The influence of emotional facial expressions and anxiety on visual attention orienting

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It has been argued that elevated anxiety is characterized by an attentional bias for threatening stimuli in the environment. That is, anxious individuals allocate attentional processing resources disproportionately toward threat material, such as angry faces. However, so far there is no agreement on the exact mechanisms of attention, responsible for such bias. Research regarding the time course of attentional processes has raised a debate, whether anxiety is associated with threat-related biases in initial shifting of attention, or with subsequent difficulties in disengaging attention. Recent experimental evidence suggests a role for disengagement difficulties in anxious individuals, manifested in increased dwell time on threatening stimuli.

The present study sought to replicate and extend the finding that the disengagement component of visual attention is biased in anxious individuals. The spatial cueing paradigm, with angry, happy, and neutral schematic faces as attentional cues, was administered to high and low trait anxious groups (n=25 and 24, respectively). In this task, the participants were required to detect peripherally presented targets, which were preceded by cues. The cues in the present study were non-informative, i.e., they did not predict the location where the target would appear. As a novel feature, four stimulus-onset-asynchrony (SOA) conditions were employed to enable a more detailed analysis of the time course of attentional processing.

At the shortest SOA of 200 ms, the basic pattern of facilitation with valid cues was found only with happy faces. All other SOAs resulted in significant inhibition of return (IOR), as expected. However, the anxiety groups did not differ in their reaction times (RTs) as a function of cue valence. Thus, the present study did not reveal any meaningful group differences in the processing of threatening stimuli. Possible reasons for the absence of facilitation and meaningful group differences include forward masking, direction of the contrast polarity of the display, state anxiety levels of the participants, and the threat value of the angry faces.

Keywords: anxiety; visual attention; attentional bias; facial expressions; spatial cueing paradigm

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1. INTRODUCTION

Attentional processes in the aetiology and maintenance of anxiety disorders have received a growing research interest in the past two decades (Derryberry & Tucker, 1994; Mathews & Mackintosh, 1998; Mogg & Bradley, 1998, 2004). Most of the research has been devoted to processes of visual attention. It has been argued that elevated anxiety is characterized by an *attentional bias* for threatening stimuli in the environment (e.g., MacLeod, Mathews, & Tata, 1986). Threatening stimuli can be, for example, angry facial expressions, pictures of blood or spiders, or words related to the personal concerns of an anxious person. In cognitive theories of anxiety, the exact mechanisms behind this bias have been modelled in different ways (see Mathews & Mackintosh, 1998; Mogg & Bradley, 1998, 2004; Williams, Watts, MacLeod, & Mathews, 1988; Öhman, 2000, for reviews). In common these theories share the assumption that anxious people allocate a disproportional amount of attentional processing resources toward threatening stimuli (e.g., Mathews & Mackintosh, 1998).

The study of attentional factors seems to be particularly relevant in the case of anxiety disorders, compared to other emotional disorders, such as depression. Earlier models (e.g., Bower, 1981) predicted that both anxiety and depression are associated with emotion-congruent biases in multiple information processing stages, such as attention, memory, and reasoning. However, subsequent research has made important corrections to this account. Studies employing the methods from cognitive psychology have mostly failed to find attentional biases associated with depression (Bradley, Mogg, Millar, & White, 1995a; MacLeod et al., 1986; McCabe & Gotlib, 1995) and explicit memory biases in anxiety (Bradley, Mogg, & Williams, 1995b; Coles & Heimberg, 2002; Mogg, Mathews, & Weinman, 1987).

The knowledge accumulated from the research on information processing in anxiety could also improve our understanding of the interaction between attention and emotion. A wealth of research has been devoted to the study of how animals and humans process fear-related information (e.g., LeDoux, 1996; Öhman & Mineka, 2001). There is evidence that fear-relevant and negatively valenced stimuli, such as angry faces, are able to capture attention more strongly than stimuli with other emotional content, also in participants not pre-selected by anxiety (Eastwood, Smilek, & Merikle, 2003; Fox et al., 2000; Pratto & John, 1991; Öhman, Lundqvist, & Esteves, 2001). For example, Eastwood et al. (2003) asked their participants to count the number of features (e.g., downward-curved arcs), which were embedded in displays of negative, positive, or neutral schematic faces. The results demonstrated that it took longer to count the features embedded in negative faces, compared to positive and neutral faces. The authors (Eastwood et al., 2003) took this as evidence of the attention-capturing power of negative facial expressions. Early event-related potentials (ERPs), recorded to facial stimuli, have also been shown to be particularly sensitive to threatening expressions: Schupp et al. (2004) reported that, compared to friendly and neutral expressions, viewing threatening faces resulted in an enlarged early posterior negativity. The viewing of threatening faces resulted also in augmented late positive potentials (LPPs) relative to other expressions, which indicates a more elaborate perceptual processing of threatening stimuli (Schupp et al., 2004). Based on the findings that anxious people allocate attention disproportionately to threatening stimuli, it has been suggested that the study of anxious individuals "provides a good opportunity to observe highly sensitized attentional processes" (Fox, Russo, Bowles, & Dutton, 2001, p. 682).

1.1. State and trait anxiety

A distinction between the concepts of *state* and *trait* anxiety is often made. Trait anxiety refers to a relatively stable personality disposition, which includes a "propensity to experience anxiety, and tendencies to perceive stressful situations as threatening" (Bieling, Antony, & Swinson, 1998, p. 780). State anxiety is conceptualized as a more fluctuating level of situational anxious mood (e.g., Öhman, 2000). A widely used tool for measuring state and trait anxiety is the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1977). The STAI is a relatively short self-report questionnaire, which contains 40 items, with equal number of items measuring state and trait anxiety.

Apart from methodological considerations, the distinction between state and trait anxiety is meaningful also theoretically. An earlier cognitive model by Williams et al. (1988) predicted that the level of trait anxiety determines the *direction* of attentional biases for threatening stimuli. That is, high trait anxious individuals tend to orient their attention preferentially toward threat, whereas individuals with low levels of trait anxiety have a tendency to orient their attention *away* from threat. Stressful situations (i.e., elevated state anxiety) intensify these directional biases, hence making low trait anxious individuals more avoidant of threat, and having high trait anxious individuals become even more vigilant for threatening stimuli. From an evolutionary view, consideration of this *interaction hypothesis* (Williams et al., 1988) raises a problem: Would it be wise for low trait anxious individuals to orient their attention away from threatening stimuli more strongly when they become more (state) anxious? Intuitively, one would conclude that such a strategy would prevent a low trait anxious individual from recognizing actual dangers in the environment when in a threatening situation (see also Mathews, 1990).

With the aforementioned considerations in mind, Mogg and Bradley (1998) introduced a cognitive-motivational view of attentional biases in anxiety (see Figure 1; see also Mathews & Mackintosh, 1998, for a similar model). In their model, a key factor in modulating the direction of attentional biases is the threat value of the stimulus (high vs. low threat). When a stimulus is appraised as highly threatening, an individual will react with increased attentional orienting towards that stimulus. Conversely, when a stimulus is perceived to be relatively harmless (low threat value), individuals will ignore it or orient their attention away from it. The level of trait anxiety has an influence on whether a high or low threat status is assigned to a particular stimulus. That is, individuals high in trait anxiety assign high subjective threat value to such negative stimuli, which others would view as trivial. This results in high trait anxious individuals orienting their attention towards such stimuli more strongly than is the case for low trait anxious individuals.

An important correction to the model of Williams et al. (1988) in these more recent models (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998) is that individuals low in trait anxiety will also, in some circumstances, assign high threat value to stimuli and orient their attention to threat (see Figure 1). This can occur, for example, when state anxiety increases to a sufficient level (resulting in milder aversive stimuli appraised as having a high threat value), or when a particular stimulus genuinely has a high threat value (an actual danger). Experimental evidence for these views (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998) has been found with pictorial scenes (Mogg et al., 2000a; Yiend & Mathews, 2001), and emotional faces (Wilson & MacLeod, 2003), with the threat levels of the stimuli systematically varied in these experiments.

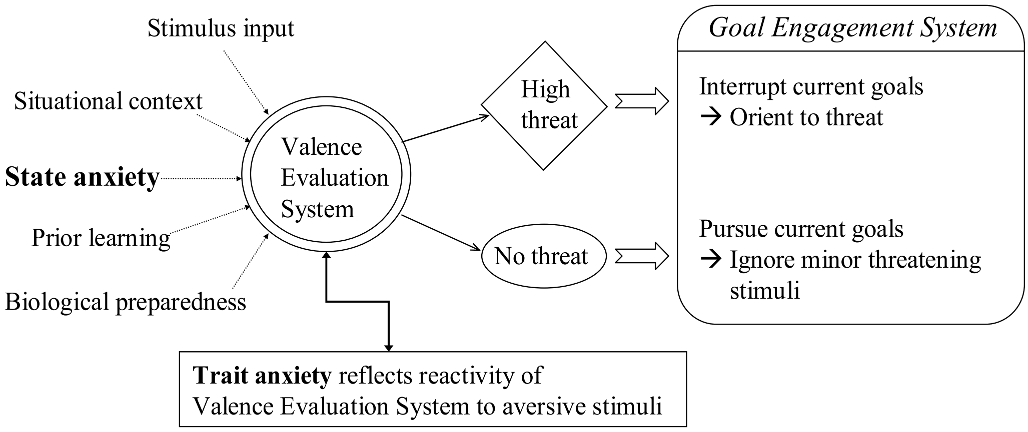

Figure 1. Cognitive-motivational model of attentional biases in anxiety. Adapted from Mogg and Bradley (1998).

1.2. Components of visuospatial attention

As most of the research on attentional biases in anxiety has been conducted in the field of visual attention, it is appropriate to describe the basic mechanisms of attentional orienting in visual space. It is assumed that the general function of visual attention is to facilitate the processing of relevant stimuli in the environment, relative to other stimuli (Posner & Dehaene, 1994). Related to this view, visuospatial attention has been described as a "spotlight" (Posner, Snyder, & Davidson, 1980). In such models, the spotlight is an area in the visual field that one currently attends to, and which serves to facilitate the detection and processing of stimuli within the area covered by the spotlight (see Cave & Bichot, 1999, for a review). The orienting of the spotlight has also been shown to be independent of eye movements, i.e., the focus of one's attention is not necessarily related to the direction of one's foveal vision (Posner et al., 1980).

1.2.1. Attentional networks

According to the highly influential model of Posner and his colleagues (Posner & Dehaene, 1994; Posner & Petersen, 1990; Posner & Raichle, 1994), attention can be divided into different subsystems that serve different functions and that can be anatomically dissociated (Posner & Petersen, 1990). For the purposes of the present study, the functions of the *posterior* and *anterior* attentional networks will be described.

The posterior network – located at the areas of superior parietal cortex, pulvinar and superior colliculus – is thought to be involved in relatively involuntary and covert (independent of eye movements) orienting to sensory stimuli, i.e., this network automatically orients the attentional spotlight from one location to another in visual space (Posner & Petersen, 1990). When a new abrupt stimulus appears in the visual field, the posterior network undergoes a chain of different cognitive operations: first, attention is *disengaged* from its current focus, then the attentional focus is *shifted* to the location of the novel stimulus, and finally, attention is *engaged* in the new location (Posner & Petersen, 1990; Posner & Raichle, 1994). Such automatic covert orienting "appears to function as a way of guiding the eye to an appropriate area of the visual field" (Posner & Petersen, 1990, p. 27).

The anterior attentional network – covering the anterior cingulate gyrus and basal ganglia – is a more conscious and voluntary system that serves an executive function (Posner & Dehaene, 1994). It has the ability to regulate the direction of attentional focus by exercising control over the posterior network, and to inhibit automatic response tendencies (Posner & Raichle, 1994). When there is no need or specific instructions given to control the direction of visual orienting, the anterior network does not actively control the posterior network (Posner & Petersen, 1990). In complex cognitive tasks, the anterior network is able to maintain attention to relevant information (Posner & Raichle, 1994). As such, the operations of the anterior attentional network resemble the functions of the central executive system, as described by Cowan (1995).

1.2.2. Facilitation and inhibition

One of the most commonly used experimental tasks to study the components of visuospatial attention is the *spatial cueing paradigm* introduced by Posner (1980). In the original task, subjects are instructed to give a manual response every time a target (e.g., a small asterisk) appears in one of two different peripheral locations, which are usually designated as a rectangle on the left and right side of a central fixation point. The appearance of the target is on the majority of trials preceded by a cue in one of the two peripheral rectangles. The cue has typically been a brightening of one of the rectangles for a short period, e.g., 150 milliseconds (ms). Trials can be *valid*, i.e., the target appears in the same location as the preceding cue, or *invalid*, when the target appears in the contralateral side of the cue. On *neutral* control trials the target is not preceded by a cue. *Catch* trials, in which the cue is not followed by a target, and the subject has to withhold from responding, are also included.

The peripheral visual cues serve to guide attention reflexively to their location (Posner & Cohen, 1984). The cues can be informative (the cue predicts the location where the target will appear on majority of the trials, e.g., with an 80/20 probability), or non-informative (the cue does not predict the target location, i.e., a 50/50 probability). Recent results (e.g., Rosen et al., 1999) are in line with the suggestion that when the cues are informative, the anterior network will exert more powerful control over the orienting functions of the posterior network. That is, with informative cues, the anterior network acts to maintain attention on the most probable target locations (e.g., Ávila & Parcet, 2002).

Usual findings in the spatial cueing tasks with peripheral cues are as follows. Reaction times (RTs) are typically faster on valid trials, compared to neutral and invalid trials (e.g., Posner, 1980). This *facilitation* (also known as a *cue validity effect*) is found with the cues being informative (e.g., Riggio & Kirsner, 1997), non-informative (e.g., Berger, Dori, & Henik, 1999), or even when the probability of the trials being valid is only 0.1 (Posner & Cohen, 1984). Facilitation reflects automatic and involuntary capturing of attention by the cue, which results in facilitation of perceptual processing at the cued location (Müller & Humphreys, 1991; Posner & Cohen, 1984). On invalid trials, attention has to be first disengaged from the cued location, and this process of shifting attention to the uncued location delays responding on invalid trials (Posner & Raichle, 1994).

Extensive research into the time course of attentional processes in the spatial cueing task has produced another well-documented attentional phenomenon. When the temporal distance between the onset of the cue and the onset of the target (*stimulus-onset-asynchrony*; SOA) is sufficiently long (over 300 ms in the original task), responses to invalid trials become faster (Posner & Cohen, 1984). This *inhibition of return* (IOR; see Klein, 2000, for a review) has been demonstrated in non-informative peripheral cueing experiments in which the subject's task has been to detect targets by pressing a single response key (Posner & Cohen, 1984), to discriminate between two targets (Lupiánez, Milliken, Solano, Weaver, & Tipper, 2001), or to indicate whether the target occurs on the left or right rectangle (Pratt, Kingstone, & Khoe, 1997). It has been shown that inhibition can be also related to objects, and not only to spatial locations, i.e., when attention is disengaged from an object, and the same object is subsequently moved to a new location, an inhibition effect has been shown to move with the object (e.g., Gibson & Egeth, 1994)

It is assumed that IOR reflects the operation of a posterior network-related mechanism that "serves to prevent attention from returning to the previously disengaged location" (Ávila & Parcet, 2002, pp. 716-717), thereby increasing the efficiency of visual search (Klein, 2000). In other words, if the target does not appear at the cued location immediately after the cue, a beneficial strategy is to explore other locations and to inhibit attention from returning to the cued location. The time course of IOR in the spatial cueing task depends on the nature of the task. In target detection tasks, IOR is evident within 300 ms after the cue onset (Posner & Cohen, 1984). When the attentional demands of the task increase, the onset of IOR is delayed: Lupiánez et al. (2001) found that IOR was evident in detection task at a SOA of 400 ms, but a target discrimination task still produced facilitation at the same SOA. With longer intervals (700 and 1000 ms) both detection and discrimination tasks produced IOR (Lupiánez et al., 2001). According to Klein (2000), both facilitation and inhibition begin immediately after the cue onset. He suggested that inhibition remains fairly constant over time, whereas facilitation decreases quite briefly, thereby obscuring inhibition for a short period.

1.3. Experimental evidence for attentional biases in anxiety

In the sections below, currently available evidence for attentional biases in anxiety will be reviewed. Focus is on how the findings have been – or could have been – explained in reference to the framework of attention outlined in the sections above. In addition to the methods described here, visual attentional processes in anxiety have also been investigated with other well-known paradigms, such as the visual search task (e.g., Gilboa-Schechtman, Foa, & Amir, 1999). It will also be noticed whether the results have been explored in reference to state or trait anxiety, an interaction of both, or a clinical anxiety disorder, such as generalized anxiety disorder (GAD).

1.3.1. The emotional Stroop task

In the original Stroop experiment, participant's task was to name as fast as possible the colour of a word presented on a card or on a computer screen (see MacLeod, 1991, for a review). The stimulus could be congruent (e.g., the word "blue" printed in blue), or incongruent ("blue" printed in green). A robust finding in such a task is that when the semantic content of the word is in conflict with the actual colour of the word, interference occurs, i.e., responses to incongruent trials are significantly slower (MacLeod, 1991). This interference can be thought to reflect the stronger activation of the anterior attention network (most notably the anterior cingulate gyrus) during incongruent trials in order to inhibit automatic response tendencies activated by the word's semantic content (Posner & Raichle, 1994).

There are several modified versions of the Stroop task, but for the present study, the most relevant is the emotional Stroop task (Mathews & MacLeod, 1985). In this colour-naming task, the emotional content of the stimulus words could be negative, positive, or neutral. Anxiety is commonly associated with greater interference (i.e., longer colour-naming latency) on threatening stimulus words, and specifically on words related to the personal concerns of the participants (see Williams, Mathews, & MacLeod, 1996, for a review). For example, Mogg, Bradley, Williams, and Mathews (1993a) presented anxiety-related negative, depression-related negative, positive, categorized neutral, and uncategorized neutral stimulus words to groups of anxious, depressed, and control participants. A half of the words was presented subliminally [i.e., very rapidly (only for 14 ms), and then masked by a random letter string], and the other half was supraliminally presented (i.e., long enough to allow conscious registration of the word meaning). Anxious participants, compared to depressed and control participants, had relatively slower responses to both subliminal and supraliminal negative words (both types of negative words). In a study of non-clinical participants by Mogg, Kentish, and Bradley (1993b), the level of trait anxiety was most strongly related to the magnitude of Stroop interference. However, Egloff and Hock (2001) found evidence also for the interaction hypothesis in their study of non-clinical students, as their results showed that only for individuals high in trait anxiety was state anxiety positively related to Stroop interference.

Different accounts of such anxiety-related Stroop interference have been put forward. Most accounts share the assumption that emotional Stroop interference to threatening words reflects a stronger capturing of attention by threatening stimuli in anxious participants (see Williams et al., 1996, for a review). Specifically, because of the evidence of Stroop interference to subliminally presented stimuli, Mogg et al. (1993a), suggested that, in anxious individuals, attention is automatically – and independently of conscious awareness – drawn toward threatening stimuli. Thus, the anxiety-related Stroop interference occurs temporally at the initial orienting stage of attention. Pratto and John (1991) came to similar conclusions after having found that also participants not pre-selected by anxiety showed interference to negative trait adjectives. When fitted in Posner’s model of visual attention (Posner & Petersen, 1990), this capturing of attention by threatening words can be seen to reflect the shift component of attentional orienting.

Some criticism towards common interpretations of the emotional Stroop interference has, however, been raised. Fox et al. (2001) noted that it is virtually impossible to determine whether the threatening words affect the shift component or the disengage component of visual attention. They suggested that the emotional Stroop interference could also reflect delayed attentional disengagement from the processing of threatening word content (Fox et al., 2001). Because the words are presented centrally, within foveal vision, they are always attended to some level. Thus, the emotional Stroop task is a fairly indirect measure of the allocation of attention toward threatening stimuli (cf. MacLeod et al., 1986).

1.3.2. The attentional probe task

In order to examine more directly whether anxiety is indeed characterized by enhanced initial orienting towards threatening stimuli (i.e., the shift component of attention), MacLeod et al. (1986) introduced the attentional probe task (also called the dot probe task). In this task, a pair of stimuli is presented simultaneously on the screen, usually for 500 ms (MacLeod et al., 1986). The stimuli are aligned either horizontally (e.g., Mogg et al., 2000a) or vertically (e.g., MacLeod et al., 1986). On critical trials, one of the stimuli is threatening, and the other emotionally neutral. Originally, the attentional probe task employed words as stimuli (MacLeod et al., 1986), but subsequently, emotional pictorial scenes (Mogg et al., 2000a), and emotional facial expressions (e.g., Bradley, Mogg, Falla, & Hamilton, 1998) have also served as stimuli. On critical trials, immediately after the offset of the stimulus pair, a small dot appears in the location of one of the stimuli, and the participant's task is to press a button as soon as he or she detects the dot (MacLeod et al., 1986). In some studies, participants' task has been to discriminate between two targets (Bradley et al., 1998), or to indicate the location of the target (Mogg et al., 2000a).

The logic behind the attentional probe task is that differences in reaction times (RTs) indicate where the participant has shifted his or her spatial attention, because manual responses to attended targets are usually faster (cf. Posner et al., 1980). A typical finding in the attentional probe task is that anxious participants are faster in responding to targets replacing threat stimuli, compared to targets replacing neutral stimuli (e.g., Bradley et al., 1998; MacLeod et al., 1986; Mogg et al., 2000a). This bias for threat locations in the attentional probe task has been found in high trait anxiety (e.g., Bradley et al., 1998), high state anxiety (Mogg, Bradley, de Bono, & Painter, 1997), GAD (MacLeod et al., 1986), and social phobia (Mogg, Philippot, & Bradley, 2004).

Authors have commonly explained the attentional probe results as indicating faster initial shifting of attention to threat in anxiety (e.g., Mogg & Bradley, 1998; Williams et al., 1988). Counterarguments for these explanations include the notion that the usual presentation time of 500 ms for the stimulus pair might allow for more than one shift of attention between the stimuli, hence the results would not necessarily indicate a tendency to initially orient attention to threat (Mogg & Bradley, 1998). Mogg and her colleagues (Mogg et al., 1997) investigated this possibility by presenting the word probes for 100, 500, or 1500 ms in their study. High state anxious participants were significantly faster in responding to targets replacing threat words already in the 100 ms exposure condition, and the results revealed similar non-significant trends in the 500 and 1500 ms conditions, too.

Moreover, recently Mogg and Bradley (2002) even found faster responding to subliminally presented angry faces in social anxiety. The authors (Bradley et al., 1998; Mogg & Bradley, 1998, 2002; Mogg et al., 1997, 2004) have taken such results as compelling evidence for the view that anxiety is associated with faster initial orienting towards threatening, compared to neutral, stimuli. Furthermore, they argue that this initial bias is not necessarily followed by subsequent active avoidance of threat-related material, as is suggested by some theories (i.e., the vigilance-avoidance hypothesis; e.g., Mathews, 1990). The initial orienting view is supported also by studies reporting faster initial eye movements toward threatening faces in anxiety (e.g., Mogg, Millar, & Bradley, 2000b).

Recently, the abovementioned explanations for the attentional probe task findings have attracted new criticism, which concerns the possible role of disengagement processes in producing the typical findings (Derryberry & Reed, 2002; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Koster, Crombez, Verschuere, & De Houwer, 2004b). The attentional probe studies have without exceptions analyzed data only from trials including a threat-neutral (T-N) stimulus pair (e.g., Bradley et al., 1998; MacLeod et al., 1986; Mogg & Bradley; 2002; Mogg et al., 1997, 2000a). When neutral-neutral (N-N) stimulus pairs have been employed (e.g., MacLeod et al., 1986; Mogg et al., 1997, 2000a), they have acted as filler trials and have not been included in the data analysis. Thus, RTs have only been compared within the T-N stimulus pair, i.e., between trials when the probe replaces the threat stimulus and trials when the probe replaces the neutral stimulus. Derryberry and Reed (2002) suggested that "the bias favouring threatening locations may often arise from slow reactions to neutral locations due to delays in disengaging from the threatening locations" (p. 226).

Koster and his colleagues (2004b) went on to experimentally examine this possibility. They analyzed the RT data from T-N and N-N stimulus pairs which were presented to a sample of students. As predicted, on T-N stimulus pairs, responses were clearly faster when the probe replaced the threatening stimulus, and this effect was stronger in high trait anxious participants. However, when the RTs on T-N trials were compared to the mean RT of N-N trials (i.e., a neutral baseline), it turned out that participants were not faster in responding to probes replacing threat stimuli on T-N trials. On the contrary, responses to probes replacing neutral stimuli on T-N trials were significantly slower than the mean RT of N-N trials. On the basis of their results, they (Koster et al., 2004b) argued that the "data from previous dot probe studies cannot unambiguously be interpreted as vigilance for threat" (p. 8). Amir and Elias (cited in Amir, Elias, Klumpp, & Przeworski, 2003) came to similar results with socially phobic participants. Thus, the findings from attentional probe studies might indicate that anxiety is associated with a difficulty in disengaging attention from threatening stimuli, and it remains uncertain whether anxiety is also associated with a bias in the initial shifting of attention.

1.3.3. The spatial cueing paradigm

Ávila and his colleagues have examined attentional processing in anxiety with the basic version of the spatial cueing task (Ávila, 1995; Poy, Eixarch, & Ávila, 2004). Ávila (1995) compared the performance of participants high or low in self-reported anxiety, and found no group differences in reaction times at a SOA of 150 ms. However, Poy et al. (2004) found that higher self-reported anxiety was associated with greater *costs* (RT difference between neutral and invalid trials) at a SOA of 100 ms with peripheral cues. This result indicated an anxiety-related difficulty in disengaging attention from a peripheral cue that signals a probable target location (the cues were informative in this study). They (Poy et al., 2004) interpreted this finding to be in line with theories suggesting greater distractibility by neutral and aversive peripheral stimuli associated with anxiety.

Stormark, Nordby, and Hugdahl (1995) were the first to introduce an "emotional" version of the spatial cueing task, which is also applied on the present study. In this modified version, instead of brightening of the peripheral rectangles, an emotional word (e.g., Ávila & Parcet, 2002), emotional facial expression (Fox et al., 2002), or an affective picture (Yiend &

Mathews, 2001) is presented briefly as a peripheral cue. The emotional version has produced facilitation (i.e., faster responding on valid trials with a short SOA) in a way similar to the original task version (Amir et al., 2003; Ávila & Parcet, 2002; Derryberry & Reed, 2002; Fox et al., 2001, 2002; but see Stormark et al., 1995, and Yiend & Mathews, 2001, for exceptions).

Fox et al. (2001, exp. 3) presented schematic faces with happy, angry, or neutral expressions as peripheral cues for 250 ms. This was followed by a blank interval of 50 ms (producing a SOA of 300 ms), after which the target appeared in the same location (valid trials), or in the opposite side of the display (invalid trials). The participants' task was to localize the side of the screen on which the target appeared. The results revealed that high state anxious participants were slower to respond to targets after an invalid angry face cue, compared to happy and neutral invalid cues (for which the RTs did not differ from each other). The low state anxious group did not exhibit differences between different face cues on invalid trials. As the authors concluded, this result indicated that anxious participants were slower in disengaging their attention from angry faces. Valid angry face cues did not result in faster responding in either group. Interestingly, responses to happy valid cues were faster than responses to valid angry cues in the high state anxious group, suggesting an influence on the shift component of attention by happy faces in anxious participants. However, the authors considered this result spurious, since it did not occur in other experiments.

The main finding of anxiety-related delayed disengagement from threatening cues has been replicated in a growing number of experiments. Fox et al. (2001, exp. 4) employed a target detection task with a 300-ms SOA, and had real photographs of emotional faces as cues. This resulted, again, in high state anxious group displaying slower responding after invalid angry cues. RTs were similar to all invalid cues in the low state anxious group. In addition, no expression-related differences on valid trials occurred. When threatening words have served as cues, delayed disengagement has been documented in clinical social phobia with a SOA of 600 ms (Amir et al., 2003). Ávila and Parcet (2002) reported a greater validity effect (RT difference between valid and invalid trials) for threat words in anxious participants with a SOA of 100 ms. Although they did not report whether the larger effect was due to faster shifting or slower disengagement, inspection of their results suggests that slower disengagement from threat words caused the effect. Their interpretation of the result was that the aversive (threat) cues activated the anterior network more strongly in anxious subjects, thereby interfering the orienting functions of the posterior network, and resulting in a larger validity effect (Ávila & Parcet, 2002).

Fox et al. (2002, exp. 1) – in an attempt to replicate and extend the main findings of their previous study (Fox et al., 2001) – employed a target discrimination task, and grouped their participants by trait anxiety. They (Fox et al., 2002, exp. 1) surprisingly found that high trait anxious participants showed delayed disengagement from both angry and happy invalid face cues (cf. Fox et al., 2001), suggesting of a general emotionality effect. Again, no other significant differences emerged. This result is interesting and requires further investigation, since other studies, which have included positively valenced peripheral cues, have produced mixed results. Amir et al. (2003) found no evidence of a social phobia-related attentional bias for positive word cues with a SOA of 600 ms, whereas Derryberry and Reed (2002) did found that high trait anxiety resulted in delayed disengagement from positive symbolic cues with 500-ms SOA.

In addition to the research by Fox and her colleagues (2001, 2002), only Pollak and Tolley-Schell (2003) have so far applied the spatial cueing paradigm with faces as cues, but they studied physically abused children, who did not differ from control children in self-reported anxiety. Emotional pictorial scenes have so far been used in only one study. Yiend and Mathews (2001) presented threatening and neutral pictures as peripheral cues for 500 ms, and then the participants had to discriminate between two different targets. The low anxious group displayed the typical, albeit quantitatively small, pattern of facilitation by valid cues, which was not affected by cue type (threat or non-threat). The high anxious group, however, showed this validity effect only with trials involving threatening cues. This effect was caused by relative slowing on invalid threatening trials. The RTs for valid and invalid non-threat trials did not differ from each other in the high anxious group.

Authors have also employed the spatial cueing paradigm to investigate the influence of anxiety and emotional stimuli on the time course of attentional processes. Ávila (1995) presented the basic non-emotional spatial cueing task to students with differing anxiety levels. With a SOA of 1000 ms, anxious subjects demonstrated a larger inhibition of return (IOR) effect. His (Ávila, 1995) interpretation of the result was that the anxious participants displayed a greater difficulties in shifting attention away from the most probable target locations (i.e., from the uncued side when the target did not appear in the cued side), and engaging attention in previously revised locations.

Fox et al. (2002) examined whether emotional cues and anxiety have any effects on IOR. They hypothesized that if attentional disengagement from angry faces takes longer in anxious individuals, then the magnitude of IOR should be reduced when angry faces serve as cues. They (Fox et al., 2002, exp. 2) employed a target localization task with a SOA of 960 ms, and found neither IOR nor facilitation with angry face cues, but significant IOR effects with happy and neutral cues. Furthermore, the results were similar with all participants regardless of trait anxiety levels, supporting the view of a general attention-capturing power of angry faces and threatening stimuli (cf. Eastwood et al., 2003; Öhman et al., 2001). In a replication, Fox et al. (2002, exp. 3) added a mood induction procedure in order to elevate the state anxiety levels, and replaced the happy faces with scrambled faces, which contained the features of an angry face. Now, the low anxious participants displayed a similar IOR to all faces, whereas the high anxiety group still showed no IOR or facilitation with angry faces.

Two other studies have so far examined whether the delayed disengagement from threatening stimuli has an effect on IOR. Yiend and Mathews (2001) used a discrimination task with pictorial cues and 2000-ms SOA. Similar to Fox et al. (2002, exp. 2), they found significant IOR only with non-threatening pictures, but not with threatening pictures, and the results were similar in high and low trait anxiety groups. Ávila and Parcet (2002) employed a detection task with word cues and SOAs of 100 ms and 500 ms. All participants displayed a significant IOR effect at the 500 ms SOA, which was not affected by cue valence or anxiety level.

Thus, with short SOAs, studies employing the spatial cueing task have produced fairly convincing evidence for anxiety-related difficulties in disengaging attention from threatening stimuli. However, research concerning attentional disengagement at longer time durations has produced quite variable results. Some proportion of this variability could be due to different response requirements in these studies (localization in Fox et al., 2002; discrimination in Yiend & Mathews, 2001; detection in Ávila & Parcet, 2002). As noted earlier, IOR typically occurs sooner in detection tasks (Lupiánez et al., 2001). This might explain why Ávila and Parcet (2002) obtained IOR at 500-ms SOA, but Amir et al. (2003), using a localization task, still obtained facilitation at 600-ms SOA. The threat level of the stimuli is also known to be of importance (Mogg & Bradley, 1998). When milder threat stimuli, such as words, are used as cues, it might be easier to disengage attention from them, and thus the possible differences in the magnitude of IOR would be diminished (cf. Ávila & Parcet, 2002). With more threatening cues, such as angry faces or pictorial scenes, there might exist a general difficulty in disengaging attention completely from such stimuli (Fox et al., 2002, exp. 2; Yiend & Mathews, 2001).

2. THE PRESENT STUDY

The present study sought to replicate and extend the existing findings gathered so far with the spatial cueing task. An emotional version of the spatial cueing task, with schematic angry, happy, and neutral faces as peripheral cues, was administered to two groups differing in trait anxiety levels. A replication of this task with face cues is of importance, since so far only one group has used such cues (Fox et al., 2001, 2002). Furthermore, the results of Fox and her colleagues have been somewhat variable. When the cue was presented for only 100 ms, all participants displayed a larger validity effect (i.e., delayed disengagement) with angry faces, compared to happy and neutral faces (Fox et al., 2001, exp. 2). Additionally, in experiment 3, valid happy faces resulted in speeded detection in the high state anxious group. Fox et al. (2002) found anxiety-related delayed disengagement from both angry and happy faces (exp. 1). As discussed earlier, the existing data concerning the effects of anxiety and emotional cues on inhibition of return are also far from unequivocal.

A novel feature of the present study is the inclusion of multiple SOAs at equally long time intervals. The shortest SOA of 200 ms is expected to yield – in addition to the basic facilitation after valid cues – delayed target detection after an invalid angry face cue. This effect should be especially apparent in high trait anxious participants. The longest SOA of 950 ms is expected to result in significant inhibition of return. How much this inhibition is affected by anxiety level, or different facial expression cues, is difficult to predict in light of the previous findings. Additionally, two intermediate SOAs of 450 ms and 700 ms were included in order to explore more accurately if there are differences in the time scale of attentional disengagement as a function of anxiety level or the emotional valence of the cue.

In regard to the debate whether anxiety is associated with threat-related biases in shifting attention (Mogg & Bradley, 1998), or with subsequent disengagement difficulties (e.g., Amir et al., 2003; Fox et al., 2001, 2002), it is acknowledged that the present study can not give a conclusive answer to this question. Peripheral cues produce reflexive shifts of attention to their location, which result in very fast RTs on valid trials with short SOAs (Posner, 1980). Thus, as also Fox et al. (2001) noted, it may not be realistic to expect further speeding of RTs by angry valid cues in anxious participants.

The present study has also some methodological alterations compared to the studies reviewed above. First, throughout the experiment, all cues were non-informative, i.e., the cues predicted the target location on a 50/50 basis. In other relevant studies, the majority of the cues have been valid (Amir et al., 2003; Ávila & Parcet, 2002; Derryberry & Reed, 2002; Fox et al., 2001, 2002; Yiend & Mathews, 2001). As IOR (Klein, 2000), and facilitation (Berger et al., 1999) typically occur with non-informative cues, it was decided to use a 50/50 probability throughout the experiment to keep all SOAs comparable. Second, neutral trials (where no cue is presented before the target) were not included. Instead, RTs after angry and happy cues were compared to RTs after face cues with neutral expressions. Some previous studies have included a neutral no-cue condition (Amir et al., 2003; Stormark et al., 1995; Yiend & Mathews, 2001), whereas others have not (Ávila & Parcet, 2002; Derryberry & Reed, 2002; Fox et al., 2001, 2002). Third, simple target detection was used as a response requirement, in order to avoid the possible confounding influence of stimulus-response compatibility effects, which might be evident in localization tasks (cf. Fox et al., 2001).

Thus, the aims of the present study are as follows:

1. The shortest SOA of 200 ms is expected to result in faster RTs to validly cued trials in all participants.
2. Additionally, based on previous findings (Fox et al., 2001, 2002), it is hypothesized that the high trait anxiety group displays delayed disengagement from angry faces (longer RTs after invalid angry cues, compared to invalid happy and neutral cues) at the 200-ms SOA.
3. For the longer SOAs, the aim of the present study is to describe more accurately the time course of IOR. Due to the inconsistencies in the currently existing data (cf. Ávila & Parcet, 2002; Fox et al., 2001, 2002; Yiend & Mathews, 2001), straightforward hypotheses about the influences of anxiety and emotional cues on IOR are not made. Because a detection task is used, all the SOAs of 450, 700, and 950 ms are expected to result in significant IOR. Should the logic of Fox et al. (2002, exp. 3) prove to be correct, all participants should display attenuated IOR for angry faces at the 450-ms SOA. For the low trait anxiety group, this attenuation might disappear with the 700-ms and 950-ms SOAs, whereas the high anxiety group should still display attenuated IOR for angry faces at the 700-ms and 950-ms SOAs.

3. METHOD

3.1. Participants

The trait version of the State-Trait Anxiety Inventory (STAI-Trait; Spielberger et al., 1977) was first administered to a pool of local upper secondary school students and introductory psychology students (*n*=224) approximately one week before the experimental session. Mean STAI-Trait score for the whole sample was 37.9 with a standard deviation (SD) of 8.2. Two groups representing high and low trait anxiety were formed on the basis of the STAI scores, and they were invited to the experimental session. Participants with scores lying near the median were not invited. Mean STAI-Trait scores were 52.3 (SD=6.5) and 28.6 (SD=3.3) for the high (*n*=25) and low (*n*=24) trait anxious groups, respectively. All participants younger than 18 years had written consent from their parents.

3.2. Stimuli and apparatus

The target to be detected was a small asterisk (*), measuring 0.4º of visual angle. Cues and the target were presented inside two black-edged rectangles, which were flanked 3.9º left and right of a central 0.4º fixation point (+). The rectangles subtended 4.7º horizontally and 5.2º vertically. Cues were schematically drawn faces displaying angry, happy, or emotionally neutral expressions, and they were similar to faces used in previous experiments (e.g., Hietanen & Leppänen, 2003; Öhman et al., 2001). The faces measured 3.2º and 3.6º of horizontal and vertical visual angle, respectively. All stimuli were black, and they were presented against a white background on a 17-inch computer monitor (1024 x 768 pixels, 75 Hz). E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) controlled the stimulus presentation and data collection, and was run on a 2,40 GHz Pentium PC. The participants gave manual responses by pushing the middle button of an E-Prime button box.

3.3. Procedure

Between one and four participants took part in the computerized experiment at the same time. After arriving to the laboratory, the participants first completed the state version of the STAI (STAI-State). They were then asked to sit in front of a computer, in which the experiment was ready to get started. A head-rest was used in order to maintain the participant's viewing angle and viewing distance from the monitor (57 cm) steady throughout the experiment.

The participant's task was to detect the target (*) every time it appeared in one of the two rectangles. The participant was instructed to press the response key with her or his dominant hand's index finger as quickly as possible after detecting the target. On catch trials (13% of all trials), no target appeared on the screen, and the participant had to withhold her or his response. The target was always preceded by a face cue presented in the *upper* half of either the left or right rectangle. The target then appeared, after a fixed time interval, in the *lower* half of the rectangle. This procedure was chosen to prevent any forward masking of the target by the cue, and it has been applied in previous studies (cf. Fox et al., 2001, 2002).

The precise sequence of events on each trial was as follows (see Figure 2): A central fixation point (+) and two peripheral empty rectangles were presented at the screen, at eye level, for 750 ms. Participants were instructed to fixate their eyes on the fixation point throughout each trial. A face cue was then presented in the left or right rectangle for 100 ms. After this, the face disappeared, and only the fixation point and two empty rectangles remained on the screen. Then, after a fixed time interval of 100, 350, 600, or 850 ms, the target appeared in the left or right rectangle, and remained visible until response, or for 2000 ms, if the participant did not respond. After this, the rectangles and the fixation point disappeared from the screen, and the screen was blank for a 1000-ms inter-trial interval.

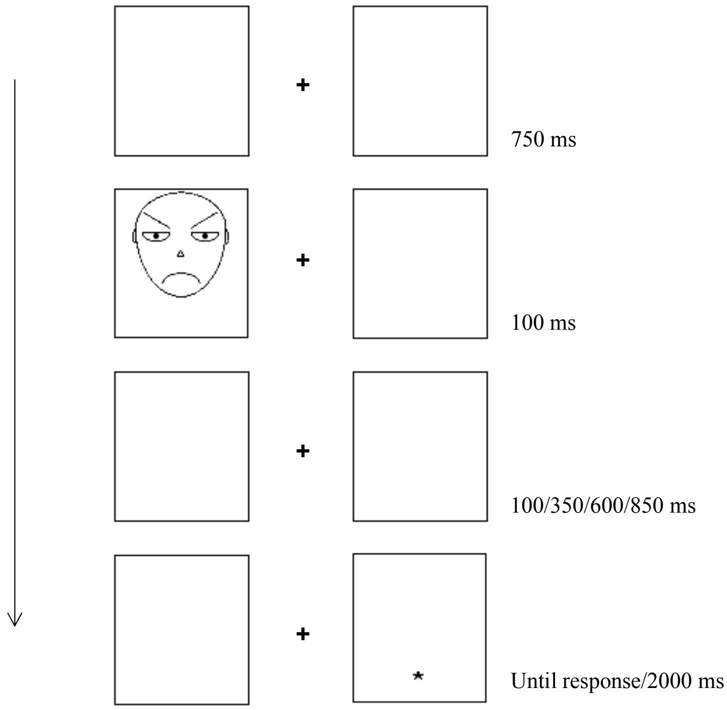

Figure 2. Sequence of events on an invalid trial with an angry face as a cue. The figure does not depict the actual size of the stimuli.

Four different stimulus-onset-asynchronies (SOAs) were thus employed: 200, 450, 700, and 950 ms. All SOAs were presented in separate blocks. The order of the block presentation was counterbalanced between the participants. The experiment started with a practice block of 15 trials, including three catch trials. Then it was assured that the participants had understood the instructions correctly. After this, the participants completed all the 552 experimental trials, which included 72 catch trials. The trials were distributed in four blocks, each block employing one SOA. The probability of valid and invalid trials was equal. Thus, one block included 60 valid trials (20 for each facial expression), 60 invalid trials, and 18 catch trials (three for each expression appearing in the left and right rectangle), giving a total of 138 trials presented in random order within a block. The probability of the cues and the target appearing in the left- or right-side rectangles was also equal. Participants were encouraged to rest as long as they wished between the blocks, and they could start the next block by pressing the response key. The duration of completing all the four blocks was approximately 30 minutes. Reaction time data were analyzed from all valid and invalid experimental trials. These 480 trials included an equal number (160) of angry, happy, and neutral face cues.

3.4. Design

A 2 × 2 × 3 × 4 ANOVA mixed design was used to analyze the reaction time data. Group (high or low trait anxiety) served as a between-subjects factor, while Validity (valid or invalid trials), Valence (angry, happy, or neutral cues), and SOA (200, 450, 700, or 950 ms) were within-subjects factors.

4. RESULTS

4.1. Data reduction

First, the practice trials were excluded. Then, the button-press data were filtered by first discarding the catch trials from the data. At this point, the data from five participants were removed from further analysis due to an excessive number of catch trial errors (i.e., more than 10% of all catch trials). This resulted in a loss of two and three participants from the high and low trait anxiety groups, respectively. For the remaining participants, on average, 3.3% of catch trial errors were made. After this, anticipatory responses, i.e., when the participant had responded between the cue and the target, were removed. On average, participants committed these anticipatory responses on 0.2% of the trials. From the remaining valid and invalid trial RT data, responses with RTs shorter than 100 ms and longer than 1000 ms were first excluded. This resulted in 0.6% of the trials being discarded. Next, individual mean RT was calculated for each participant. RTs exceeding the time-window of individual mean RT plus or minus two standard deviations were discarded. This filtering resulted in a further loss of 3.6% trials on average.

4.2. Group characteristics

As can be seen in Table 1, the low trait anxious (LTA) and high trait anxious (HTA) groups differed in their trait and state anxiety scores. Importantly, no differences were noted between the groups in the data reduction procedure (Table 1). The groups were also matched by sex and handedness (both ps $> .3$)

Table 1. Group characteristics as mean percentages. Standard deviations in parentheses.

	Group			
Measure	**HTA**	**LTA**	***t***	***df***
n	23	21		
Age	22.3 (6.5)	20.2 (4.3)	1.2	42
Trait anxiety	52.6 (6.7)	28.7 (3.2)	14.9**	42
State anxiety	38.7 (8.6)	28.1 (3.3)	5.3**	42
Catch	2.9 (2.4)	3.8 (2.7)	1.1	42
AR	0.2 (0.3)	0.3 (0.4)	0.7	42
100/1000	0.4 (0.5)	0.8 (0.8)	1.9	42
RT ±2 SD	3.6 (1.0)	3.5 (0.9)	0.3	42

Note. HTA = high trait anxious; LTA = low trait anxious; Catch = mean percentage of catch trial errors; AR = mean percentage of anticipatory responses; 100/1000 = mean percentage of responses under 100 ms and over 1000 ms; RT ±2 SD = mean percentage of responses exceeding the individual mean RT ±2 standard deviations.
** $p < .001$.

4.3. Reaction time data

Mean RTs are displayed graphically in Figure 2. The RT data were subjected to a 2 (Group: high and low trait anxiety) × 2 (Validity: valid and invalid) × 3 (Valence: angry, happy, and neutral) × 4 (SOA: 200, 450, 700, and 950 ms) ANOVA. The analysis revealed main effects for Valence, $F(2, 84) = 4.8$, $p \leq .01$, and Validity, $F(1, 42) = 173.0$, $p \leq .001$. The main effect of Valence arose from shorter overall RTs to trials with happy cues, compared to angry [$t(43) = 2.8$, $p \leq .008$], and neutral [$t(43) = 2.4$, $p \leq .02$] cues. Responses to angry and neutral cues did not differ from each other. There was also a significant two-way interaction between Validity and SOA, $F(3, 126) = 74.6$, $p \leq .001$. Inspection of Figure 3 suggests that this interaction is due to IOR effects at all longer SOAs, but not at the 200-ms SOA. This interaction will be analyzed in more detail below. Valence × Validity × Group interaction approached significance, $F(2, 84) = 2.9$, $p = .058$. All other interactions failed to reach statistical significance (all *p*s > .1), and thus, no theoretically interesting group differences emerged.

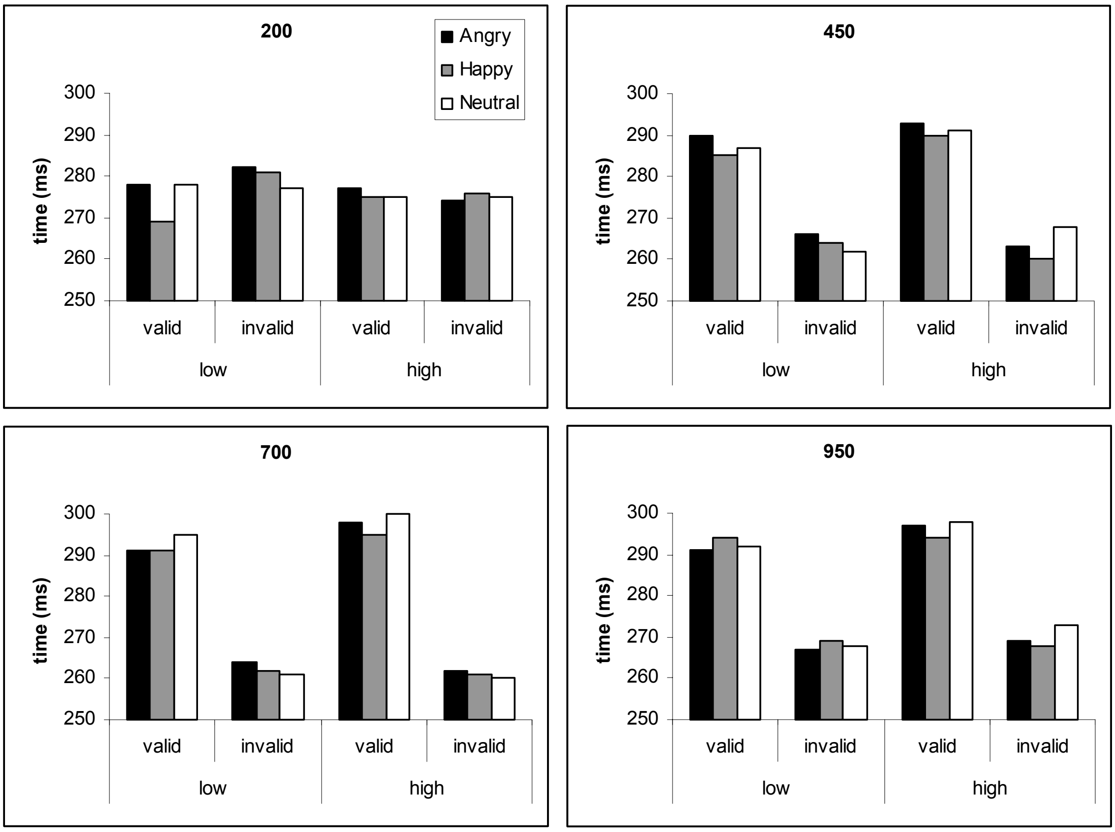

Figure 3. Mean reaction times in milliseconds (ms) for low and high trait anxious groups as a function of Validity, Valence, and SOA.

The data were further analyzed separately for each SOA to examine the patterns of facilitation and inhibition in a more detailed manner. However, it is acknowledged that this procedure is not fully justified, given that the four-way Valence × Validity × SOA × Group interaction did not reach significance.

A 2 × 2 × 3 ANOVA for the data with the 200-ms SOA yielded no significant main effects (both *p*s > .2). The Valence × Validity interaction was significant, $F(2, 84) = 4.1$, $p \leq .02$, while the Validity × Group interaction approached significance, $F(1, 42) = 3.5$, $p = .07$. Thus, facilitation occurred only with happy cues, $t(43) = 2.4$, $p \leq .02$. Inspection of Figure 3 suggests that such facilitation was apparent only in the LTA group. However, the Valence × Validity × Group interaction only approached significance, $F(2, 84) = 2.5$, $p = .09$.

Analyses for the longer SOAs (450, 700, and 950 ms) yielded main effects for Validity (all *p*s ≤ .001), thus revealing significant IOR effects, as can be seen also from Figure 3. The

450-ms SOA gave a near-significant main effect also for Valence, $F(2, 84) = 3.0$, $p = .06$. Despite a nearly significant Valence × Group interaction in the 950-ms SOA [$F(2, 84) = 2.9$, $p = .06$], all other main effects and interactions were non-significant (all ps > .4, and .1, respectively).

5. DISCUSSION

The present study sought to replicate and extend the finding that the disengagement component of visual attention is biased in anxious individuals, manifested in increased dwell time on threatening stimuli. To date, only Fox and her colleagues (Fox et al., 2001, 2002) have administered the spatial cueing task with face cues to groups differing in anxiety levels. Other authors have used words (Amir et al., 2003; Ávila & Parcet, 2002), affective pictures (Yiend & Mathews, 2001), symbolic cues with positive or negative value (Derryberry & Reed, 2002), and aversively conditioned stimuli (Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004a) as cues. Fox et al. (2001, 2002) have found evidence for anxiety-related difficulties in disengaging attention from angry faces at a SOA of 300 ms. Investigating the relationship of IOR with anxiety and emotional cues, they (Fox et al., 2002) got mixed results: in exp. 1, none of the participants displayed IOR with angry faces (with a SOA of 960 ms). However, in a replication (exp. 3), the low anxious participants displayed significant IOR with all faces, whereas the high anxiety group still showed neither facilitation nor IOR with angry faces. In addition to conducting a needed replication of the IOR study, the present study added two intermediate SOAs of 450 and 700 ms to explore more accurately the time course of attentional processing in the two groups studied.

The results of the present study did not replicate the findings of Fox et al. (2001, 2002). Meaningful differences as a function of anxiety or cue valence were not found. That is, both groups' responses were essentially the same throughout the experiment. As expected, the experiment produced IOR successfully for all SOAs other than the 200-ms SOA. However, no notable differences in the magnitude of IOR between the groups (or as a function of facial expressions) were found. Thus, there was not any attenuation in IOR for angry faces in the HTA group, as could have been expected on the basis of the results by Fox et al. (2002). The absence of IOR differences between groups in the present study bears similarity to the findings of Ávila and Parcet (2002). The RT data at the 200-ms SOA, on the other hand, raises a problem, as facilitation was only noted with happy faces. Inspection of Figure 3 suggests that such facilitation was apparent only in the LTA group. However, this assumption is not fully verified by statistical analyses, and, therefore, it is obvious that the basic pattern of facilitation with a short cue-target interval was not reliably achieved with all valid cues in the present experiment.

Important methodological aspects need to be considered when discussing the present results. First, because facilitation did not occur with all types of valid cues, it seems possible that, despite careful pilot-experimentation, and the placing of the stimuli (cf. Fox et al., 2001), the 200-ms SOA might still have suffered from forward masking. There is a possibility that this could be due to the direction of the contrast polarity in the task (i.e., black stimuli on a white background). In the basic version of the spatial cueing paradigm, the attentional cue has been a brightening of a white or grey rectangle on a black or grey background (e.g., Berger et al., 1999; Lupianez et al., 2001; Posner & Cohen, 1984). Authors using the emotional version of the task have also used a black (Amir et al., 2003; Ávila & Parcet, 2002; Fox et al., 2001, 2002; Pollak & Tolley-Schell, 2003) or grey background (Derryberry & Reed, 2002). There seems to be no published reports on the influences of the direction of the contrast polarity on forward masking or on other parameters of the spatial cueing task.

Second, the schematic face stimuli of the present study were more complex than the stimuli of Fox et al. (2001; 2002). In previous studies (Hietanen & Leppänen, 2003; Öhman et al., 2001), the same schematic faces have been suggested to be effective in signalling the prototypical expressions of anger, happiness, and emotional neutrality. However, considering the brief presentation time of the cues (100 ms) in the present study, perhaps the participants were unable to sufficiently extract the emotional information from the peripherally presented faces, which could partly explain the absence of valence effects. Another interesting question is, whether the contrast polarity of the display could also affect the power of different faces in drawing attention to them, possibly by diminishing the perceptual clarity and discriminability of the facial feature configuration.

On a theoretical level, authors (Mathews & Mackintosh, 1998; Mogg & Bradley, 2004) have suggested different reasons why anxiety-related attentional biases may sometimes be suppressed, or even reversed. One possibility is that, although high trait anxious individuals have a tendency to assign high subjective threat value to fairly innocuous stimuli (Mogg & Bradley, 1998), the threat value provided by the faces might not have been sufficiently high in the present study. Furthermore, Mathews and Mackintosh (1998) argued that when high trait anxiety is not coupled with high state anxiety or chronic stress, and the threat cues are relatively weak, attentional biases are not necessarily elicited. In the present study, the HTA group scored significantly higher also on the State-scale of the STAI. However, the overall state anxiety was fairly low in the present sample (39 and 28 for the HTA and LTA groups, respectively). Thus, it could be that a mood induction procedure, or cues with higher actual threat value, might have had the effect of eliciting attentional biases in anxious participants. One way to attach higher and imminent threat value to the cues could be achieved by employing an aversive-conditioning procedure (Koster et al., 2004a).

Another possibility is that by directing controlled effort to the detection of targets, anxious participants might have been able to counter the emotional reactions elicited by threatening faces. This assumption follows the logic of Mathews and Mackintosh (1998), who described such 'override'-mechanism in explaining the absence and suppression of interference effects, which are occasionally found in the emotional Stroop task with anxious or phobic subjects (e.g., Mathews & Sebastian, 1993). However, it is impossible to determine, whether these top-down control processes were operating in the present study. Williams et al. (1996) suggested that, in the Stroop task, such controlled effort should lead to faster responses, which was in fact evident in the Mathews and Sebastian (1993) study. However, in the present study, no differences were found between groups in the overall response latency.

Levels of depression were not measured in the present study. According to Mogg and Bradley's (1998, 2004) cognitive-motivational model, attentional biases for threat may be absent in comorbid anxiety and depression, at least when the disorders are manifested in their clinical forms. This is due to the view that whereas anxiety and depression are both associated with a negatively oriented *Valence Evaluation System* (see Figure 1), depression is characterized by reduced engagement in external stimuli, thus suppressing the vigilance for external threat prompted by anxiety (Mogg & Bradley, 1998). However, it should be noted that when depression has been measured in the spatial cueing experiments (e.g., Amir et al., 2003; Fox et al., 2001; Yiend & Mathews, 2001), high trait anxious participants have had higher scores on depression measures, but the attentional biases associated with anxiety have, nevertheless, been evident.

Thus, from all published reports, the present results mirror only the results of Ávila and Parcet (2002), who also did not obtain any IOR differences as a function of cue valence or anxiety, although they did observe facilitation and a greater validity effect (RT difference between valid and invalid trials) for threat words in anxious participants with a SOA of 100 ms. Nevertheless, further research in the field of anxiety and attention is needed to clarify several unresolved issues, which include: the exact nature of underlying attentional mechanisms (e.g., shift vs. disengagement); the interplay between state and trait variables; underlying brain mechanisms; distinctive features of attentional processing in different anxiety disorders; and the specificity of attentional biases (anxiety-specific vs. general motivational processes). Regarding the specificity of the biases, there are some interesting recent studies suggesting similar attentional biases in motivational states, such as drug dependence (Lubman, Peters, Mogg, Bradley, & Deakin, 2000), and even hunger (Mogg, Bradley, Hyare, & Lee, 1998). Such findings led Mogg and Bradley (2004) to question whether attentional biases could be mediated by a general motivational mechanism, which causes attention to be captured and possibly also maintained by appetitive and aversive stimuli. Considering the brain basis of attentional biases, Mathews, Yiend, and Lawrence (2004) found that the same mechanisms that are involved in freezing behaviour in animals (e.g., hippocampal and periaqueductal grey activation), were also differentially activated in anxiety-prone individuals when viewing fear-related pictures. They (Mathews et al., 2004) suggested that the disengagement difficulties seen in anxiety could be due to a similar mechanism (cf. Fox et al., 2001).

Even though the debate concerning the underlying mechanisms (i.e., shift vs. disengagement) possibly remains unresolved, the investigation of the exact attentional processes continues to be of importance, as recent studies have shed light on the possible causality of attentional processes in anxiety disorders. Compton (2000) demonstrated that participants who were slowest in disengaging attention in an orienting task, also showed more pronounced increases in self-reported distress in response to an affect-inducing film. Recently, it has been shown (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2002) that training non-anxious volunteers to repeatedly attend to threatening locations in an attentional probe task resulted in faster detection of targets replacing threatening stimuli in a non-contingent test phase. Importantly, although the attentional training did not produce immediate increases in state anxiety, the trained participants got significantly more anxious, when encountered with a stressful situation. The authors' (MacLeod et al., 2002; Mathews & MacLeod, 2002) interpretation was that the acquired attentional biases causally mediated emotional vulnerability. Such results will, in the future, be integral in the development of therapeutic interventions aimed directly to correct biased attentional processing. Preliminary support for such goals already exist, as MacLeod, Campbell, Rutherford, and Wilson (2004) reported the beneficial effects of training anxious participants to correct their style of processing threatening material.

REFERENCES

Amir, N., Elias, J., Klumpp, H., & Przeworski, A. (2003). Attentional bias to threat in social phobia: Facilitated processing of threat or difficulty disengaging attention from threat? *Behaviour Research and Therapy, 41,* 1325-1335.

Ávila, C. (1995). Facilitation and inhibition of visual orienting as a function of personality. *Personality and Individual Differences, 18,* 503-509.

Ávila, C., & Parcet, M. A. (2002). The role of attentional anterior network on threat-related attentional biases in anxiety. *Personality and Individual Differences, 32,* 715-728.

Berger, A., Dori, H., & Henik, A. (1999). Peripheral non-informative cues do induce early facilitation of target detection. *European Journal of Cognitive Psychology, 11,* 119-137.

Bieling, P. J., Antony, M. M., & Swinson, R. P. (1998). The State-Trait Anxiety Inventory, Trait version: Structure and content re-examined. *Behaviour Research and Therapy, 36,* 777-788.

Bower, G. H. (1981). Mood and memory. *American Psychologist, 36,* 129-148.

Bradley, B. P., Mogg, K., Falla, S., & Hamilton, L. R. (1998). Attentional bias for threatening facial expressions in anxiety: Manipulation of stimulus duration. *Cognition and Emotion, 12,* 737-753.

Bradley, B. P., Mogg, K., Millar, N., & White, J. (1995a). Selective processing of negative information: Effects of clinical anxiety, concurrent depression, and awareness. *Journal of Abnormal Psychology, 104,* 532-536.

Bradley, B. P., Mogg, K., & Williams, R. (1995b). Implicit and explicit memory for emotion-congruent information in clinical depression and anxiety. *Behaviour Research and Therapy, 33,* 755-770.

Cave, K. R., & Bichot, N. P. (1999). Visuospatial attention: Beyond a spotlight model. *Psychonomic Bulletin & Review, 6,* 204-223.

Coles, M. E., & Heimberg, R. G. (2002). Memory biases in the anxiety disorders: Current status. *Clinical Psychology Review, 22,* 587-627.

Compton, R. (2000). Ability to disengage attention predicts negative affect. *Cognition and Emotion, 14,* 401-415.

Cowan, N. (1995). *Attention and Memory: An Integrated Framework.* New York: Oxford University Press.

Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology, 111,* 225-236.

Derryberry, D., & Tucker, D. M. (1994). Motivating the focus of attention. In P. M. Niedenthal & S. Kitayama (Eds.), *The heart's eye: Emotional influences in perception and attention* (pp. 167-196). San Diego, CA: Academic Press.

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

Egloff, B., & Hock, M. (2001). Interactive effects of state anxiety and trait anxiety on emotional Stroop interference. *Personality and Individual Differences, 31,* 875-882.

Eriksen, C. W., & Yeh, Y. (1985). Allocation of attention in the visual field. *Journal of Experimental Psychology: Human Perception and Performance, 11,* 583-597.

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

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130,* 681-700.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16,* 355-379.

Gibson, B. S., & Egeth, H. (1994). Inhibition of return to object-based and environment-based locations. *Perception & Psychophysics, 55,* 323-339.

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

Hietanen, J. K., & Leppänen, J. M. (2003). Does facial expression affect attention orienting by gaze direction cues? *Journal of Experimental Psychology: Human Perception and Performance, 29,* 1228-1243.

Klein, R. M. (2000). Inhibition of return. *Trends in Cognitive Sciences, 4,* 138-147.

Koster, E. H. W., Crombez, G., Van Damme, S., Verschuere, B., & De Houwer, J. (2004a). Does imminent threat capture and hold attention?. *Emotion, 4,* 312-317.

Koster, E. H. W., Crombez, G., Verschuere, B. & De Houwer, J. (2004b). Selective attention to threat in the dot probe paradigm: Differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy, 42,* 1183-1192.

LeDoux, J. E. (1996). *The Emotional Brain.* New York: Simon & Schuster.

Lubman, D. I., Peters, L. A., Mogg, K., Bradley, B. P., & Deakin, J. F. W. (2000). Attentional bias for drug cues in opiate dependence. *Psychological Medicine, 30,* 169-175.

Lupiánez, J., Milliken, B., Solano, C., Weaver, B., & Tipper, S. P. (2001). On the strategic modulation of the time course of facilitation and inhibition of return. *Quarterly Journal of Experimental Psychology, 54,* 753-773.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109,* 163-203.

MacLeod, C., Campbell, L., Rutherford, E., & Wilson, E. (2004). The causal status of anxiety-linked attentional and interpretive bias. In J. Yiend (Ed.). *Cognition, Emotion and Psychopathology: Theoretical, Empirical and Clinical Directions.* Cambridge: Cambridge University Press.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95,* 15-20.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111,* 107-123.

Mathews, A. (1990). Why worry? The cognitive function of anxiety. *Behaviour Research and Therapy, 28,* 455-468.

Mathews, A., & Mackintosh, B. (1998). A cognitive model of selective processing in anxiety. *Cognitive Therapy and Research, 22,* 539-560.

Mathews, A., & MacLeod, C. (1985). Selective processing of threat cues in anxiety states. *Behaviour Research and Therapy, 23,* 563-569.

Mathews, A., & MacLeod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognition and Emotion, 16,* 331-354.

Mathews, A., & Sebastian, S. (1993). Suppression of emotional Stroop effects by fear-arousal. *Cognition and Emotion, 7,* 517-530.

Mathews, A., Yiend, J., & Lawrence, A. D. (2004). Individual differences in the modulation of fear-related brain activation by attentional control. *Journal of Cognitive Neuroscience, 16,* 1683-1694.

McCabe, S. B., & Gotlib, I. H. (1995). Selective attention and clinical depression: Performance on a deployment of attention task. *Journal of Abnormal Psychology, 104,* 241-245.

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy, 36,* 809-848.

Mogg, K., & Bradley, B. P. (2002). Selective orienting of attention to masked threat faces in social anxiety. *Behaviour Research and Therapy, 40,* 1403-1414.

Mogg, K., & Bradley, B. P. (2004). A cognitive-motivational perspective on the processing of threat information and anxiety. In J. Yiend (Ed.). *Cognition, Emotion and Psychopathology: Theoretical, Empirical and Clinical Directions.* Cambridge: Cambridge University Press.

Mogg, K., Bradley, B. P., De Bono, J., & Painter, M. (1997). Time course of attentional bias for threat information in non-clinical anxiety. *Behaviour Research and Therapy, 35,* 297-303.

Mogg, K., Bradley, B. P., Hyare, H., & Lee, S. (1998). Selective attention to food-related stimuli in hunger: Are attentional biases specific to emotional and psychopathological states, or are they also found in normal drive states? *Behaviour Research and Therapy, 36,* 227-237.

Mogg, K., Bradley, B. P., Williams, R., & Mathews, A. (1993a). Subliminal processing of emotional information in anxiety. *Journal of Abnormal Psychology, 102,* 304-311.

Mogg, K., Kentish, J., & Bradley, B. P. (1993b). Effects of anxiety and awareness on colour identification latencies for emotional words. *Behaviour Research and Therapy, 31,* 559-567.

Mogg, K., Mathews, A., & Weinman, J. (1987). Memory bias in clinical anxiety. *Journal of Abnormal Psychology, 96,* 94-98.

Mogg, K., McNamara, J., Powys, M., Rawlinson, H., Seiffer, A., & Bradley, B. P. (2000a). Selective attention to threat: A test of two cognitive models of anxiety. *Cognition and Emotion, 14,* 375-399.

Mogg, K., Millar, N., & Bradley, B. P. (2000b). Biases in eye movements to threatening facial expressions in generalized anxiety disorder and depressive disorder. *Journal of Abnormal Psychology, 109,* 695-704.

Mogg, K., Philippot, P., & Bradley, B. P. (2004). Selective attention to angry faces in clinical social phobia. *Journal of Abnormal Psychology, 113,* 160-165.

Müller, H. J., & Humphreys, G. W. (1991). Luminance increment detection: Capacity-limited or not? *Journal of Experimental Psychology: Human Perception and Performance, 17,* 107-124.

Pollak, S. D., & Tolley-Schell, S. A. (2003). Selective attention to facial emotion in physically abused children. *Journal of Abnormal Psychology, 112,* 323-338.

Posner, M. I. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology, 32,* 3-25.

Posner, M. I., & Cohen, Y. (1984). Components of visual orienting. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and Performance X: Control of Language Processes* (pp. 531-556). London: Lawrence Erlbaum Associates.

Posner, M. I., & Dehaene, S. (1994). Attentional networks. *Trends in Neurosciences, 17,* 75-79.

Posner, M. I., & Petersen. S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25-42.

Posner, M. I., & Raichle, M. E. (1994). *Images of Mind.* New York: Scientific American Library.

Posner, M. I., Snyder, C. R. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General, 109,* 160-174.

Poy, R., Eixarch, M. del C., & Ávila, C. (2004). On the relationship between attention and personality: Covert visual orienting of attention in anxiety and impulsivity. *Personality and Individual Differences, 36,* 1471-1481.

Pratt, J., Kingstone, A., & Khoe, W. (1997). Inhibition of return in location- and identity-based choice decision tasks. *Perception & Psychophysics, 59,* 964-971.

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61,* 380-391.

Riggio, L., & Kirsner, K. (1997). The relationship between central cues and peripheral cues in covert visual orienting. *Perception & Psychophysics, 59,* 885-899.

Rosen, A. C., Rao, S. M., Caffarra, P., Scaglioni, A., Bobholz, J. A., Woodley, S. J., Hammeke, T. A., Cunningham, J. M., Prieto, T. E., & Binder, J. R. (1999). Neural basis of endogenous and exogenous spatial orienting. A functional MRI study. *Journal of Cognitive Neuroscience, 11,* 135-152.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime User's Guide*. Pittsburgh: Psychology Software Tools Inc.

Schupp, H. T., Öhman, A., Junghöfer, M., Weike, A. I., Stockburger, J., Hamm, A. O. (2004). The facilitated processing of threatening faces: An ERP analysis. *Emotion, 4,* 189-200.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1977). *State-Trait Anxiety Inventory, Form Y.* Palo Alto, CA: Consulting Psychologists Press.

Stormark, K. M., Nordby, H., & Hugdahl, K. (1995). Attentional shifts to emotionally charged cues: Behavioural and ERP data. *Cognition and Emotion, 9,* 507-523.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120,* 3-24.

Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. (1988). *Cognitive psychology and emotional disorders.* Chichester: John Wiley & Sons.

Wilson, E., MacLeod, C. (2003). Contrasting two accounts of anxiety-linked attentional bias: Selective attention to varying levels of stimulus threat intensity. *Journal of Abnormal Psychology, 112,* 212-218.

Yiend, J., & Mathews, A. (2001). Anxiety and attention to threatening pictures. *The Quarterly Journal of Experimental Psychology, 54,* 665-681.

Öhman, A. (2000). Fear and anxiety: Evolutionary, cognitive, and clinical perspectives. In M. Lewis & J. M. Haviland-Jones (Eds.). *Handbook of Emotions* (2nd ed.). New York: Guilford.

Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology, 80,* 381-396.

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