., 12 faces arranged in a 3 × 4 matrix), asking them whether one showed an emotional expression differing from the others. Using this task, Byrne and Eysenck (1995) found that high trait-anxious participants were faster to find angry than happy faces among neutral faces, whereas no difference between the two was found for nonanxious control participants. Similar results were reported by Gilboa-Schechtman et al. (1999) for patients with social phobia. These studies suggest that speeded detection of threat-related stimuli in anxiety does exist, that is, faster shift or engagement of attention rather than slower disengagement. Moreover, it seems to occur both in high trait anxiety (Byrne & Eysenck, 1995) and in clinical anxiety (Gilboa-Schechtman et al., 1999).

Taking these demonstrations of speeded detection in visual search as convincing evidence for attentional biases in the shift or engagement component of attention would be premature, however, because failures to find speeded detection have also been reported. Rinck, Becker, Kellermann, and Roth (2003) used a visual target search task (originally introduced by Neisser, 1963) to study detection and distraction in general anxiety disorder (GAD) and speech phobia (SP). The task was similar to the one used by Byrne and Eysenck (1995) or Gilboa-Schechtman et al. (1999): First, participants were shown a target word for which they were to search. Afterward, a matrix of letters or words was displayed on the screen and the participant had to decide whether the target word was present in the matrix. All participants were tested with all combinations of GAD-related, SP-related, positive, and neutral target words hidden among GAD-related, SP-related, positive, and neutral distractor words. Clear and disorder-specific distraction effects were observed for GAD patients, who where particularly slow when asked to find target words in matrices made up of GAD-related distractors. In contrast, no evidence of speeded threat

detection was found: Neither GAD patients nor SP patients found threat words related to their disorder particularly quickly. Moreover, the lack of speeded detection in the presence of increased distraction was replicated in a study with SP patients and depressed patients (Rinck & Becker, 2005). These results are compatible with those reported by Fox and her colleagues (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002), suggesting that even in anxiety disorders, it is slowed disengagement rather than speeded engagement that causes attentional biases.

Unfortunately, it is hardly possible to draw firm conclusions from the few and mixed results observed with different variations of the visual search task. There are a few demonstrations of speeded detection of threat and increased distraction by it, found with the odd-one-out variant of the search task. In contrast, the target search variant of the task yielded increased distraction without speeded detection. This contradiction suggests that the speeded detection effect is either unreliable—and therefore of little theoretical importance— or dependent on unknown procedural details of the visual search task. Thus, the first goal of the present experiments was to replicate the speeded threat detection effect. If the effect is real and replicable, the second goal was to exclude *methodological differences* as an explanation for the inconsistencies in previous studies. Unfortunately, many methodological differences might be responsible for the inconsistency because the studies differed with regard to materials, procedures, participant groups, and sample sizes. Most obviously, pictures of feared stimuli were presented in the odd-one-out studies (Byrne & Eysenck, 1995; Gilboa-Schechtman et al., 1999; Öhman et al., 2001), whereas Rinck et al. (2003) and Rinck and Becker (2005) presented words. Pictures may be better suited for demonstrating speeded detection of threat because they may be processed quickly by the limbic system (Le Doux, 1996). Words, on the other hand, are not threatening in and of themselves, and they require more complex cognitive processing. Another difference is related to the participant groups because until now, only social-phobic individuals participated in both tasks. To exclude methodological differences as an explanation for the contradictory pattern of results, we made sure that Experiment 1 involved both a target search task and an odd-one-out search task with the same participants and the same materials and with experimental designs that were at least partially identical. Thus, any remaining differences between the results observed in the two tasks should be due to *task-related processing characteristics* rather than methodological factors. Assuming that methodological differences cannot explain the pattern of results observed previously, the second experiment served to study task-related processing characteristics by identifying boundary conditions for the occurrence of speeded detection effects in visual search. Finally, the present experiments were designed to answer a question left open by all previous studies using variations of visual search tasks: What are the process characteristics of the visual search process? This general question comprises more detailed ones, such as the following: Do participants really find the target stimulus before they respond positively? Do anxiety patients spend less time fixating the target stimulus before they react to it? Which processes of the search-decide-and-respond chain are accelerated when speeded threat detection occurs, and which are slowed when selective distraction by threat occurs? These questions are of theoretical relevance, and none of them may be answered by collecting reaction times of yes–no responses, as researchers have

mostly done so far. Therefore, we continuously recorded eye movements in the present experiments. While participants were searching for target pictures among distractor pictures, we recorded fixations, saccades, and gaze durations on targets and distractors, in addition to latencies of the manual yes–no responses. These variables were recorded in both experiments, allowing for a direct comparison of the visual search processes involved.

Experiment 1: Target Search Versus Odd-One-Out Search

Method

General Aspects

Participants. Twenty-four spider-fearful individuals (SFs) and 24 nonanxious control participants (NACs) without any animal-oriented fears participated in the experiment. Participants were recruited after screenings in classes at several departments of the Dresden University of Technology, Dresden, Germany, using the German Spider Anxiety Screening (SAS; Rinck et al., 2002), which has a possible range from 0 to 24. Participants with scores lower than 5 or higher than 14 were invited for further interviews and testing. Before the experiment, these potential participants completed German versions of the Spider Phobia Questionnaire (SPQ; Watts & Sharrock, 1984; see Rinck et al., 2002) and the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995; see Rinck et al., 2002) as well as the *Fragebogen zur Depressionsdiagnostik nach DSM–IV* (FDD-*DSM–IV* Inventory; Kühner, 1997), which is a German translation of the Questionnaire for Depression Diagnosis (Zimmermann, Coryell, Wilson, & Corenthal, 1986). Moreover, they were questioned by trained interviewers, using the Diagnostisches Interview bei psychischen Störungen (F-DIPS; Margraf, Schneider, Soeder, Neumer, & Becker, 1996), which is the German version of the Anxiety Disorders Interview Schedule for *DSM–IV* (ADIS; DiNardo, Brown, & Barlow, 1994). Only candidates reaching a minimum F-DIPS fear score of 4 and a minimum avoidance score of 3 regarding spiders qualified for the SF group. Moreover, they had to have a minimum score of 50 in the FSQ (Szymanski & O'Donohue, 1995). Seven of the 24 SFs fulfilled all F-DIPS criteria for a specific phobia of spiders. The remaining ones met all criteria except Criterion E, which requires significant impairment in everyday life. Considering the relative ease of avoiding threatening spiders in Northern Europe, the lack of fulfilling this criterion is comprehensible and does not affect the questions of interest. Two of the SFs complied with the diagnosis of another specific phobia; two others complied with the diagnosis of social phobia. None of these participants were excluded. Four additional participants were excluded from the analyses, however, because they indicated fear of beetles, dragonflies, or butterflies. The SF group and the NAC group were matched with regard to age, gender, and educational level. All participants had a high school degree and were students of the Dresden University of Technology. On average, the 22 female and 2 male members of the NAC group were 22.5 years old (*SD* = 2.43); the 23 female and 1 male SF participants had a mean age of 22.1 (*SD* = 4.37). All of the final 48 volunteers were without history of any psychiatric disorder and had normal or corrected-to-normal vision. All of them were informed of their rights as experimental participants and gave their consent. In return for their participation, they received course credit or a payment equivalent of $6/hr.

Materials and apparatus. The visual stimuli consisted of 21 pictures of spiders, beetles, butterflies, and dragonflies, respectively. They were chosen after extensive pretesting. Thirty-two individuals without fear of spiders rated large samples of pictures in each category regarding emotional valence and recognizability. These individuals did not participate in the experiments reported here. Valence was rated on a 5-point scale ranging from −2 to 2, indicating unpleasant versus pleasant valence. Recognizability was rated on a 5-point scale ranging from 1 to 5, that is, from bad

to very good. Only images with mean recognizability ratings higher than 2 were selected. Valence ratings differed according to the type of picture: They had to be lower than −1 for spiders (clearly negative), higher than 1 for butterflies (clearly positive), between −0.4 and 0.5 for dragonflies (neutral to slightly positive), and between −0.22 and 0.22 for beetles (neutral). From all pictures meeting these requirements, 21 were selected for each type, such that the best possible heterogeneity within each picture type was achieved. All pictures were 3.6 cm high and 4.4 cm wide. During the experiment, pictures were presented in "matrices" made up of 20 pictures each: On each trial, 20 pictures occupied pseudorandomly chosen locations defined by an imaginary 5 × 4 grid. Within this invisible frame, the outlines of the pictures were horizontally separated by 2.5 cm and vertically by 2.3 cm.

The pictures were presented on a black background on a 17-in. (43.18-cm) monitor with a resolution of 1,024 × 768 pixels. While participants were working on the experimental tasks, their eye movements were recorded automatically by an EyeLink eye-tracking system, distributed by SensoMotoric Instruments (Berlin, Germany). The eye tracker is an infra-red, video-based tracking system combined with hyperacuity image processing. Two cameras (one for each eye) are mounted on a headband, together with two infrared LEDs for illuminating each eye. The cameras sample pupil location and pupil size at the rate of 250 Hz. Registration was done monocularly, although binocular registration is possible as well. The resolution of eye position is 15 s of arc and the spatial accuracy approximately 0.5°. Head position with respect to the computer screen is measured with a head-tracking camera mounted on the center of the headband. Four light emitting diodes (LEDs) attached to the corners of the computer screen are viewed by the head-tracking camera while the participant is facing the screen. Possible head motions are detected as movements of the four LEDs and are compensated for automatically. The compensation is better than 1° over the acceptable range of head motion. Thus, the system is fairly comfortable because it is not necessary to use a head rest or other means to fixate the participant's head. To reduce reflections, we conducted the experiment in a dimly lit room.

Procedure. Prior to the experimental session, participants were informed about the general procedure of the experiment, and they completed the State form of the German State–Trait Anxiety Inventory (STAI–S; Laux, Glanzmann, Schaffner, & Spielberger, 1981). After calibration and validation of the eye-tracking system, written instructions regarding the first task were presented on the computer screen placed approximately 70 cm away from the participant. The order of the two experimental tasks was counterbalanced across participants. In both tasks, a number of eye-tracking variables were measured: gaze duration on distractors, number of fixated distractors, and number of distractor fixations. In case of *target present trials*, we also measured gaze duration on the target picture, number of target fixations, and number of "late" distractor fixations (i.e., distractor fixations subsequent to a fixation of the target). In both tasks, participants responded by pressing a "yes" key or a "no" key on the computer keyboard; therefore, we also recorded manual reaction time and accuracy of the manual reaction. There was a break between the two tasks, during which the participants completed the Trait form of the German State–Trait Anxiety Inventory (STAI–T; Laux et al., 1981). After finishing the second task, they completed the STAI State form a second time. Afterward, the participants were debriefed. A complete session lasted for about 90 min.

Target Search Task

Materials, procedure, and design. On each trial of the target search task, participants were first shown a fixation cross in the center of the screen. Upon validation of the fixation by the eye tracker, a single target picture of a spider, beetle, or butterfly was displayed. It disappeared automatically after 2 s, to be replaced by a matrix of 20 pictures. Participants were instructed to find the target picture in the matrix and to press a key labeled "yes" on the computer keyboard as soon as they found it. If

they could not find it, they were asked to press a key labeled "no." During this phase, their eye movements were recorded by the eye tracker. As soon as they pressed a key, the matrix disappeared, and the next trial started.

The target search task followed a $2 \times 3 \times 3 \times 2$ experimental design with the between-subjects factor of *participant group* (SFs vs. NACs) and the within-subjects factors of *target type* (spider, beetle, butterfly), *distractor type* (spider, beetle, butterfly), and *trial type* (target present vs. target absent). No dragonfly pictures were presented in this task. Only target present trials are of interest to the hypotheses tested here. Target absent trials were included to encourage careful processing and to keep participants from responding "yes" before they found the target. Target present trials were created by fully crossing the three target picture types with the three distractor picture types, such that the target picture was included exactly once and the remaining 19 pictures were different but of the same type (e.g., a spider among 19 different butterflies). These rules also applied when target type and distractor type were identical—for instance, when a particular spider picture had to be found among 19 other spider pictures. Each of the nine possible combinations was shown six times to each participant, using different target pictures and different arrangements of the distractor pictures. Between these 54 experimental target present trials, 18 target absent trials were interspersed, and 6 practice trials were presented at the beginning of the task, yielding a total of 78 trials. The order of the trials was pseudorandomized; that is, all participants received the same mixed sequence determined prior to the experiment. The position of the target was also distributed pseudorandomly across the trials, excluding the two positions directly above and directly below the fixation point. It took participants about 20 min to complete the target search task. To test for possible speeding of detection and increased distraction in fear of spiders, we recorded the dependent variables mentioned above. In the analyses of these variables, interactions including the factor "group" were of main interest: If the SF participants show increased distraction by spiders, the Group $\times$ Distractor Type interaction should be significant, and if they also show enhanced detection of spiders, the Group $\times$ Target Type interaction should also be significant.

Odd-One-Out Search Task

Materials, procedure, and design. On each trial of the odd-one-out search task, participants were first shown a fixation cross in the center of the screen. Upon validation of the fixation by the eye tracker, a matrix of 20 pictures was displayed immediately. In contrast to the target search task, no target picture was shown before presentation of the matrix. Participants were instructed to indicate whether the matrix was made up of 20 animal pictures of the same kind (e.g., 20 dragonflies) or whether it included one animal that was different from the rest (the odd one out). If there was an odd-one-out picture (henceforth called the *target picture*), they were to respond by pressing as quickly as possible the "yes" key on the computer keyboard. If they could not find an odd-one-out picture, they were asked to press the "no" key. While the matrix was displayed, their eye movements were recorded by the eye tracker. As soon as they pressed a key, the matrix disappeared, and the next trial started.

In the odd-one-out search task, it is impossible to create target present trials if target type and distractor type are identical, because the target would not be "odd." Instead, these cases are considered to be target absent trials because the correct response is "no." As in the target search task, however, only target present trials were of interest. Therefore, a fourth picture type was used in the odd-one-out search task, namely, dragonfly pictures. With these pictures, speeded detection of threat and increased distraction by threat were assessed with separate materials sets. To measure speeded threat detection, we made sure that target present trials consisted of matrices with 19 dragonflies and a single spider, beetle, or butterfly. These three matrix types differed only with regard to target type, while distractor type was identical. Each of the three possible combinations (spider among dragonflies, beetle among dragonflies, or butterfly among dragonflies) was shown eight times to each participant, using different

target pictures and different arrangements of the distractors. The same dependent variables as in the target search task were measured. To assess possible speeding of threat detection, we analyzed the dependent variables according to a 2×3 experimental design with the between-subjects factor of participant group (SFs vs. NACs) and the within-subjects factor of target type (spider, beetle, butterfly). The interaction of these factors was of main interest: If SFs show enhanced detection of spiders, the Group $\times$ Target Type interaction should be significant.

To measure distraction effects, we made sure that target present trials consisted of matrices with a single dragonfly and 19 spiders, beetles, or butterflies. These three matrix types differed only with regard to distractor type, while target type was identical. Each of the three possible combinations (dragonfly among spiders, dragonfly among beetles, dragonfly among butterflies) was shown eight times to each participant, using different target pictures and different arrangements of the distractors. The same dependent variables were measured. To assess possible distraction effects, we analyzed the dependent variables according to a 2×3 experimental design with the between-subjects factor of participant group (SFs vs. NACs) and the within-subjects factor of distractor type (spider, beetle, butterfly). If SFs show increased distraction by spiders, the Group $\times$ Distractor Type interaction should be significant.

In sum, three different types of matrices served to study speeded threat detection, and another three types were used to study increased distraction by threat (unlike the target search task, in which the same materials could be used to assess both effects), yielding a total of 48 target present trials. To allow for a direct comparison of the odd-one-out search task to the target search task, we also included matrices not containing any dragonflies. These matrices correspond to those combinations of the target search task, in which target type differs from distractor type. Two of these combinations contain a spider target (a spider among beetles; a spider among butterflies), two of them contain spider distractors (a beetle among spiders; a butterfly among spiders), and two are spider free (a beetle among butterflies; a butterfly among beetles). Each of the six combinations was presented six times to each participant, using different target pictures and different arrangements of the distractors. These 36 matrices were taken directly from the materials of the target search task. Practice trials and target absent trials were also included, namely, 6 matrices at the beginning of the task as practice trials and 40 homogeneous matrices consisting of 20 dragonflies, 20 spiders, 20 beetles, or 20 butterflies as target absent trials. In sum, a total of 133 trials were presented to each participant. Trial order and target position followed the same restrictions as in the target search task. It took participants about 30 min to complete the odd-one-out search task.

Results

Questionnaires

The mean questionnaire scores for the two groups of participants are shown in Table 1. As expected, SFs scored dramatically higher than NACs on the SAS, the FSQ, and the SPQ. Moreover, they also showed slightly higher depression scores on the FDD and slightly higher trait anxiety scores on the STAI-Trait scale. However, scores for both groups fell within the normal range, giving no indication of depression or heightened trait anxiety. The same was true for state anxiety: Both groups had comparably low scores before the experiment. The SFs' state anxiety rose slightly during the experiment, yielding a small, but significant difference between the two groups after the experiment (see Table 1). However, all state anxiety scores were still in the normal range. None of these results compromises interpretation of the results reported below.

Table 1

Questionnaire Scores (Means, Standard Deviations, and t *tests) for Each Group in Experiment 1*

	Nonanxious control		Spider fearful		Significance of *t* test
Questionnaire	*M*	*SD*	*M*	*SD*	*df* = 46
SAS	2.3	2.2	19.4	2.7	.001
FSQ	2.2	2.7	64.2	15.8	.01
SPQ	7.0	2.6	21.0	6.2	.01
FDD	3.7	3.5	8.1	7.0	.01
STAI–T	34.7	7.9	39.9	9.4	.05
STAI–S					
Preexperiment	33.2	6.4	36.2	6.5	*ns*
Postexperiment	32.7	4.8	39.1	6.9	.01

Note. SAS = Spider Anxiety Screening; FSQ = Fear of Spiders Questionnaire; SPQ = Spider Phobia Questionnaire; FDD = *Fragebogen zur Depressionsdiagnostik nach DSM–IV* (Questionnaire for Diagnosis of Depression according to DSM–IV); STAI–T = State–Trait Anxiety Inventory—Trait form; STAI–S = State–Trait Anxiety Inventory—State form.

Experimental Tasks

For both tasks, practice trials and target absent trials were discarded from the data set prior to the statistical data analyses. False alarm rates to the target absent trials were uniformly low (4% on average) and did not differentiate between tasks, experimental conditions, or groups. All target present trials to which participants had responded inaccurately (approximately 2% misses) and all trials containing indications of measurement errors (approximately 8%) were also excluded from the analyses. In both tasks, 90% of all target present trials remained and the dependent variables were computed for them. There were no differences in accuracy between experimental conditions in either task; therefore, results regarding the dependent variables "percentage correct responses" are not reported below. Mean manual reaction time is reported below, to allow for a comparison with earlier experiments. Regarding the eye-tracking variables, we found that some of them did not vary across experimental conditions: The target picture was usually fixated once and for a short period of time, after which the participants responded directly with a keypress (as they were instructed). Thus, the mean number of target fixations was always very close to one, mean gaze duration on the target picture averaged 550 ms, and the number of late distractor fixations was always very close to zero. Most important, these measures did not vary across conditions in either task; therefore, they are not reported below. As expected, the three dependent variables related to processing of the distractor pictures (gaze duration on distractors, number of fixated distractors, and number of distractor fixations) were highly correlated and yielded very similar results; therefore, we restrict our descriptions to the most fine-grained variable, namely, gaze duration. Analyses of all other variables are available from Mike Rinck upon request.

In the two tasks, two effects were found repeatedly in almost all analyses. These effects, although large and ubiquitous, are not relevant to the theoretical questions addressed by the experiment. Therefore, we quickly summarize them here. First, we always found a significant main effect of target type, indicating that spider targets were generally the hardest to find, and butterflies were easiest. This is hardly surprising, given the conspicuous appearance of butterflies, compared with the rather camouflaged appearance of most spiders. Second, analyses of the target search task always yielded a significant interaction of target type and distractor type. The interpretation of this effect is also fairly trivial: Finding the target was always difficult, if target type and distractor type were identical (e.g., if a particular spider was hidden among other spiders).

Target Search Task

The results observed for the target search task are depicted in Tables 2 and 3. Table 2 shows mean manual reaction times; Table 3 gives mean gaze durations on distractors. As mentioned above, interactions involving the group factor are of main interest to our search for selective detection of threat and selective distraction by threat.

Detection of threat. The $2 \times 3 \times 3$ analysis of variance (ANOVA) of the manual reaction times revealed that the Group × Target Type interaction was not significant, $F(2, 92) = 2.50$, $p = .088$, providing no reliable support for selective threat detection. The three-way interaction of group, target type, and distractor type was not significant either, $F(4, 184) < 1$. Moreover, inspection of the means shown in Table 2 suggest that, if anything, SFs tended to take longer than NACs to find spider targets. Analyses of the mean gaze durations on distractors confirmed these results: Again, neither the Group × Target Type interaction, $F(2, 92) = 1.86$, *ns*, nor the three-way interaction were significant, $F(4, 184) < 1$.

Distraction by threat. The $2 \times 3 \times 3$ ANOVA of the manual reaction times revealed a significant Group × Distractor Type interaction, $F(2, 92) = 6.73$, $p = .002$, indicating that the animals differed in the degree to which they distracted the two groups during the search task. To explore this significant interaction in more detail, the two groups were compared with each other separately for each type of distractor picture. These comparisons revealed no difference between the two groups for beetle or butterfly distractors, both $F(1, 46) < 1$. Spider distractors, however, caused longer reaction times in SFs than in NACs, $F(1, 46) = 8.68$, $p = .005$. Analyses of the mean gaze durations on distractors confirmed these results, revealing a significant Group × Distractor

Table 2

Mean Manual Reaction Times (and Standard Deviations) in Seconds for Each Group in Target Search Task of Experiment 1

	Nonanxious control		Spider fearful	
Target and distractor type	*M*	*SD*	*M*	*SD*
Spider				
Spider	2.18	.58	2.71	.87
Beetle	1.83	.52	2.00	.73
Butterfly	1.77	.32	1.79	.44
Beetle				
Spider	1.73	.40	2.05	.51
Beetle	2.20	.44	2.18	.60
Butterfly	1.60	.34	1.58	.42
Butterfly				
Spider	1.27	.32	1.44	.39
Beetle	1.28	.30	1.37	.45
Butterfly	2.06	.62	1.85	.65

Table 3

Mean Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group in the Target Search Task of Experiment 1

Target and distractor type	Nonanxious control		Spider fearful	
	M	SD	M	SD
Spider				
Spider	1.02	.50	1.38	.52
Beetle	.69	.41	.76	.42
Butterfly	.54	.21	.54	.17
Beetle				
Spider	.70	.39	.90	.31
Beetle	1.00	.37	1.01	.42
Butterfly	.46	.17	.39	.18
Butterfly				
Spider	.33	.17	.41	.25
Beetle	.29	.13	.30	.26
Butterfly	.87	.43	.88	.40

Type interaction, $F(2, 92) = 4.67$, $p = .012$. Again, no difference between the two groups occurred for beetle or butterfly distractors, both $F(1, 46) < 1$, and spider distractors caused longer gaze durations in SFs than in NACs, $F(1, 46) = 7.62$, $p = .008$.

In summary, the results of the manual reaction times and the gaze durations on distractors provide clear evidence that SFs were selectively distracted by spiders, but no evidence was found for the hypothesis that SFs show faster detection of spiders.

Odd-One-Out Search Task

Detection of threat. Table 4 shows the results observed in the odd-one-out search task, which are relevant to possible accelerations of threat detection. The mean manual reaction times and mean gaze durations on distractors shown in Table 4 belong to matrices with dragonfly distractors, differing only in the single targets that are odd. As in the target search task, interactions involving the group factor are critical to our hypotheses. Indeed, the 2×3 ANOVA of the manual reaction times revealed a significant interaction of group and target type, $F(2, 92) = 13.78$, $p < .001$. To explore this interaction, we compared the two groups

with each other separately for each type of target picture. These comparisons revealed no difference between the two groups for beetle or butterfly targets, both $t(46) < 1$. With spider targets, however, SFs responded more quickly than NACs, $t(46) = 5.57$, $p < .001$. These RT results were corroborated by analyses of the gaze durations on distractors shown in Table 4. The 2×3 ANOVA of these gaze durations also yielded a significant Group $\times$ Target Type interaction, $F(2, 92) = 18.14$, $p < .001$. Again, the auxiliary group comparisons revealed no difference between the two groups for beetle or butterfly targets, both $t(46) < 1$. With spider targets, however, SFs spent less time fixating on the distractors than NACs, $t(46) = 7.59$, $p < .001$. Together, these results provide evidence for speeded threat detection in SFs.

Distraction by threat. Table 5 shows the mean manual reaction times and gaze durations on distractors relevant to possible distraction effects in the odd-one-out search task. These data stem from matrices with dragonfly targets, differing only in the distractors, which may be spiders, beetles, or butterflies. The 2×3 ANOVA of the manual reaction times revealed a significant interaction of group and distractor type, $F(2, 92) = 10.5$, $p < .001$. To explore this interaction, we compared the two groups with each other separately for each type of distractor picture. These comparisons revealed no difference between the two groups for beetle or butterfly distractors, both $t(46) < 1.3$, *ns*. With spider distractors, however, SFs responded more slowly than NACs, $t(46) = 7.33$, $p < .001$. Again, the reaction time results were corroborated by gaze durations on distractors (see Table 5). The 2×3 ANOVA of these gaze durations also yielded a significant Group $\times$ Target Type interaction, $F(2, 92) = 5.93$, $p = .004$. Again, the auxiliary group comparisons revealed no difference between the two groups for beetle or butterfly distractors, both $t(46) < 1.2$, *ns*. With spider distractors, however, SFs spent more time fixating on the distractors than NACs, $t(46) = 4.95$, $p < .001$. Together, these results provide clear evidence for selective distraction effects in SFs.

Target Search Versus Odd-One-Out Search

The results reported so far indicate that the target search task and the odd-one-out search task yielded similar distraction effects but that speeded threat detection occurred only in the odd-one-out search task. However, this comparison is based on different ma-

Table 4

Mean Manual Reaction Times (RTs) and Mean Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group in the Odd-One-Out Search Task for Detection Effects in Experiment 1

Dependent variable and target type	Nonanxious control		Spider fearful	
	M	SD	M	SD
Manual RT				
Spider	2.04	.42	1.48	.25
Beetle	1.66	.41	1.66	.39
Butterfly	1.53	.32	1.60	.45
Gaze duration				
Spider	.78	.22	.40	.09
Beetle	.61	.22	.63	.24
Butterfly	.55	.22	.60	.30

Table 5

Mean Manual Reaction Times (RTs) and Mean Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group in the Odd-One-Out Search Task for Distraction Effects in Experiment 1

Dependent variable and distractor type	Nonanxious control		Spider fearful	
	M	SD	M	SD
Manual RT				
Spider	1.99	.25	2.58	.31
Beetle	1.95	.38	2.11	.46
Butterfly	1.52	.30	1.59	.38
Gaze duration				
Spider	.86	.20	1.22	.29
Beetle	.86	.24	.97	.35
Butterfly	.46	.12	.56	.24

terials. Most important, dragonflies occurred only in the odd-one-out search task, whereas only the target search task allowed for a full combination of all picture types. Therefore, the following additional analyses are based on identical matrices used in both tasks. The relevant means are shown in Table 6.

Spider target matrices. Two of the matrix types displayed in both tasks contained spider target pictures (spider among beetles; spider among butterflies). If speeded threat detection does indeed occur solely in the odd-one-out search task, a difference between the two groups should be observed in this task only. Indeed, the 2 (group) × 2 (task) ANOVA of the manual reaction times for these matrices revealed a significant interaction, $F(1, 46) = 8.91, p = .005$: SFs responded more quickly than NACs in the odd-one-out search task, $t(46) = 3.16, p = .003$, but not in the target search task, $t(46) < 1$. These results were corroborated by parallel analyses of the gaze durations on distractors. Again, the interaction was significant, $F(1, 46) = 11.5, p = .001$, and SFs had shorter gaze durations than NACs in the odd-one-out search task, $t(46) = 4.02, p < .001$, but not in the target search task, $t(46) < 1$.

Spider distractor matrices. Two of the common matrix types contained spider distractors (beetle among spiders; butterfly among spiders). If distraction effects do indeed occur in both tasks, a difference between the two groups should be observed in both of them. Indeed, the 2 × 2 ANOVA of the manual reaction times for these matrices revealed a significant main effect of group, $F(1, 46) = 93.92, p < .001$, whereas the interaction was not significant, $F(1, 46) < 1$. SFs were slower than NACs in both the target search task, $t(46) = 2.35, p = .023$, and the odd-one-out search task, $t(46) = 2.97, p = .005$. Again, parallel results were observed in the gaze duration analyses: The main effect of group was significant,

Table 6
Mean Manual Reaction Times (RTs) and Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group, Matrix Type and Task in Experiment 1

Dependent variable, Matrix type, and task	Nonanxious control		Spider fearful	
	M	SD	M	SD
Manual RT				
Spider target				
Visual search	1.80	.33	1.89	.52
Odd-one-out	2.39	.40	2.04	.36
Spider distractor				
Visual search	1.50	.33	1.74	.39
Odd-one-out	2.20	.46	2.59	.46
Spider-free				
Visual search	1.44	.30	1.47	.36
Odd-one-out	1.85	.41	1.93	.39
Gaze durations				
Spider target				
Visual search	.62	.26	.65	.26
Odd-one-out	1.09	.27	.80	.23
Spider distractor				
Visual search	.52	.24	.66	.20
Odd-one-out	.94	.26	1.27	.31
Spider-free				
Visual search	.38	.13	.35	.19
Odd-one-out	.73	.24	.81	.31

$F(1, 46) = 92.83, p < .001$, whereas the interaction was not, $F(1, 46) = 3.29, ns$, and SFs had shorter gaze durations than NACs in both the target search task, $t(46) = 2.2, p = .033$, and the odd-one-out search task, $t(46) = 4.06, p < .001$.

Spider-free matrices. Two of the common matrix types did not contain spider pictures at all (beetle among butterflies; butterfly among beetles). These constitute a control condition, in which neither speeded detection nor increased distraction should occur. Thus, we expect no differences between the two groups with these matrices, neither in the target search task nor in the odd-one-out search task. Indeed, in the 2 × 2 ANOVA of the manual reaction times, only the main effect of task was significant because participants were generally faster in the target search task than in the odd-one-out search task, $F(1, 46) = 42.78, p < .001$. Neither the main effect of group nor the interaction reached significance, both $F(1, 46) < 1$. Parallel results were observed in the gaze duration analyses: Participants showed shorter gaze durations on distractors in the target search task than in the odd-one-out search task, $F(1, 46) = 115.03, p < .001$, and neither the main effect of group nor the interaction reached significance, both $F(1, 46) < 2.06, ns$.

In two additional analyses, the spider-free matrices were used as a control condition to confirm the results observed for spider target matrices and spider distractor matrices, respectively. In a joint analysis of the manual reaction times for spider target matrices and spider-free matrices, the three-way interaction of group, task, and matrix type was highly significant, $F(1, 46) = 12.44, p = .001$, confirming the finding that SFs showed faster reactions than NACs only with spider target matrices in the odd-one-out search task. The three-way interaction was also observed when gaze durations on distractors were analyzed in the same way, $F(1, 46) = 21.82, p < .001$. A second joint analysis of the manual reaction times involved spider distractor matrices and spider-free matrices. As expected, the three-way interaction of group, task, and matrix type was not significant in this analysis, $F(1, 46) < 1$. Instead, the Group × Matrix Type interaction was significant, $F(1, 46) = 7.06, p = .01$, confirming the finding that regardless of the task, SFs were slower than NACs with spider distractor matrices but not with spider-free matrices. In sum, the analyses of these materials corroborated those reported before: SFs did indeed show selective distraction by spider distractors in both tasks, whereas selectively speeded detection of spider targets occurred only in the odd-one-out search task.

Discussion

Taken together, the results of Experiment 1 confirm the findings of previous experiments. Both selective detection and distraction occurred in the odd-one-out search task, corresponding to the findings of Byrne and Eysenck (1995); Gilboa-Schechtman et al. (1999), Öhman et al. (2001), and others. Similarly, only selective distraction was observed in the target search task, as was reported by Rinck et al. (2003) and Rinck and Becker (2005). Thus, it seems safe to conclude (a) that in addition to increased distraction by threat, speeded threat detection does indeed occur during visual search and (b) that its occurrence depends on how information is processed during the visual search task. Moreover, analyses of the eye-tracking variables suggested the locus of the effects: For both speeding and distraction, it was the amount of time spent on distractors, rather than the speed of reacting to the target, that

determined overall reaction time. That is, SFs spent more time looking at spider distractors when the manual reaction times indicated threat-related distraction, and they spent less time looking at neutral distractors when speeded threat detection occurred. We return to the implications of this finding in the *General Discussion* section, after trying to replicate it in the second experiment. In any case, our finding of speeded threat detection is difficult to explain in terms of disengagement of attention, and it is not obvious why it occurred only in the odd-one-out variant of the task and not in the target search variant. Simple methodological differences may be excluded as an explanation for this discrepancy because in this study, the two tasks involved the very same participants, stimuli, and procedural details. Therefore, one needs to consider *task-related processing characteristics*, which could be responsible for the lack of threat-specific speeding of detection in the target search task. This hypothesis was investigated in Experiment 2.

Experiment 2: Category Search

Although both the odd-one-out search task and the target search task involve a single target object among many distractor objects, the tasks differ with regard to an important aspect: the amount of visual detail available before visual search and necessary during it. First, for each trial of the target search task, the participants know exactly which target picture they have to search for and what the picture looks like. In contrast, in the odd-one-out search task, no previous knowledge about the visual details of the target object is available because the target is not shown in advance. Second, participants also have to process visual details during the target search task: In a third of the trials, target type and distractor type are identical, such that a search for details is required. For instance, when asked to find a specific spider picture in a matrix of 20 spider pictures, it is necessary to pay attention to details of the spiders. Processing at this level of detail is not necessary in the odd-one-out search task: Whenever an odd item is included, it is easy to spot because of its discrepant visual appearance (e.g., a spider among butterflies). Although this task also includes matrices in which all 20 animals belong to the same category, these matrices do not require detailed processing: No single animal has to be identified, and seeing that the 20 animals are alike suffices for a "no" response. Thus, one might conclude that it is the level of visual processing and not the target search task per se that extinguishes the effect of speeded threat detection. If this is the case, the effect should reappear in a search task that is similar to the target search task but that does not afford or require processing at the level of visual detail. To test this prediction, we conducted Experiment 2. We attempted to find speeded threat detection in this experiment in order to increase the validity of the effect and to identify boundary conditions for it. Moreover, the results of Experiment 2 should allow us to offer some hypotheses and speculations regarding the origin of speeded threat detection and increased distraction by threat in fear of spiders.

In Experiment 2, we modified the target search task of the first experiment by not presenting the to-be-found target picture. Instead, only the target category was named: On each trial, participants were instructed to search for a butterfly, beetle, dragonfly, or spider, respectively. Therefore, this *category search task* does not provide any visual detail of the target picture before presentation of the matrix. As before, participants did not know whether a target

picture would be contained in the matrix of pictures. In addition, they did not know exactly which butterfly, beetle, dragonfly, or spider would be presented, if the target was present in the matrix. Moreover, this task is similar to the odd-one-out search task in that it is not necessary to search for visual details: If an animal of the target category was included in the matrix, it was clearly different from the other 19 animals (e.g., a spider among 19 butterflies). Target present trials in which target type and distractor type are identical were not included because in this case, the participant would find 20 targets instead of a single one (e.g., if the participant is instructed to find a spider and a matrix of 20 spiders is shown). Instead, Experiment 2 used the design and materials of the odd-one-out search task of Experiment 1, allowing for separate analyses of speeded threat detection and increased distraction by threat. Thus, Experiment 2 was basically a combination of modified target search task instructions with the materials and designs of the odd-one-out search task.

Method

The category search task of Experiment 2 was very similar to the odd-one-out search task of the first experiment; therefore, only the differences are explained in detail.

Participants.   The same recruitment and selection procedures as in Experiment 1 were used to recruit 24 new SFs and 25 new NACs without any animal-oriented fears. As before, the two groups were matched with regard to age, gender, and educational level. On average, the NACs were 21.8 years old ($SD = 2.1$), and the SFs' mean age was also 21.8 ($SD = 2.0$). Questionnaire scores for the two groups are given in Table 7.

Materials, apparatus, procedure, and design.   All of these were adopted from the odd-one-out search task of Experiment 1. There were only two differences. First, SFs and NACs participated in a single task only, namely, the category search task. Second, this task involved the presentation of the target category instead of the individual target picture before presentation of the 4 × 5 matrix. As in the target search task, participants were first shown a fixation cross in the center of the screen. Upon validation of the fixation by the eye tracker, a single word was displayed, namely, the German word for *SPIDER*, *BEETLE*, *BUTTERFLY*, or *DRAGONFLY*. The word denoted the type of animal to search for. It disappeared automatically after 2 s, to be replaced by the matrix of 20 pictures. As before, the target category was included in the matrix exactly

Table 7

Questionnaire Scores (Means, Standard Deviations, and t *tests) for Each Group in Experiment 2*

Questionnaire	Nonanxious control		Spider fearful		Significance of *t* test
	M	*SD*	*M*	*SD*	*df* = 47
SAS	1.6	1.4	20.1	3.3	.001
FSQ	3.1	3.6	70.5	14.1	.001
FDD	4.6	4.1	5.7	3.7	*ns*
STAI–T	33.7	9.2	36.8	6.4	*ns*
STAI–S					
Preexperiment	31.0	5.2	33.3	5.1	*ns*
Postexperiment	30.6	5.8	36.6	7.3	*ns*

Note.   SAS = Spider Anxiety Screening; FSQ = Fear of Spiders Questionnaire; SPQ = Spider Phobia Questionnaire; FDD = *Fragebogen zur Depressionsdiagnostik nach DSM–IV* (Questionnaire for Diagnosis of Depression according to *DSM–IV*); STAI–T = State–Trait Anxiety Inventory—Trait form; STAI–S = State–Trait Anxiety Inventory—State form.

once (target present probes) or not at all (target absent probes). For target present probes, the category label corresponded exactly to the type of target picture contained in the matrix. For target absent probes, each category label was used equally often.

Results

Questionnaires

The mean questionnaire scores for the two groups of participants are shown in Table 7. As expected, SFs scored dramatically higher than NACs on the SAS and the FSQ. Depression scores in the FDD and trait anxiety scores in the STAIT-Trait scale were low in both groups and did not differ significantly (see Table 7). Moreover, the two groups did not differ from each other with regard to state anxiety, either before or after the experiment (see Table 7).

Category Search Task

The data were analyzed in the same way as those of the odd-one-out search task in the first experiment. As before, both false alarm rates (3%) and rates of misses (5%) were low, and neither of them varied with experimental conditions or groups. The mean number of target fixations was always very close to one, mean gaze duration on the target picture did not vary across conditions, and the number of late distractor fixations was always very close to zero. Moreover, the three dependent variables related to processing of the distractor pictures (gaze duration on distractors, number of fixated distractors, and number of distractor fixations) yielded highly similar effects of the experimental manipulations. Therefore, manual reaction times and gaze durations on distractors were again used as the main dependent variables.

Detection of threat. Table 8 shows the results related to speeded threat detection. The mean manual reaction times and mean gaze durations on distractors shown in Table 8 belong to matrices with dragonfly distractors, differing only in the single targets to be found. The 2×3 ANOVA of the manual reaction times revealed a significant interaction of group and target type, $F(2, 94) = 8.07$, $p < .01$. To explore this interaction, we compared the two groups with each other separately for each type of target picture. These comparisons revealed no difference between the two groups for beetle or butterfly targets, both $t(47) < 1.39$, *ns*.

Table 8
Mean Manual Reaction Times (RTs) and Mean Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group for Detection Effects in Experiment 2

Dependent variable and target type	Nonanxious control		Spider fearful	
	M	*SD*	*M*	*SD*
Manual RT				
Spider	1.94	.46	1.49	.29
Beetle	1.77	.61	1.59	.23
Butterfly	1.47	.40	1.41	.29
Gaze duration				
Spider	.47	.24	.27	.12
Beetle	.44	.35	.34	.14
Butterfly	.32	.20	.30	.12

With spider targets, however, SFs responded more quickly than NACs, $t(47) = 4.09$, $p < .001$. These reaction time results were corroborated by analyses of the gaze durations on distractors shown in Table 8. The 2×3 ANOVA of these gaze durations also yielded a significant Group $\times$ Target Type interaction, $F(2, 94) = 5.5$, $p < .01$. Again, the auxiliary group comparisons revealed no difference between the two groups for beetle or butterfly targets, both $t(47) < 1.34$, *ns*. With spider targets, however, SFs spent less time fixating on the distractors than NACs, $t(47) = 3.68$, $p < .01$. Together, these results provide clear evidence for selective threat detection in SFs.

Distraction by threat. Table 9 shows the mean manual reaction times and gaze durations on distractors related to possible distraction effects. These data stem from matrices with dragonfly targets, differing only in the distractors, which may be spiders, beetles, or butterflies. The 2×3 ANOVA of the manual reaction times revealed a significant interaction of group and distractor type, $F(2, 94) = 8.15$, $p < .01$. To explore this interaction, we compared the two groups with each other separately for each type of distractor pictures. These comparisons revealed no difference between the two groups for beetle or butterfly distractors, both $t(47) < 1.11$, *ns*. With spider distractors, however, SFs responded more slowly than NACs, $t(47) = 3.31$, $p < .01$. Again, the reaction time results were corroborated by gaze durations on distractors (see Table 9). The 2×3 ANOVA of these gaze durations also yielded a significant Group $\times$ Target Type interaction, $F(2, 94) = 11.72$, $p = .001$. Again, the auxiliary group comparisons revealed no difference between the two groups for beetle and butterfly distractors, both $t(47) < 1.63$, *ns*. With spider distractors, however, SFs spent more time fixating on the distractors than NACs, $t(47) = 3.24$, $p < .01$. Together, these results provide clear evidence for selective distraction by threat in SFs.

Control analyses. The results reported so far suggest that speeded threat detection occurred because no visual detail of the target stimulus was provided or needed in this task. There is an alternative explanation, however, in that the effect may depend on the materials: It occurred when dragonflies were used as targets or distractors (Exp. 2 and the odd-one-out search task of Exp. 1), and it was absent when the materials did not include dragonflies (the target search task of Exp. 1). Although this hypothesis seems highly unlikely, the following analyses were computed to test it. These analyses are based solely on trials involving matrices without dragonflies, as in Experiment 1. The corresponding means and standard deviations are given in Table 10. Two of these matrix types are *spider target matrices* (spider among beetles; spider among butterflies). For these matrices, disorder-specific threat detection was observed in manual reaction times and gaze durations on distractors: SFs responded more quickly than NACs, $t(47) = 5.04$, $p < .001$, and they had shorter gaze durations on distractors than NACs, $t(47) = 4.48$, $p < .001$. Two other matrix types were *spider distractor matrices* (beetle among spiders; butterfly among spiders). For these, the expected disorder-specific distraction effect occurred: SFs responded more slowly than NACs, $t(47) = 3.1$, $p = .003$, and they had longer gaze durations on distractors than NACs, $t(47) = 2.94$, $p = .005$. Finally, two other matrix types were *spider-free matrices*; that is, they did not contain spider pictures at all (beetle among butterflies; butterfly among beetles). As expected, neither speeded threat detection nor increased distraction by threat were observed with these matrices:

Table 9

Mean Manual Reaction Times (RTs) and Mean Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group for Distraction Effects in Experiment 2

Dependent variable and distractor type	Nonanxious control		Spider fearful	
	M	SD	M	SD
Manual RT				
Spider	1.81	.29	2.28	.66
Beetle	1.67	.57	1.52	.31
Butterfly	1.77	.53	1.68	.36
Gaze duration				
Spider	.45	.21	.75	.41
Beetle	.44	.32	.33	.11
Butterfly	.38	.27	.29	.11

SFs and NACs differed neither in manual response time nor in gaze duration on distractors, both $t(47) < 1.4$, *ns*. In sum, the analyses of these control materials corroborate the analyses reported for matrices containing dragonflies.

Discussion

The category search task in this experiment yielded results that were perfectly comparable with those of the odd-one-out search task in the first experiment. In particular, manual reaction times indicated that both disorder-specific speeding of threat detection and disorder-specific distraction by threat occurred. Moreover, analyses of the eye-tracking variables suggested that spider distractors were fixated more often and for a longer time when selective distraction by threat occurred, whereas neutral and positive distractors were fixated less often and for shorter times when speeded threat detection was observed. In contrast, fixations and gaze durations of the target itself did not vary systematically with detection and distraction effects. The distraction effect was also observed in both tasks of Experiment 1, suggesting that slowed disengagement from threat occurs independently of the specific features of the visual search task. This finding is fully compatible with the role of disengagement suggested by Fox et al. (2001, 2002). In contrast, the speeded threat detection observed here is not easily explained by differences in the ability to disengage attention. Therefore, it is worth noting that the effect was observed in a task other than the odd-one-out search task used previously. This lends credibility to the effect, and it also suggests that the lack of speeded detection in the target search task is not due to the search for a target per se. Moreover, analyses of the control materials indicated that it is not due to the particular materials either. Instead, the detection effect seems to depend on how much visual detail of the target stimulus is available before the search task and how much visual detail needs to be processed during the task.

General Discussion

The first goal of the present experiments was to find out whether speeded detection of threatening stimuli may be observed in anxiety disorders, in addition to increased distraction by these stimuli. In two experiments, disorder-specific increases in distraction by

threat did indeed occur across the three variants of a visual search task. This is illustrated by Figure 1, which shows that averaged manual reaction times to spider distractors were longer for SFs than for NACs. In contrast, speeded threat detection was also observed, but its occurrence depended on specific features of the search task. This finding is illustrated by Figure 2, which indicates that SFs showed speeded detection of spider targets in the odd-one-out search task and the category search task but not in the target search task. The finding of speeded threat detection is particularly relevant to theoretical explanations of attentional biases in anxiety: All relevant theories agree in predicting disorder-specific increases in distraction (e.g., Clark & Wells, 1995; Eysenck, 1992; Fox et al., 2001; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams et al., 1997), whereas speeded detection of threat runs counter to the suggestion that attentional biases are based on differences in the ability to disengage attention from threat stimuli (Fox et al., 2001, 2002). This hypothesis is quite unlikely because in our experiments, in order to show speeded detection of threat, we made sure that participants would have to disengage attention from neutral or pleasant distractors before finding the threatening target. Thus, the finding of speeded threat detection in SFs suggests that clinically anxious people do indeed show attentional biases in both the shift and disengage component of visual attention, as suspected by Fox et al. (2001). The second goal of our experiments was to exclude methodological differences as an explanation for the divergent findings from the odd-one-out search task and the target search task. This was achieved in Experiment 1: Despite identical participants and materials as well as highly comparable designs, the experiment replicated earlier findings. The odd-one-out search task yielded both disorder-specific detection and distraction, whereas only disorder-specific distraction occurred in the target search task. The results of Experiment 2 suggest that task-related differences between the two tasks are responsible for the divergent findings: When participants only knew the type of animal they had to find—instead of seeing a particular picture—and when they did not have to examine visual details of targets and distractors, disorder-specific speeding of threat detection occurred even in the category search task. In summary, the two experiments reported here show that disorder-specific speeding of threat detection does exist, although its occurrence depends on specific features of the experimental task (see also Byrne & Eysenck, 1995; Gilboa-

Table 10

Mean Manual Reaction Times (RTs) and Gaze Durations on Distractors (and Standard Deviations) in Seconds for Each Group by Matrix in Experiment 2

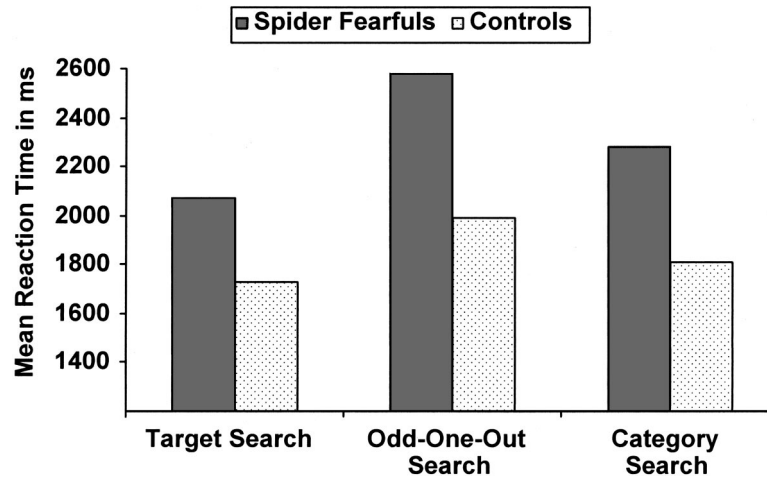| Dependent variable and matrix type	Nonanxious control		Spider fearful	
	M	SD	M	SD
Manual RT				
Spider target	2.61	.47	2.05	.28
Spider distractor	2.30	.52	2.85	.70
Spider-free	1.93	.59	1.80	.31
Gaze durations				
Spider target	.77	.26	.50	.16
Spider distractor	.67	.25	.92	.34
Spider-free	.52	.33	.42	.12

Figure 1. Mean manual reaction times for spider distractors in the target search task, odd-one-out search task, and category search task.

Schechtman et al., 1999; Öhman et al., 2001). In comparison, disorder-specific distraction by threat seems to be a more widespread and reliable phenomenon, which was observed with many different paradigms (for reviews, see Becker & Rinck, 2005; Fox et al., 2001, 2002; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; or Williams et al., 1997).

With the current experiments, we tried to demonstrate the existence of speeded threat detection and to identify boundary conditions of its occurrence. The success of this attempt, however, raises a more difficult question: How can the effect be explained? Although our experiments were not designed to test alternative hypotheses regarding the origin of the effect, the eye-tracking data and manual reaction times allow us to evaluate at least some of the explanations and to propose promising candidates for further testing. First, some explanations based on processes other than attention were rendered unlikely. The mean number of target fixations before responding was always close to one or slightly above,

suggesting that participants did not respond positively without really finding the target when it was present. This finding is also in line with the false alarms to target absent trials, which were rare and did not vary with experimental conditions or groups. Moreover, some of the target present trials in which participants responded without registration of a target fixation may have been caused by technical registration problems rather than their real behavior (in any case, all of these trials were excluded from the analyses reported above). Also, in both experiments, participants hardly ever fixated a distractor after fixation of the target, suggesting that participants reacted immediately and according to instructions. Thus, response biases do not seem to offer a plausible explanation of the observed effects. Second, the delay between fixation of the target and manual response was short (500–600 ms, on average), and it did not vary with experimental conditions, suggesting that the observed effects are not related to decision processes or motor processes.
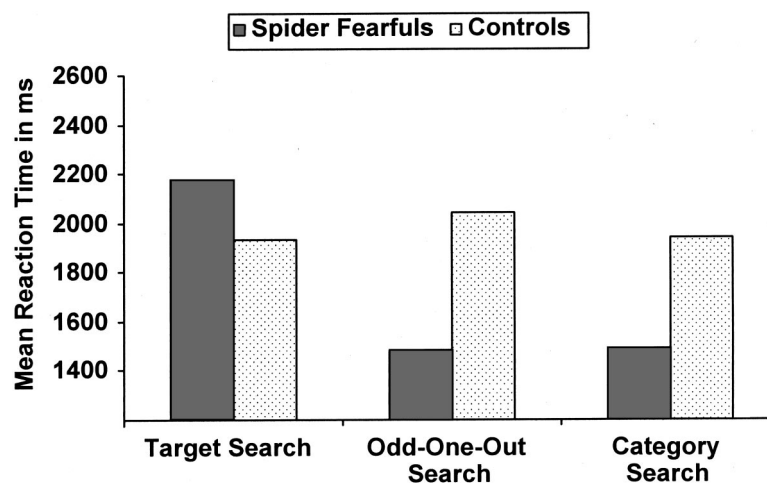

Figure 2. Mean manual reaction times for spider targets in the target search task, odd-one-out search task, and category search task.

Assuming that attentional processes did indeed govern the biases observed here, one may ask how attention was biased toward the distraction and detection effects observed. For the observed *distraction by threat*, the answer seems straightforward: as Fox et al. (2001) suggested, anxiety disorders may be characterized by slowed disengagement from threatening stimuli. Although this hypothesis may not be perfectly compatible with other theoretical accounts (e.g., Eysenck, 1992; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams et al., 1997), it explains the distraction effect parsimoniously, and it has been confirmed empirically (Fox et al., 2001, 2002). For the observed speeding of *threat detection*, the situation is more complicated, however. It can hardly be explained by differences in disengagement, because one would have to make the assumption that anxiety patients disengage more quickly from neutral and positive stimuli in order to detect threatening stimuli more quickly. In the current experiments, this assumption is particularly implausible because only a third of the matrices contained threatening targets, and the participants could not predict whether matrices containing neutral or positive distractors (beetles, dragonflies, butterflies) would contain a spider target. Instead, it seems necessary to draw on speeded shifting or accelerated engagement as an explanation of speeded threat detection.

Although the present experiments were not designed to investigate the shift and engagement processes in detail, they revealed critical features of the search task that favor the occurrence of speeded threat detection. One such feature may be the unpredictability of the specific target item. It seems that only "unpredictable" threat stimuli (in the sense that it is not known in advance which individual target stimulus will be presented) are detected more quickly by spider-phobic individuals. If, on the other hand, they are instructed to search for a particular, known threat stimulus, they are not any faster than NACs. Although this hypothesis is speculative, it fits in with previous findings of attentional biases in anxiety: Robust biases were found with the visual dot probe task (for a review, see Mogg & Bradley, 1998) and the dichotic listening task (see Williams et al., 1997). In these paradigms, participants only know the type of stimuli they have to process (e.g., words or pictures of faces), but they do not know which individual stimulus will be presented on each trial.

Another critical feature seems to be the level of visual detail that is available for the visual search task and that is needed for a successful search. Speeded threat detection in SFs only occurred when visual detail was neither available nor necessary. This finding suggests that the detection effect is more likely in, or even limited to, situations in which participants may use a more superficial, holistic visual search for the "Gestalt" of the target, rather than an analytic and focused search, in which details of different pictures have to be compared with each other. Future experiments should try to disentangle availability and necessity of visual details: We expect that speeded threat detection will occur as long as participants may use a holistic search by ignoring details of the target picture, even when these details are available. This prediction could be tested by implementing a variation of the target search task, in which the target picture is shown in advance but is followed only by matrices in which target type and distractor type are different. In this situation, participants should quickly learn that it is unnecessary to focus on details of the target picture because it can be identified easily using a holistic search strategy. A possible explanation of the way that analytical, focused search

prevents speeding of threat detection in anxiety involves the assumption that two processes are involved in the search task: focusing and alerting.[1] The target search task induces a more focused search, and focusing of attention may be more effective in anxious people under negative conditions (Derryberry & Reed, 1998). At the same time, prior presentation of a threatening target picture should increase arousal, particularly in SFs. Thus, both focusing and arousal are increased in SFs compared with NACs. The two processes have opposite effects on reaction times, however, with focusing slowing down the search process and arousal speeding it up (as long as arousal is increased, but not high enough to interfere with cognitive processes). Therefore, the effects of focusing and arousal may cancel each other out, leaving no overall difference between SFs and NACs. In the odd-one-out search task and category search task, in contrast, there is no increase in focusing, leaving only differences in arousal, which speed up search processes in SFs more than in NACs. Additional studies will be needed to test this hypothesis.

Another potential explanation of the pattern of results related to speeded threat detection refers to working memory load. In the target search task, participants have to memorize the particular stimulus to search for and then keep it in working memory while executing the search. This should be particularly difficult when target type and distractor type are identical (e.g., a target spider among distractor spiders), contributing to the increased RTs we observed in these cases. In contrast, in the odd-one-out search task, participants only have to keep in working memory the stimulus category they have seen while searching and react as soon as they encounter a second category. Thus, the increased working memory load of the target search task may also be involved in the lack of speeded detection effects in the target search task. The results of Experiment 2, however, suggest a restriction of this explanation: In the category search task, participants also had to keep the to-be-found category in working memory. Nevertheless, selective speeding of threat detection occurred. Thus, one would have to assume that only high levels of working memory load suffice to extinguish the speeded detection effect in anxiety.

Finally, the present results also speak to the role of reflexive versus voluntary processes in the allocation of attention. Regarding disorder-specific distraction by threat, it seems quite unlikely that the SFs voluntarily chose to look at spider distractors longer than necessary. After all, this would be unpleasant and against instructions. In fact, in a related eye-tracking study involving an unrestricted viewing situation, we recently found that SFs showed an attentional bias toward threat during the first 500 ms of stimulus presentation: When pictures of four different animals were shown simultaneously, the SFs' first fixation tended to be on the spider picture more often. After that, however, they showed avoidance of threat, focusing less often and for shorter durations on the spider picture (Rinck & Becker, 2004). Moreover, experimental paradigms such as the visual dot probe task have revealed attentional biases in anxiety many times (see Mogg & Bradley, 1998) but mainly with short presentation times that limit allocation of attention to reflexive processes (for similar conceptions, see LeDoux, 1996; Öhman, 1993). Indeed, the distinction between reflexive

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[1] We are grateful to one of the anonymous reviewers for suggesting this hypothesis.

versus voluntary attention has also been corroborated by neurophysiological data: Recent evidence suggests that different brain areas are involved in goal-directed search for stimuli versus reflexive detection of salient or unexpected stimuli (see Corbetta & Shulman, 2002).

Regarding the speeded threat detection observed here, voluntary allocation of attention seems an unlikely explanation as well. As mentioned above, this explanation would imply that SFs decided to spend less time looking at the neutral or pleasant distractors before they could know that the matrix contained a spider target. Therefore, one has to consider how reflexive attentional processes may be biased toward threat, and particularly so in anxiety disorders. In fact, in one way or another, most cognitive theories of anxiety postulate that threat stimuli receive a processing advantage, for instance, by being primed such that they are processed more efficiently by the perceptual system (e.g., by the "threat evaluation system" postulated by Mathews & Mackintosh, 1998; see also Clark & Wells, 1995; Eysenck, 1992; Mogg & Bradley, 1998; Williams et al., 1997). In the visual search task used here, this could be achieved by parafoveal vision: SFs may be particularly fast at shifting attention to spider pictures that are processed parafoveally while neighboring distractors are fixated. This hypothesis would also explain why no speeding of threat detection occurred when target type and distractor type are identical: In this case, parafoveal vision is insufficient because visual details have to be processed, for which they need to be fixated. Therefore, future studies should use eye-tracking techniques to study parafoveal processing more thoroughly than it was possible to do here.

Finally, what may be the function of an attentional bias that works in the way described here: directing reflexive attention toward threat, thereby creating increased distraction by threat, and sometimes also speeded detection of threat? In fact, it may be just the bias that humans and other animals need to survive in a dangerous world. Following other researchers (e.g., Fox et al., 2001; LeDoux, 1996; Öhman, 1993), we suggest that an important evolutionary function of anxiety is the quick detection of unexpected threat, enabling the individual to interrupt ongoing activities and react quickly by flight or fight. Thus, threat stimuli should be detected particularly quickly by any individual, anxious or nonanxious. Indeed, there is evidence that this is the case (e.g., Öhman et al., 2001). In anxiety patients, this adaptive bias is heightened to a suboptimal level, however. As a result, they tend to interpret innocent stimuli as threatening, their reflexive attention is captured by threat stimuli, they are overly distracted by them, and they find it hard to disengage attention from them. In addition, their physiological reactions to threat stimuli may be overly strong (Öhman & Mineka, 2001). In short, they mostly suffer from the disadvantages of an amplified attentional bias, without gaining much of an advantage.

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