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“We can understand how our freedom is greater than that of other creatures, and see how this heightened capacity carries moral implications: *noblesse oblige*. We are in the best position to decide what to do next, because we have the broadest knowledge and hence the best perspective on the future. What that future holds in store for our planet is up to all of us, reasoning together.” (Dennett, 2003, p. 308)

ABSTRACT

The evolutionary perspective on the functionality of prioritizing efficient threat detection (Öhman, 1986, 1993) provided the foundation for a hypothesis of an attentional bias for preferential detection of angry faces in a group of faces. Furthermore, an evolutionary analysis implied that such a threat bias would be enhanced in socially anxious individuals, whose bias for detecting threat in faces would be potentiated by their increased sensitivity for facial signals of social dominance. In Study I, we used a standardized set of photographed real faces in examining visual search for happy, angry, and fearful target faces among neutral distractor faces in three separate experiments. Contrary to the hypothesis about prioritized threat detection, there was a strong happy-advantage and no consistent effects of social anxiety or social phobia, even when it was activated by a fear-induction procedure. However, in the final experiment, with perceptually controlled schematic faces, in support of the hypotheses, we obtained more effective detection of angry than happy faces, which was most obvious for highly socially anxious individuals when their social fear was experimentally activated. In Study II, we developed and tested a theory to reconcile the opposing findings with real and schematic faces in Study I. This theory was based on three theoretical concepts: (a) Rauschenberger and Yantis's (2006) theory of stimulus redundancy, (b) Lavie's (2005) concept of perceptual load, and (c) the differential ease of recognizing facial emotions of anger and happiness in the two genders (Becker et al., 2007). The results were predicted on the presumptions that redundant (i.e., "familiar") distractor faces should leave more perceptual processing resources for finding the target stimulus, which would lead to a larger facilitation of the processing of angry, than happy, faces, because their recognition seems to require a configural facial analysis. Our results demonstrated that two interacting conditions were required to obtain the angry face advantage: (a) a small stimulus set (i.e., they should be highly redundant); and (b) a male target face. In Study III we addressed the uncertainty about which attentional process was involved in the enhanced threat bias that had been observed in Study I. Thus, we recruited high and low socially anxious individuals for two different tasks. The first one was designed to reveal a potential association between social anxiety and (enhanced) attentional shifts to socially threatening stimuli; the second task examined the (dis-) ability to disengage attention from a socially threatening stimulus. Consistent with Study w found the superior orienting towards social threat in a visual search task to be unaffected by self-reported social anxiety. The socially anxious participants performed worse than the low-anxious control group in trials where a socially threatening task-irrelevant facial stimulus was presented. A prolonged threat dwelling explanation for the socially anxious participants' slowed RT performance was undermined by the recorded eye-movement patterns, which suggested that they rather had problems with controlling attention. Thus, while not being preoccupied with the threatening stimulus in itself, their unstable attentional focus seemed to reflect the draining of attentional resources available for the cognitive task, suggesting that endogenous attentional control efforts were compromised.

LIST OF PUBLICATIONS

I. Juth, P., Lundqvist, D., Karlsson, A., & Öhman, A. (2005). Looking for Foes and Friends: Perceptual and Emotional Factors When Finding a Face in the Crowd. Emotion, 5, 379-395.

II. Öhman, A., Juth, P., & Lundqvist, D. (in press). Finding the face in a crowd: Relationships between distractor redundancy, target emotion, and target gender. Cognition and Emotion.

III. Juth, P., Lundqvist, D., & Öhman, A. (submitted). Social Threat and Attention Control Problems in Social Anxiety.

CONTENTS

1 THESIS SUMMARY

1.1 EMOTION

Emotions are evolved action-programs (Oatley and Jenkins, 1996) which have been shaped by evolutionary history to provide solutions to ancient survival-related problems, and they still serve their ordained function. Many different perspectives have been adopted by emotion scientists, although most benefit from taking advantage of the evolutionary perspective in some way. Thus, emotion research uses different schemes, perhaps focusing on emotional behaviors in a close comparison with other mammals, categorizing emotions in broad terms as related to seeking, panic, rage and fear, or, employing the dichotomy reward and punishment in the study of learning. The so-called 'basic' emotions (e.g., fear, anger, happiness) are often used in human research about fundamental emotional processes, while psychiatric or social psychological studies may use more complex constructs such as the 'social' emotions (shame, guilt, jealousy).

From an evolutionary perspective, emotions are motivational sources for guiding behaviors in situations which must have been important to our group-living forefathers, for example, to elicit care and protection, to claim access to shared resources, to find mates, and to build social relationships (Öhman, 1986). Emotions are systems of responses that cluster together to form an "action-set" involving the entire organism, typically including psychophysiological activation, facial expressions and other behaviors, and the subjective feeling (Oatley and Jenkins, 1996). The feeling of fear, for instance, is regarded as a functional response which has evolved as a behavioral coping with threatening stimuli. In a basic sense, fear serves to protect the organism.

To respond quickly and adequately to a threatening encounters, whether from predators or from members of the same species, has been an evolutionary maxim since the evolution of early mammals (Öhman & Dimberg, 1984). Presumably, the perceptual systems were pressured by the environmental contingencies to adapt the visual mechanisms for a low threshold for detecting potential threat, to accomplish enough time for fight or flight behaviors (Öhman, 1993, 1996; Öhman, Flykt, & Lundqvist, 1996). Thus, the adaptive advantage in responding quickly to a threatening encounter probably has resulted in the visual perceptual systems being biased for a "quick and dirty" processing (LeDoux, 1996) and for relatively automatic perceptual processing of threat (Esteves, Dimberg, & Öhman, 1994; Öhman, 1986; 1996; LeDoux, 1996).

According to Mayr (1974) there are three types of primordial behavioral contexts that might have shaped our set up of defensive mechanisms. Two such behavioral contexts are "communicative", which means that they rely on some communicated danger (for instance, from behavioral sign or facial signal), and one is non-communicative, involving physical dangers from the environment. The two former contexts refer for their functioning to the systematic reencounters with predating animals from other species and with aggressive members of our own species, which are likely to have shaped our defensive mechanisms (Mayr, 1974; Öhman, 1986).

In particular, the *adaptive problem* (Tooby & Cosmides, 1990) of reoccurring social conflicts (e.g., about social rank) should have generated a selective pressure for a behavioral solution that approximates the best benefit for the least cost.

By organizing a hierarchical social structure, our ancestors were able to achieve some group stability (assuming that the benefit of stability outweighs the cost of increased social stress in low-rank members) (Chance, 1988; de Waal, 1988; Öhman, Dimberg, & Öst, 1985).

1.2 FEAR AND ANXIETY

Several influential biopsychosocial evolutionary approaches to psychopathology have found inspiration in the work by Blanchard and Blanchard (1988), who saw fear as closely linked to a set of behaviors that are elicited by a predator (e.g., Gilbert, 2001b; Gray, 1971; LeDoux, 1996; Öhman 1993, 1986, 1996). In their perspective fear is characterized by avoidance, while anxiety is characterized by 'risk assessment'. Thus, anxiety is activated in uncertain, potentially threatening situations when more information gathering is required, for instance, to determine the distance to the threatening stimulus, before response selection. Thus, perceiving the threatening stimulus as close by may result in explosive attack (the psychological state of panic), while an intermediate distance to it may result in freezing and flight (phobic avoidance), and, finally, a very great distance may result in normal non-defensive behavior (Fanselow, 1994).

A closely related perspective on anxiety is proposed by McNaughton & Corr (2004; Gray & McNaughton, 2000). They distinguish their view on anxiety from that which was posited by Blanchard and Blanchard (1988) proposing that the key difference between fear and anxiety is 'defensive direction' rather than, immediacy versus potentiality of threat (Blanchard and Blanchard, 1988). Fear is seen as operating in active avoidance, that is, when leaving a dangerous situation. Anxiety occurs when entering it (e.g. active approach behavior) or withholding entrance in passive avoidance (but not active avoidance, which is fear) (McNaughton & Corr, 2004). They suggest that there are three distinct behavioral elements to consider in relation to anxiety (but not fear): approach, avoidance, and the conflict between the two.

In the views of McNaughton and Corr (2004) all defensive behaviors have a basic *direction* (i.e. approach or avoid) which is modified by "hierarchical" system concerned with *defensive distance*. They suggest that the way defensive distance controls defensive behaviors is determined by both stimulus-related factors, like the real distance to the threatening stimulus, and by observer-related factors, like the internal cognitive construct of the intensity of the perceived threat (i.e., the "felt" distance to the threat). Specifically, individual differences in this construct are seen as a reflection of the personality dimension underlying punishment sensitivity. Thus, anxiety is related to a conflict between opposing motivational states. Threatening stimuli or situations that require approach (because of positive outcomes that could be obtained), but where the aversive consequence is perceived as unavoidable, and where it is so great as to prevent the appetitive behavior from occurring, will therefore cause anxiety.

1.2.1 A brief overview of cognitive models of anxiety

Fitting these ideas into a cognitive model of anxiety, Gray (1985) proposed that vulnerability to anxiety is associated with a highly reactive behavioral inhibition system (BIS)**,** which is a cognitive control function that compares the *actual* incoming perceptions of stimuli with the *expected* perceptions (e.g., from experience).

The BIS enacts its power to inhibit ongoing behavior (while also increasing arousal and attention to threat) when there is an incompatibility between the actual and the expected stimuli, that is, if the present situation involves novelty and uncertainty, or is associated with punishment or failure (Gray, 1985).

In their review of cognitive models of anxiety, Mogg & Bradley (1998) suggested that during the 1980s the evidence indicated an attentional bias for threat information in anxiety and a memory bias for negative information in depression. They argue that this led, among others, Williams and coworkers (Williams et al., 1988) to put forward a model of anxiety which predicted that different emotional disorders are associated with different patterns of cognitive bias (e.g., anxiety vs. depression). In their model, a permanent vigilance for threat was hypothesized to represent a cognitive vulnerability factor for clinical anxiety. This model also predicted an interaction between the direction of the attentional bias to threat stimuli and the level of anxiety (e.g. MacLeod and Mathews, 1988). Thus, high anxious individual would be prone to orient attention towards threat, whereas low anxious individuals would be more inclined to avoid threat. The key difference underlying susceptibility for anxiety was seen as the direction of allocation of processing resources.

LeDoux's (1996) and Öhman's (1993, 1996; Öhman & Soares, 1993) models of anxiety share an important feature in that they are primarily concerned with the brain's "fear circuits". The central role is thus given to the amygdala, which provides both an automatic primary appraisal of threat based on limited 'quick-and-dirty' analysis of threatening stimulus features and, a slower, more elaborate analysis of stimulus detail and context via cortical and, to some extent, hippocampal pathways (Adolphs & Spezio, 2006). There is an emphasis on the role of automatic, preattentive processes for threatening stimuli in mediating vulnerability to fear and anxiety, and the automatic attentional shift mechanism which might make the fear response immune to consciously controlled efforts to modify it (Öhman & Mineka, 2001; Öhman, & Rück, 2007; Öhman & Wiens, 2004). Thus, fear is seen as part of a specialized defense system which can bias attention for an automatic shift of cognitive resources to the location of the threatening object. Since psychopathology utilizes this fear module fear may help to illuminate the evolved basis of typical forms of anxieties and phobias.

Mogg and Bradley's (1998) dimensional motivational model postulates that anxiety is mediated by two orthogonal variables, emotional valence and goal engagement, in which anxiety is associated with an externally-focused future-oriented cognitive mode, which is scanning the environment for threat, whereas depression is characterised by a cognitive mode which is inwardly-focused and past-oriented (Mogg & Bradley, 1998). According to their cognitive-motivational view, as the stimulus threat value increases, all individuals show increasing vigilance for threat. Although trait anxiety reflects the allocation of too much attentional resource to threatening stimuli, this bias is not seen as playing a major causal role in the etiology of clinical anxiety states.

Finally, Eysenck's (1992) and Mathews' (1990) suggested that vulnerability for anxiety is related to the proneness for being in an emotional state of stress. Stress imposes a threat vigilant mode of operation within the cognitive system, which serves to prioritize the encoding of threatening stimuli in an automatic way. Furthermore, Eysenck (1992) and coworkers (Eysenck, Derakshan, Santos, & Calvo, 1997) proposed that the threat-related *hypervigilance* (associated with a broadening of the focus of attention prior to the detection) was complemented by *distractability* for task-irrelevant threatening stimuli (associated with a narrowing of attention post detection). In the more recent attentional control theory (Eysenck et al., 2007), Eysenck and co-workers specifically propose that anxiety is decreasing the influence of the goal-directed attentional system and increasing the influence of the stimulus-driven attentional system (e.g., Corbetta & Shulman, 2002; Posner & Petersen, 1990), which then reduces attentional control and impairs the inhibition and shifting functions.

The evolutionary derived rational for the reduced attentional control theory of anxiety is the potential danger in maintaining very high attentional control when perceiving a specific threatening stimulus or location (Eysenck, 1992; 1997). The optimal strategy is rather to allocate attentional resources widely, which reduces attentional control with respect to any ongoing task. This lack of attentional control seems to be reflected in the lack of activity in the anterior cingulate cortex (ACC), an area which is considered to be involved in top-down attentional control (Bishop, Duncan, Brett, & Lawrence, 2004). The anxious individual's impaired ability to inhibit threat-related material (Derryberry & Reed, 2002; Fox, 1994a) typically reduces attentional focus on the current task unless it involves the threatening stimuli.

In her review of the empirical findings (2005), Fox shows that anxious individuals are more distracted than non-anxious individuals by irrelevant emotional words in Stroop color-naming tasks (Williams, Mathews, & MacLeod, 1996), that they detect probes more quickly when they occur in the location of fearful or angry, as opposed to neutral, faces (Fox, 2002; Mogg & Bradley, 1999), that anxious individuals take longer to disengage their attention from angry faces or threat-related pictures (Fox, Russo, Bowles, & Dutton, 2001; Georgiou, Bleakley, Hayward, Russo, Dutton, K., Eltiti, & Fox, 2005; Yiend & Mathews, 2001), and, finally, that they are quicker to follow the gaze of fearful faces relative to that of neutral faces (Mathews, Fox, Yiend, & Calder, 2003). She suggests that such behavioral evidence for an attentional threat bias in anxiety is pointing to a hypervigilant fear-system (Eysenck, 1992) and to a relatively lesser ability for attention control in their emotion processing (Derryberry & Reed, 2002).

1.3 PERCEPTION OF FACES AND FACIAL EXPRESSIONS

There are specialized areas of the brain devoted to face perception (Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997) They include a large number of different brain structures in occipitotemporal cortices, amygdala, orbitofrontal cortex, basal ganglia, and right parietal cortices, among others, in a distributed patterns of specific regions in visual cortex (Adolphs, 2002). Occipital and temporal neocortices, of which the lateral parts of the inferior occipital gyrus, fusiform gyrus, and superior temporal gyrus are disproportionately important, can very quickly extract perceptual information on the basis of the structural properties in an image of a face, and produce a coarse categorization of the stimulus as expressing an emotion or not.

In particular, the fusiform gyrus is involved in representing the so called static features of faces, and consequently in contributing to encoding identity. On the other hand, the superior temporal gyrus is especially involved in representing the dynamic, changeable features of faces, and therefore in contributing to encoding facial expression and direction of gaze. Thus, it appears that after an initial processing in lateral occipital regions, the cortex in the fusiform gyrus then processes static feature information about identity, while the cortex in the superior temporal gyrus processes dynamic feature information, about emotional expression (Haxby, Hoffman, & Gobbini, 2000). However, a more prominent role of the STS in coding changeable characteristics might reflect the manner in which changeable cues require constant online monitoring during social interaction. It may also be associated with the fact that identity rarely is ‘simulated’ by observers, but that changeable, emotional, facial cues often are imitated, even without awareness (Dimberg, Thunberg, Grunedal, 2002).

The cortical regions that are engaged in face processing provide highly processed input to the amygdala, which is put to use in social cognition. The roles for the amygdala and the orbitofrontal cortices seems to include modulating perceptual representations via feedback and to trigger associated knowledge, via projections to other regions of neocortex and to the hippocampal formation. As suggested by Adolphs and (2002) and by him and Spezio (2006) these two structures could also take part in the generation of an emotional response, via motor structures, hypothalamus, and brainstem nuclei, via the process of motor mimicry, or via the generation of a somatosensory image of the associated body state. In this scenario, the reason that perception and evaluation of faces is so closely intertwined is because the information can reach the amygdala not only top-down, both via a series of visual processing stages in the visual cortices and, subsequently, the temporal lobe, but also bottom-up, for a feedback on visual processing, even at very early stages.

Presumably, through this architecture the amygdala can link the perception of stimuli to an emotional response, and then subsequently modulate cognition on the basis of the value of the perceived stimulus (e.g., Adolphs, 2002). Functional neuroimaging studies indicate that activation in the human amygdala predicts extrastriate cortex activation specific to fearful facial expressions (Morris, Friston, Büchel, Frith, Young, Calder, & Dolan, 1998), while lesions of the amygdala eliminate facial expression-specific activations in occipital and fusiform cortices (Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004). Visual input to the amygdala, which can occur very rapidly via the superior colliculus and the pulvinar, results in initial modulation of subsequent visual inputs from visual cortex (e.g., Öhman, 2005). For instance, emotional faces that are backward-masked to restrict awareness nevertheless elicit autonomic responses and prime corresponding facial expressions in observers (Dimberg, Thunberg, & Elmehed, 2000; Esteves, Dimberg, & Öhman, 1994). If amygdala can modulate the visual cortex in a bottom-up fashion to select emotionally salient features (e.g., the eyes in a face), then emotional responses will be more rapidly generated (Adolphs & Spezio, 2006).

In two recent visual search tasks (i.e., Eastwood, Smilek, & Merikle, 2003; Eastwood, Frischen, Reynolds, Gerritsen, Dubins, & Smilek, 2008) the authors presented arrays of very simple schematic faces, composed of upward- and downward-curved arcs. The premise for their hypotheses was that previous studies had shown that perception of a face gestalt impairs discrimination of its component features (e.g., Suzuki & Cavanagh, 1995). The face gestalts in the study, expressed an either positive or negative emotion, which was determined by the up- or down-ward curvature of the mouth arc. On each trial in Eastwood (2003), participants were required to count the number of either upward- or downward-curved arcs, disregarding the faces and the expression they conveyed. Even though facial affect was task-irrelevant, the results showed that RTs were slower for negative than for positive faces. The authors suggest that experiments performed in 2008 demonstrated that this interference by facial expression is ‘‘automatic’’, in the sense of being insensitive to attentional set and stimulus attributes, referring such conceptualizations of automaticity by Bargh (1992) and by Posner and Snyder (1975). This was tested by making a local feature more salient when participants were required to count the local features. If the positive/negative face difference had been driven by individual features, the authors argue, then increasing their salience should have enhanced rather than abolished the emotional difference. This was not the case. The authors interpret the findings (Eastwood et al., 2003, 2008) in terms of emotional valence rather than as driven by perceptual features. Thus, their results suggest that the affective meaning of the global gestalt that is critical and that it is processed in a relatively automatic way.

1.3.1 Emotional Facial Expressions

Social communication was afforded to our pre-language ancestors, in particular, in the use of facial displays of emotion and eye-gaze orientation. The stereotype facial expression of social dominance is a quite angry stare, while the submissive counterpart is marked by avoiding eye-contact, or even expressed in a facial display of fear (Ekman, 1972; Öhman, Dimberg, & Öst, 1985). Humans and other primates have a well developed neural control of facial muscles (Fridlund, 1994) that provide the physical basis for using the face’s natural expressions for social communicative purposes. It seems that the emotional expressions that are spontaneously (reflexive) associated with the activation of a subjective feeling have been subjected to intentionally controlled use, because there is some consistency between basic psychobiological behavioral repertoires for play, attack, etc., and their emotional displays in the face (Panksepp, 1998).

These two characteristics of facial emotional expressions, that is, their association with an inner emotional state (Ekman, 1972) and the affordance coming from displaying them voluntarily, in *symbolic* facial expressions, provided a major social toolbox for group-living. The usability of a facial emotional expression is in their providing some predictability of future events, as the other person’s forthcoming behavior is reliably (enough) signaled by the emotional display. However, the critical feat of emotional expressions is that they can communicate behavioral intentions without these intentions ever becoming realized (Öhman & Dimberg, 1984; Fridlund, 1994). That is, because emotional expressions communicate intentions they can be used to affect the behavior of another person (Fridlund, 1994).

Thus, because the early group-living Homo sapiens was confronted with recurrent social conflicts about social rank, the facial signs of submission (fear, avoidance of eye-contact) became ritualized signals of submissiveness which afforded a substitute for actual fight and flight, and functioned as a superior means to uphold group stability (de Waal, 1988, 2005; Öhman, 2009; Öhman, Dimberg, & Öst, 1985). Cross-cultural research (i.e, Ekman, 1972), has provided strong corroborating evidence for this description of the use of emotional facial displays in social pre-language communication (to send these signals and, to receive and interpret them) as a universal human capacity.

How exactly do the emotions (or, rather, the emotional processes) get the job done that was assigned to them by natural selection? One of their mechanistic effects simply involves putting a value on sensory events. Some things, by the force of their emotional association, will look appetitive to us, while other things will scare us, by learning or prewired meaning. Emotional processes also adjust our perception of incoming sensory stimulation, for instance, when accomplishing a prioritized detection of a threatening stimulus (e.g., Öhman, Flykt, & Esteves, 2001a; Öhman, Lundqvist, & Esteves, 2001b). In fact, several selective mechanisms exist and operate simultaneously during perceptual processing (Driver, 2001), and they function on each level of representation of sensory events, until the level of behavioral action (Kastner & Ungerleider, 2000). It may be that the emotional "meaning" of a visual input reaches the amygdala very rapidly via the pulvinar of the Thalamus, and results in initial modulation of subsequent visual inputs from visual cortex (Adolphs & Spezio, 2006), for an "emotional attention" (Vuilleumier, 2004).

Because some predictive value of events and actions comes from associative learning, it is particularly fortunate that this research has been able to identify the role for amygdala as the key brain structure involved in conditioned fear (LeDoux, 2000; Ledoux & Phelps, 2008). In fact, the amygdala, which is important for learning what to be afraid of, is providing an essential part of the feeling of fear (autonomic arousal), and is, which is of particular interest in the present context, differently affected by various facial expressions (Adolphs & Spezio, 2006). In line with this suggestion, functional imaging studies have shown that the amygdala discriminates between fearful expressions and angry or happy ones (Breiter, Etcoff, Whalen, Kennedy, Rauch, Strauss, Hyman, & Rosen, 1996). Fear conditioning even occurs for subliminal facial stimuli (Morris et al 1998; Whalen, Rauch, Etcoff, McInerney, Lee, & Jenike, 1998), while, on the other hand, human lesion studies have consistently found impaired recognition of fear following bilateral amygdala damage (Adolphs, Tranel, Hamann, Young, Calder, Anderson, Phelps, Lee, & Damasio, 1999).

When the activity of the amygdala during fear conditioning is cross-correlated with the activity in other regions of the brain, the strongest relations are seen with subcortical (faster), not cortical (slower), areas (Morris, Öhman, & Dolan, 1999). Amygdala even seems to be required for facial expression-specific activation of early visual cortex (Vuilleumier et al., 2004). This study, showing that amygdala can influence processing in remote visual cortical areas, compared two groups of patients having the same temporal hippocampal damage but which either included amygdala, or left amygdala intact. They showed that the normal enhancement (as found in a healthy control group and in two previous studies) in fusiform face-selective areas for fearful versus neutral faces was lacking in the patient group with amygdala damage. The severity of this damage even correlated negatively, within each hemisphere, with the enhancement of fusiform activity by fearful faces, without any such correlation between hemispheres. Because other relevant attentional systems (fronto-parietal) were functioning normally, this suggested to the authors that the amygdala also can have attentional effect on fusiform activity for fearful faces (Vuilleumier et al., 2004).

Some of the sources for how we assign (negative) value to the things around us, and how we perceive the world (as frightening), may well be related to the functional properties of our defensive systems (Öhman & Wiens, 2004). There is indirect evidence for this hypothesis from studies demonstrating that people pay attention to emotional more readily than to neutral stimuli (Adolphs & Spezio, 2006). This has been shown in Stoop tasks (Williams, et al., 1996), in visual search tasks (Öhman et al., 2001a, 2001b), in attentional blink paradigms (Anderson, 2005), and, exogenous cuing paradigms (Mogg & Bradley, 1999). Individual differences, too, in personality or anxiety level can modulate the emotional-driven attentional biases (Fox, 2002). Higher-order effects from emotion have been demonstrated in studies finding faster orienting to threat stimuli in high-anxious participants than in low-anxious controls (Mogg & Bradley, 1999), in studies showing a slower disengagement from threat in anxious individuals (Fox, et al., 2001) or reduced avoidance in anxious relative to non anxious people (Yiend & Mathews, 2001), and, finally, in studies showing differences in habituation or emotional regulation (Ochsner & Gross, 2005).

Thus, emotional processes are relevant to understanding how we assign value to the things around us, how emotions affect our perception of the world, and, finally, how emotions can affect behavior differently in different people, apparently depending on whether the emotions are smoothly integrated, or, as in the case of anxiety, were negative feelings seem to cause interference with normal cognitive functioning.

1.3.2 Eye Gaze as an Important Modulator of Emotional Expression

Humans are able to almost reflexively follow the gaze of another human being (e.g., Langton, & Bruce, 1999; Langton, Watt, & Bruce, 2000). It has been suggested by Baron-Cohen (1995) that the human ability to just determine facial gaze-orientation may be associated with an evolved predator-detection mechanism which is common to many animals, even outside the mammalian species, whereas the mechanisms for mediating a shared attentional focus is an evolved social skill that is found more exclusively among higher primates. In fact, the reflexive gaze-following mechanism is critical for several important psychological functions related to, for instance, expressing intimacy and exercising social control (e.g., Baron-Cohen, 1995; Langton, Watt, & Bruce, 2000).

Humans are particularly sensitive to facial features that have potential emotional meaning. One such facial feature is the direction of the eyes' focus or, in short, the gaze-direction. Gaze-direction is involved in the communication of an emotional expression (Emery, 2000) and it has been shown to modulate psychophysiological responses to facial threat (Dimberg, 1986; Dimberg & Öhman, 1983; see review by Dimberg & Öhman, 1996). Using an aversive conditioning procedure in a learning paradigm Dimberg & Öhman (1983) showed that gaze-orientation is crucial for the emotional effect of a face. If an angry face is directed towards the observer in the acquisition phase (when it is associated with something unpleasant) and is averted from the observer in the extinction phase (when the unpleasant association is no longer present), the learnt fear response towards the angry face disappears.

Associated with an emotional facial expression, the eye gaze of the "sender" determines the relevance of its emotional "message" for this observing "receiver" (Emery, 2000; Fridlund, 1994). Basically, a sender with a directed face-orientation communicates the emotional message to the observer, while an averted face-orientation is, so to speak, communicating with someone else. As intuitively known, the maintained eye contact between two persons is a good indication that social communication is taking place. Even just the timing of this eye contact can have emotional implications, for instance, a prolonged eye contact (the "long-lasting-stare-without-flinching" behavior) is often used in aggressive and in sexual contexts. Findings from comparative research on other primates suggest that a directed gaze communicates social dominance, while an averted gaze signals social submission (de Waal, 1988, 2005).

1.4 SELECTIVE ATTENTION

In our visual representation of the world, attention is likely to be involved at every step of the analysis (Adolphs, 2002). Visual perceptions are dynamically being molded by these selective forces, in what has been proposed to be a competition for representational resources in the brain (Desimone and Duncan, 1995). Selective attention can be seen as the brain's way of shifting over resources to new or important incoming information against a background of ongoing behavior. Our perceptions of the world seem to be influenced by a basic functional dichotomy in attentional processes. Attention can be influenced by stimulus-driven, *bottom-up* processes, for instance, by the better discriminability of some salient stimulus feature. Attention can also be guided by goal-driven, *top-down* processes, like cognitive task demands or voluntary efforts (e.g., Corbetta & Shulman, 2002; Posner & Petersen, 1990). Current psychological evidence supports the idea that orienting to sensory stimuli depends on a dynamic interaction between bottom-up and top-down signals. Thus, both bottom-up and top-down signals regularly determine which objects are selected for recognition and action.

Bottom-up attentional selection is fast and often compulsory (e.g., Treisman and Gelade, 1980; Treisman, 2006). It permits attention being "captured" by low-level simple stimulus information, for instance, luminance, color, or orientation, already at the level of striate and extrastriate cortex. In principle, bottom-up processing lets sensory input pass "straight through" the perceptual analysis, to be expressed in behavior, without receiving any feedback information from "higher" centers. Selective attention can increase the "weight" for this incoming visual information, by affecting the base-line activity in primary visual cortex (Kanwisher & Wojciulik, 2000). It can also enhance the visual processing of stimulus features, or parts, of objects, which are represented in later processing in the ventral visual stream (McCarthy, Puce, Belger, and Allison, 1999).

Top down attentional selection is the much slower and more elaborate processing, and is influenced by the observer's own expectations or intentions (e.g., Folk, Remington, & Johnston, 1992; Corbetta & Shulman, 2002). The basis for top-down driven selection of information is derived from previous experience, rather than from incoming sensory stimulation. Focused attention is what appears to assemble the relevant stimulus features into the percept of an object and what weeds out the incorrect conjunctions of features (e.g., illusions) (Treisman & Gelade, 1980). Here is also room for voluntary control, which permits us to *choose* to focus on the stimuli that we consider the most relevant to our current goals.

Controlled attention in relation to task demands is when there is top-down provision of support for the task-relevant processes, by using the representations of task demands to bias processing in favor of task-relevant stimuli and responses. Basically, if we know what we are looking for (its location, motion or color) this facilitates detection. The brain's representation of our goal makes this possible. It is used to bias the processing of incoming visual information (Corbetta & Shulman, 2002). This ability to direct attention has immense importance in that it enhances the visual processing of the particular things we *wish* to see. Obviously, top down, voluntary controlled, attention provides a very useful flexibility for us in our daily lives.

This a dynamic balance between a relatively more stimulus-driven attention and a more goal-directed attention is regulated by several functional architectures of attentional systems with their distinct neural underpinnings (e.g., Posner & Petersen, 1990). The partially segregated networks of brain areas (parts of the intraparietal cortex and superior frontal cortex versus - mainly right hemisphere - temporoparietal cortex and inferior frontal cortex) carry out different attentional functions (Corbetta & Shulman, 2002). One system prepares and applies goal-directed (top-down) selection for stimuli and responses, while still being modulated by the detection of stimuli. The other system is not involved in top-down selection, but is specialized for the detection of behaviorally relevant stimuli, particularly when they are salient or unexpected. This ventral frontoparietal network works as a 'circuit breaker' for the dorsal system, directing attention to salient events. For instance, stimulus-driven attention is subserved by parietal brain areas, while top-down control functions are subserved by frontal brain areas. There are also functional divisions between the medial and the lateral areas of the frontal lobes, which are associated with goal-related (endogenous) and stimulus-driven (exogenous) control of attention, respectively. Other systems involve subcortical areas of the brain, for instance, the superior colliculus and the pulvinar of thalamus (LaBerge, 1998). A network of several frontal and parietal brain components are concerned with representing and orienting attention towards spatial locations (i.e., the posterior, parietal component of the network), and with target detection, alerting and motor representation (i.e., the anterior, frontal component of the network), respectively. Selection of the behaviorally relevant information often requires that several attention mechanisms work together. That is, the sensory (or bottom-up) distinctiveness of the stimulation is modulated by the ongoing cognitive (top-down) goal, or, the attentional 'set' (Folk, et al., 1992). In our limited capacity for visual processing, attention is the "control tool" that adapts what we see to our current goals (Treisman, 2006).

1.4.1 Selective Attention and Perceptual Load

Although early theorizing conceptualized selective attention basically as a filtering process, working at the lowest level of simple physical sensations (e.g., Broadbent, 1958), this assumption soon had to be widened by empirical findings showing that meaningful aspects of the stimulation, like personal relevance, played a role in determining what is selected for further visual processing (e.g., Treisman, 1960). In early selection, focused attention at an early stage of visual processing prevents perceptual processing of irrelevant distractors. In late selection, only processes such as memory or response selection, which occur after the perceptual processing, are affected by selective attention (e.g., Shiffrin & Schneider, 1977).

Most models of attention still distinguish between the two processing stages that are implied in this conceptualization. That is, they distinguish between what happens before, and after, attentional focus has played its role (Cave and Wolfe, 1990; Findlay and Walker, 1999; Neisser, 1967; Theeuwes, 1993; Treisman and Gelade, 1980; Wolfe, 1994). Early studies proposed that distinctive sensory stimuli attract attention automatically, independently of intention or of the current task, but more recent studies have revised this idea. The salience of objects is strongly influenced by their behavioral relevance. It is still debated to which extent motivational and emotional influences are able to modulate what features are selected for further processing, that is, how extensive preattentive processing really is. Studies that demonstrate emotional effects on attention (Morris, et al., 1999) are indicating that emotional properties can influence our perceptions even before their semantic meaning is analyzed.

Lavie's work (1995, 2005) suggests that, in visual processing, attentional selection need not be located at a fixated stage at all, but can come about in a flexible way depending on the perceptual processing demands of the situation. According to Lavie (1995, 2005), attention is always fully deployed. If there is any spare attentional capacity left over when the main task is perceptually analyzed, it is automatically redirected to irrelevant stimuli. She sees a role for cognitive control processes, mediated by frontal cortices (e.g., Desimone & Duncan, 1995; Posner & Petersen, 1990). They are serving to control selective attention in accordance with task-relevant information by actively maintaining the current stimulus processing priorities between relevant targets and irrelevant distractors. Her idea is that cognitive control processes mediated by frontal cortices (e.g., Desimone & Duncan, 1995; Posner & Petersen, 1990) serve to control selective attention in accordance with task-relevant information by actively maintaining the current stimulus processing priorities between relevant targets and irrelevant distractors.

The proposed relationship between task load and selective attention leads to a late selection when there is low perceptual load from the task and to an early selection when the task is high in perceptual load. Perceptual load is defined within the specific task or context. It implies either that more items are added for the same task or that for the same number of items, a more demanding perceptual task is carried out under higher perceptual load. It is these items or operations that consume attentional capacity in the relevant process.

Lavie (1995, 2005) poses that there are two mechanisms of selective attention, one passive, perceptual, selection mechanism that excludes irrelevant distractor stimuli under situations of high perceptual load, because there is insufficient capacity for their processing. Basically, perception becomes more selective under high perceptual load (Lavie, Hirst, de Fockert, & Viding, 2004). On the other hand, processing will spill over to the irrelevant distractors in situations of low perceptual load. When both relevant and irrelevant stimuli are perceived, the irrelevant distractors can compete to control behavior. The accurate response selection in this context requires the rejection of distractors which must depend on some active control process (Lavie et al., 2004). Thus, early selection is predicted for situations of high perceptual load and late selection is predicted for situations of low perceptual load. Thus, Lavie's hybrid model of attention combines aspects from both early and late selection views. Lavie's (1995, 2005) model of selective attention under load predicts that the extent to which selective attention will be able to discard threatening distractor stimuli will depend on low perceptual load conditions, and that it is here that individual differences in the ability to prevent subsequent processing of salient distractors will be observed.

1.4.2 The Visual Search Paradigm and Its' Perceptual Determinants

The visual search paradigm is presently being used extensively in experimentally based analysis on the interplay between emotional processes and attention. Thus, visual search has been frequently used as a tool to study the role of selective attention in visual processing, with the aim of understanding how simple visual features are integrated and recognized as objects (Neisser, 1967; Treisman, 2006). Selective attention is believed to have an important functional role in this visual integration process.

The typical procedure in a visual search task is to present to the participant with a series of arrays (an array is a display of multiple stimuli) presented one at a time on a computer screen. They are instructed to look at this series of arrays and decide, for each one of them separately, whether a so called *target* (a stimulus that is different from the rest of the stimuli, which are called *distractors*) is present in the array, or not, and to use different response-buttons to indicate their decision. Participants are told to perform the task as quickly as possible while maintaining accuracy. On one half of the *trials*, a target is present and, on the other half of the trials, the target is absent (the array consisting of only distractor stimuli).

The attentional influences that determine the visual search process largely can be derived from two quite simple factors: (1) the perceptual discriminability of targets and distractors and, (2) the perceptual differences between the distractors (Duncan and Humphreys, 1989). The visual search task is therefore sensitive to *any* discriminable perceptual feature which emanates in a systematic way from the stimuli that are used in the arrays. Principally, it does not seem to matter what the "source" of visual identifiable difference is. Translating to the present context, with facial stimuli, the search outcome may just as well be the result of emotional aspects of the faces, like smiles or frowns - or result from some non-emotional facial feature, like a big nose or deep lying eye sockets. This means that any facial feature, emotional or non-emotional, may be selected by attentional processes, if only they are sufficiently discriminable (although, as we shall see, things get a bit more complicated when the perceptual load comes into play too).

The first perceptual factor, the target-distractor discriminability, refers to the finding that the target (presuming that there are at least two different targets in the experiment) which is most different from its surrounding distractors will be most efficiently detected (Duncan & Humphreys, 1989; Wolfe, 1998). The second factor, the distractor-distractor discriminability (their *homogeneity*) refers to the finding that a set of distractors that are perceptually similar are easier to encode than a set of more variable distractors. It is as if in the search for a target, the distractors are perceptually grouped and become the background against which a target appears more or less distinctly. This means that a target which is present among homogeneous (similar) distractors will be more efficiently detected than if it is present among heterogeneous (different) distractors.

If target A is detected more quickly and accurately, than is target B, this effect might be due to either of these principles being at work, or both. The target-distractor difference could be greater for target A than for target B, making it more discriminable from the "background" of surrounding distractors. Or, it may result from the way that the distractors are perceptually grouped together: if they share several visual features they may be easy to encode as a group, making it easy to dismiss them. In the reverse case, if the distractors have many unique non-target features, they may be hard to encode, meaning that they require more processing before they can be disregarded as non-target stimuli. The way that these perceptual factors may interact in a design needs to be carefully controlled. One way of executing this control is to employ a varied or constant mapping design; by either using all stimuli as both target and distractors, or, by keeping the same distractors across different target conditions. Using the right design and stimulus material is of course critical in preparing an experiment. In Experiment 1-3 we used constant mapping, that is, the distractor faces were always displaying a neutral expression. This choice avoided the problem of potential differences in variability among angry and happy faces, which could have been a problem in a varied mapping design, in which all stimuli are used as both targets and distractors, making it hard to disentangle target-related effects from distractor-related effects.

1.4.3 The Concept of Stimulus Redundancy

The performance in a visual search task is in principle related to perceptual distractor-distractor differences and to target-distractor differences (Duncan & Humphrey, 1989). Basically, these two perceptual factors relate search efficiency (Wolfe, 1998), quite simply, to what is present in front of the observer. However, this visual search model needs to be supplemented by the concept of stimulus *redundancy* (Rauschenberger & Yantis, 2006), to account for the special effects that are observed when some "special stimuli", such as faces, are used as stimulus material

Stimulus redundancy is a theoretical construct that has been developed within the field of attention research employing the visual search paradigm. The "redundancy" is defined in relation to the size of the *implicit set* of alternative stimuli that a given stimulus can be confused with (Rauschenberger & Yantis, 2006). The rule of thumb is: the higher the redundancy, the more efficient is the search performance (see figure 1).

Every observed stimulus refers implicitly or explicitly to larger or smaller stimulus sets that it may be confused with (Rauschenberger & Yantis, 2006). For example, using copies of a single individual face in our visual search task, we could get a homogeneous crowd of "cloned" faces. Since in this crowd all stimulus attributes are completely shared, the required visual analysis is completely specified by one of its members, making this crowd *highly redundant*. They induce no alternative stimuli, and, consequently any deviant feature is a cue to target presence.

On the other hand, using different faces in our task, every new face would add to the implicit set size because each of them will confer their unique stimulus attributes (i.e., from gender-, identity-, age-related differences) that potentially could be mistaken for belonging to some other face. This shows intuitively why it takes the perception of many more visual characteristics to identify the target when the stimulus has *low stimulus redundancy*.

1.5 GENERAL BACKGROUND OF STUDY I

1.5.1 Finding the emotional face in a crowd

Hansen and Hansen (1988) were pioneers in using emotional features of facial stimuli as a basis for differentiating between targets and distractors in a visual search task. Their point of departure was the question if emotional processes may influence the visual processing of faces. In particular, they were interested in whether evolutionarily shaped human innate defense systems, focused on detecting threat in the environment would influence attention differentially for different categories of emotional faces. Specifically they examined if angry faces, because of their status as threat signals, would more effectively recruit attention than would happy faces, thus resulting in faster detection of angry, than happy faces in a crowd of faces Accordingly, they predicted that attention processes would bias observers' visual face analysis to promote automatic detection of an angry expression, whereas a happy expression would not be favored by automatic detection. In their terminology, the angry face would "pop out" from the background thus allowing effortless detection by the observer. In agreement with their theoretical predictions, they reported that the participants were more effective in finding an angry target face in a happy crowd of faces, than they were in finding a happy target face in an angry crowd.

However, Purcell, Stewart, and Skov (1996) demonstrated that a simple, low-level perceptual confound was a major factor in the prioritized detection of angry faces that were reported by Hansen and Hansen (1988). When this confounding factor was removed, there were no differences in detection latencies for between angry and happy faces. Likewise, they did not obtain any difference between these two categories of emotional faces when a standard set of faces (Ekman & Friesen, 1976) was used. Purcell (et al., 1996) showed how vital it is to exclude the possibility that the search performance merely reflects the perception of physical features that have no interesting psychological relevance for the research question at hand, before making inferences about an emotional modulation of selective attentional processes.

1.5.2 Facial stimuli in the study of emotional effects on attention

Visual search studies that followed-up on the Hansen and Hansen (1988) findings using photographed pictures of real faces, and were reported before the inception of the present project, showed very inconsistent emotional results concerning a social threat bias (e.g., Gilboa- Schechtman, Foa, & Amir, 1999; Byrne & Eysenck, 1995; Purcell, et al., 1996). Those that used stimuli that were stereotypical and schematic, on the other hand, all demonstrated the expected threat-biased attention effects on search performance (e.g, Esteves, 1999; Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000; Lundqvist & Öhman, 2005; Öhman et al., 2001b; Tipples, Atkinson, & Young, 2002). Perhaps these mixed results reflected the use of different face materials. The lack of a consistent angry advantage in studies using photographed real faces was perhaps related to the greater amount of visual noise confounding the search performance with in these stimuli.

The schematic facial stimuli (see Figure 2), are in many ways preferable in the context of the visual search paradigm. Furthermore, they lack irrelevant visual information from differences in texture, shade, color, etc., that is inherent in photographed pictures of real faces. It may even be that in bypassing the interindividual variability that is inherent in real face, perhaps by directly contacting prototypical feature detectors, their effectiveness as emotional stimuli may be larger than that for photographed real faces (Öhman, et al., 2001b). In any case, they achieve good perceptual control and they isolate the emotionally meaningful features well (see Lundqvist, Esteves, & Öhman, 1999, 2004).

In contrast to the schematic faces, there is a substantial variation among photographed pictures of real faces (see Figure 3). A critical source of perceptual variability stems from their unique individual physical features. But also differences in color, contrast, head tilt, distance to the observer, to mention a few examples, may produce considerable variability. This kind of perceptual information is not relevant to the emotional message per se, although it confers information about the sender's personal characteristics (which might be relevant to how the emotional content is perceived)

Ideally, in the present research context, a face displaying an emotional expression in a crowd of neutral faces will be detected because of its emotional features, and not for anything else. Lundqvist, Flykt and Öhman (1998) had developed a large photographed set of faces, The Karolinska Directed Emotional Faces, the aim of which was to achieve good control over perceptual features (the clothes worn by the portrayed individuals were identical, so were the lightning conditions, the distance to the camera, and the angle of the face, etc.). Samples of faces from this facial material were used in Study I, II, and III.

1.5.3 Social anxiety in the study of emotional effects on attention

At the core, social anxiety consists in the fear of being negatively evaluated by other people (Watson & Friend, 1969). Social situations typically seem to the socially anxious individual to include an element of being evaluated and judged by other people, a scrutinizing of which they are certain that they will fail. The socially anxious individual has an intense fear of making some social mistake which will make him/her appear stupid or embarrassing in front of others. The fear of being found lacking by other people is often internalized in expectations of a negative outcome of social interaction. In a social situation, the socially anxious individual's attention is largely self-focused, engaged in monitoring fear-related bodily symptoms, like trembling hands or a shaky voice. This preoccupation with personal inadequacy more often than not amounts to a negative loop of negative self evaluations.

Characteristically, the socially anxious individual's coping strategies in social situations consist in avoidance behaviors (avoiding eye contact in conversations and in acting the silent observer in a group of people) and in efforts to try not to display any visible signs of nervousness (which are regarded as signs of failure). The clinical criteria for social anxiety or social phobia mainly revolve around the core apprehension that other people are judging them negatively, as stupid, embarrassing or socially incompetent.

Incorporating individual differences in levels of social anxiety in an experimental design provides a way of studying emotional effects on processes of selective attention. The underlying assumption behind this is that social anxiety runs on the inborn natural defense mechanisms, of which the threat-biased attentional orienting is a natural part (Öhman, 2005). Thus, in the heightened level of social anxiety, there might be a potentiation of the original orienting response towards the presence of a threatening stimulus in the environment. If this is the case, then, confronted with a feared threat-relevant stimulus (i.e., an angry face), socially anxiety should further facilitate its detection. To sum up, because angry facial expressions are primordial signals of social dominance and since social anxiety is likely to have its phylogenetic origin in defensive social behaviors, this is stimulus that the anxious individual should be sensitive about (Öhman, et al., 1985; Trower and Gilbert, 1989).

There several ways to cope with social threat: fight, flight, submit, and help-seeking (de Waal, 1988, 2005; Gilbert, 2001a, 2001b). Help-seeking is a coping behavior, for instance, in children who elicit care from the parent (Bowlby, 1969; Panksepp, 1998). Support from other individuals can help directly coping with a threat, but may also have important physiological effects, lowering arousal levels (Schore, 1994) and affecting the immune system (Uchino, Cacioppo, & Kiecolt-Glaser, 1996). There are also many ways in which social coping may fail (Gilbert, 2001b). Thus, individuals may deny someone's claims for a raised social status to gain more control over resources if this threatens their own status. Success in social situations is related to having some skill at manipulating the (positive) emotions of others and to becoming valuable and attractive to others (Gilbert, 1997). Thus, social defensive behaviors can fail because, for instance, one does not successfully escape; or one constantly loses; or one gets insufficient support from others (Gilbert, 2001b).

Social anxiety is considered to be the most common anxiety disorder. At least in Western countries, social anxiety has the lifetime prevalence in the 7–13% range (see Furmark, 2002, for a review). According to a review by Musa and Lépine (2000) there are three major cognitive models of social phobia. Briefly sketched, in one of them, social phobia is associated with dysfunctional beliefs about the standards for social behavior, for example, 'I must not show any signs of weakness'), or about social evaluation, for example, 'If I make mistakes others will reject me', or, finally, about the self, for example, 'I'm inadequate' (Beck & Clark, 1997). In another model, social anxiety is associated with an attentional self-focus which occurs when social phobic patients believe they are in danger of negative evaluation by others. This self-focus produces increased awareness of feared anxiety responses and interferes with processing the situation and other people's behavior (Clarke & Wells, 1995). In a third model, the social phobic patient forms negative mental representation of his/her behavior as seen by others (e.g., voice, blushing, etc.) and also monitors the social situation, looking for external threats i.e., negative evaluation (frowns, signs of boredom, etc.). The discrepancy between the mental representation of self and ideas about what others expect determines the perceived probability of negative evaluation from other people (Rapee & Heimberg, 1997).

1.5.4 Finding a role for threat-biased attention in social anxiety

The same argument about behavioral adaptiveness as was used by Hansen and Hansen (1988) applies to the socially anxious individual too, only even more, because innate defense systems, focused on detecting threat in the environment, might be further sensitized in socially anxious individuals (Öhman et al., 1985). This association between social anxiety and being sensitive for social displays of dominance should keep the socially anxious individual on the alert, constantly monitoring the environment for signals about approaching dominant group members. Social fear should keep the socially anxious individual on the alert, ready to signal back non-threat, in a display of fear or in a submissive smile (Chance, 1988; de Waal, 1988, 2005; Öhman, et al., 2001b).

The prediction of enhanced threat monitoring among socially anxious individuals implies more efficient detection of a socially threatening display in a crowd of faces. In agreement with this prediction, Gilboa-Schechtman and coworkers (1999), who tested individuals with social phobia in a visual search paradigm, reported that phobics detected angry faces relatively more quickly than happy faces among neutral distractors, compared to non-anxious controls.

1.6 STUDY I: LOOKING FOR FOES AND FRIENDS

1.6.1 Introduction

Visual search studies which have used schematic facial stimuli support the existence of a social threat advantage (Eastwood, Smilek, & Merikle, 2001; Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000; Öhman, et al., 2001b; Tipples, et al., 2002), similar to the threat bias reported in visual search for snakes and spiders (Öhman, et al., 2001a; Soares, Esteves, Lundqvist & Öhman, 2009) Therefore we expected that in our visual search studies with real faces, we would find an advantage for detecting a target displaying an angry (threatening) emotional expression, before a target displaying a happy (non-threatening) emotional expression. In Experiment 1-3 we manipulated four experimental factors: (a) the emotional expressions of the target faces (angry versus happy); (b) the emotional valence of the distractors (neutral versus emotional, i.e., happy distractors for angry target and vice versa); the orientation of the stimulus faces (directed versus averted) for both (c) target and (d) distractor faces. In addition, we investigated whether the effect of these manipulations would be enhanced by social anxiety by comparing different groups of participants who were selected to be either high or low in social anxiety. The hypotheses for Experiment 1 and 2 were the following: (a) Angry faces will be found more quickly than happy faces among neutral distractor faces; (b) this effect will be more obvious when the target faces are directed toward the observer than when they are averted; and (c) both these effects will be more obvious among participants high rather than low in social anxiety. In Experiment 3, we predicted a reversed effect of face-orientation, because a fearful expression replaced the angry one as the (potentially) threatening target stimulus. An averted fearful face implies an unknown source of threat in the surroundings (Morris, Frith, Perrett, Rowland, Young, Calder, & Dolan, 1996 ; Öhman et al., 1985; Whalen, 1998; Whalen, Shin, McInerney, Fischer, Wright, & Rauch, 2001), whereas a directed fearful face suggests an explicitly non-threatening submissive gesture. Thus, in Experiment 3, we predicted that a *fearful* target with an *averted* face-orientation would be more efficiently detected than a directed fearful target (associated with social submission). Finally, since previous studies comparing individuals selected to be fearful and non-fearful of the threatening target stimulus (e.g., Öhman, et al., 2001a) showed enhanced attentional bias for detecting threat-relevant stimuli, we predicted that the heightened level of social anxiety would promote a more efficient orienting toward social threat, compared to healthy controls.

1.6.2 Hypotheses for Experiments 1-3

We tested our hypotheses using 60 different stimulus individuals from the KDEF photographed stimulus material in our visual search tasks. By employing this large set of faces we wanted to make sure that no visual noise, such as from a small shade on some individual's chin, would be systematically associated with one emotional expression and, thus, be undermining the interpretations of our results.

In Experiments 1-3, we used the visual search task to investigate whether attentional processes were biased for an efficient detection of socially threatening facial stimuli. In each of the three experiments, two emotional expressions were used as targets (an angry and a happy in Experiments 1 and 2, and, a fearful and happy in Experiment 3. The distractors were always neutral in their facial display. We also varied the face-orientation (which was congruent with gaze-orientation) in both target and distractors (directed or averted, directed either side at 45°), because the facial orientation indicates who will be the likely target of actions implied by the emotional display (Emery, 2000). By this logic, a directed threatening face poses a potential threat to the observer, but an averted face is less concerning to the observer (except if it is fearful, as in Exp.3). In each of the three experiments, two face-orientations were used. The distractors always shared face-orientation, jointly as a group. The eight pictures in an array were arranged in a circle around the fixation point (see Fig. 2). The set of trials included an overall balanced set of portrayed individuals as to identity, gender, the emotional expression of the target, the direction of target and the distractors, and position in the display of eight pictures. The design and procedures in the second and the third experiments were identical to those of Experiment 1, except for the social fear manipulation procedure in Experiment 2 (described later) and the exchange of the angry target for a fearful target in Experiment 3 (described later).

All three experiments recruited participants, using the Fear of Negative Evaluation questionnaire, FNE (Watson & Friend, 1969) to allocate participants into the high and the low social anxiety groups, except in Exp. 3, where individuals diagnosed with social phobia were recruited into the high anxious group. The FNE questionnaire includes questions like: "I feel very upset when I commit some social error"; "I rarely worry about what kind of impression I am making on someone (reversed)"; "I become tense and jittery if I know I am being judged by my superiors".

1.6.3 Results and Discussion of Experiment 1

The results from this experiment showed that the detection of happy target faces was more effective (both in terms of detection latency and accuracy) than the detection of angry targets, and the face-orientation had a stronger effect on happy than on angry faces (see Figure 4). Neither emotional expression nor face-orientation interacted with level of social anxiety. There was a strong effect of the facial direction of targets and an interaction between the face-orientations of targets and distractors, showing that a directed target among averted distractors resulted in faster and more accurate detection than when all faces in the array were congruent in face-orientation, which modulated the effect of emotion, resulting in a happy advantage primarily in the conditions in which targets and distractors shared face-orientation.

1.6.4 Results and Discussion of Experiment 2

Some previous findings had suggested that the social anxiety needs to be activated to affect attentional performance (Chen, Lewin, & Craske, 1996; Mansell, Clark, Ehlers, & Chen, 1999). For this reason we decided to include a fear manipulation in Experiment 2, which intended to induce a state of social anxiety in all participants. The social fear induction procedure was meant to activate social anxiety by prompting self-focusing in the participants (e.g., Clark, & Wells, 1995). Thus, all participants were told that an expert rater would observe them closely during the whole test, looking for signs of nervousness. The observer was a tall 24-year-old man who used a fake protocol and a stopwatch to make his observations appear realistic. (The fear induction procedure was applied both in Experiment 2 and in Experiment 5, which were administered to the same participants, although the two experiments were analyzed independently, as they used different facial stimuli and different designs.)

The results from this experiment concurred with those in Experiment 1, that is, in failing to support our hypotheses (see Figure 5). Again, a happy target was easier to detect, than was an angry target, in a crowd of neutral faces. There was a similar strong effect of the facial direction of targets and an interaction between the gaze-orientations of targets and distractors, as in Experiment 1. There were some minor effects of social anxiety in this experiment, relating to gaze-orientation, which were difficult to interpret.

1.6.5 Results and Discussion of Experiment 3

Experiment 3 served both to rule out that the happy advantage was specific to the happy–angry comparison and to try to increase the individual differences in levels of social anxiety. To accomplish the first purpose the angry target was exchanged for a fearful target. To accomplish the second purpose we recruited 15 indivduals diagnosed with social phobia to our high-anxious group, using *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) criteria and an experienced psychiatrist. The socially phobic participants were matched in age and gender to 15 individuals with no history of psychiatric disorder.

A happy target was more effectively detected than a fearful target, and a directed target was more effectively detected than an averted one (see Figure 6). Again, there was a strong interaction between target- and distractor-orientations of the gaze. The participants with social phobia performed overall less accurately in target detection than controls.

1.6.6 Summary of Experiments 1-3

Detection was both quicker and more accurate for a target displaying a happy facial expression, than for one displaying an angry (Exp. 1 and 2) or a fearful (Exp. 3) expression. The results from Experiment 1-3 all revealed strong interactions from the various combinations of face-orientations of the targets and the distractors. In fact, it was even easier to detect an averted target among directed distractors than it was to detect a directed target among directed distractors (see Figure 5, for an example of this), which was opposite to the main effect showing that a directed target was detected more quickly than an averted one. This suggested that it was a differential *global* cue which cued the presence of a target. This effect most likely should be attributed to the impression that the directed and the averted face-orientations were associated with different head shapes. That is, the overall shape of the array appeared as a smooth circle or as a jagged circle, depending on whether the face-direction of the target and the distractors were congruent or incongruent. This interaction also modulated the effect of emotion, showing that there was a less pronounced happy advantage when the faces shared gaze-orientation, suggesting that the emotional expression of the target only served as cue to target presence when directional cues were lacking. This fact raised the suspicion that the happy advantage was not even an emotional effect at all.

In reporting the happy advantage, we discussed several arguments promoting the perceptual interpretation. One such argument pointed to the observed higher prevalence of smiling faces, than of frowning angry, in the every-day life (Bond & Siddle, 1996; Whalen, 1998) which could have primed the happy target for superior detection by extensive training (Tong and Nakayama, 1999). Another important argument (which prompted us to run the Experiments 4A and 4B) pointed at the considerable support showing that recognition for a happy expression in focal attention is easier than for any other emotional faces (e.g., Esteves & Öhman, 1993; Kirita & Endo, 1995; Leppänen & Hietanen, 2003).

Finally, as already mentioned, we proposed that in Experiments 1-3 the strong reliance on directional discrepancy to locate the deviant face in the crowd suggested that the participants only secondarily used emotional expression as a cue to target presence. More recent experimental research by Calvo and Nummenmaa (2008) has added credibility to this perceptual interpretation of the happy advantage in Experiments 1-3, by demonstrating in a series of visual search experiments that detecting the presence of a happy target face in a crowd of neutral faces can be managed by simple perceptual processing that relies on only a featural visual analysis of the target face.

1.6.7 Brief report of Experiments 4A and 4B

To investigate differences in the recognition of the various emotional expressions, all the stimulus faces used in the visual search task were presented one at the time to be categorized as belonging to one of the four emotional categories: angry, happy, fearful, or neutral in a choice RT task, This was done separately for photographed real faces (Experiment 4A) and for schematic faces (Experiment 4B, the emotional categories here were: threatening, friendly, or neutral).

The results from Experiment 4A showed that a photographed happy expression was much better recognized than a photographed angry, fearful or neutral expression. They also showed that angry, fearful and neutral expressions were easily confused with one another, whereas the happy expression was distinctly different from these three expressions. The results of Experiment 4B showed highly accurate identification of all three expressions with no differences between them and a somewhat slower identification of the friendly than the threatening and the neutral schematic faces.

1.6.8 Methods in Experiment 5

In Experiment 5, a so called varied mapping design was used: the distractors were either neutral or emotional faces in separate conditions. Thus, with emotional distractors there were threatening distractors for a friendly target and friendly distractors for a threatening target, respectively. Also used in Experiment 5 was the procedure of inducing a situational social anxiety by having an observer being present in the room. All participants performed the visual search task once with and once without being scrutinized by the allegedly critical observer, balancing the order of this condition over groups.

1.6.9 Results and Discussion of Experiment 5

Experiment 5 consistently produced more effective detection of threatening, than of non-threatening, targets among both neutral and emotional distractor faces. However, for response accuracy, the angry advantage was obvious only with emotional distractors, which suggests a trade of according to which the participants maintained speed at the expense of accuracy in the most demanding condition when the distractors were emotional. For accuracy data there was an important interaction confirming the expected enhanced threat bias among the group of socially anxious participants, compared to the low-anxious control group (see Figure 6).

The enhanced threat bias in accuracy by heightened levels of social anxiety only occurred when the participants' social fear was further enhanced by the social fear induction procedure, suggesting that high levels of social anxiety are required for the attentional bias to become manifested in performance (see Figure 7). The enhanced anxiety-related threat bias was limited in other respects too. In particular, it primarily concerned search conditions with emotional distractors. The results therefore pointed to the possibility that the socially anxious participants were *distracted* by threatening faces when targets were friendly, rather than reflecting a bias for attending to threatening targets.

1.6.10 General Discussion

The unexpected, consistent happy advantage in this series of three independent visual search experiments with photographed real faces most likely reflects perceptual rather than emotional factors, such as expression, face-orientation or levels of social anxiety. This was suggested by the diminished emotional influence when targets and distractors had discrepant face-orientations. This interpretation is supported by the fact that the happy advantage receded when a low level feature, such as the global shape of the array (see Fig. 2) allowed reliable discrimination between displays with and without targets. In addition, the advantage for happy targets possibly could be reflect the distinctiveness of happy faces from the angry fearful and neutral faces that constitute a group of mutually confusable stimuli. This interpretation is consistent with the results in Experiment 4A, and accords with other empirical findings (e.g., Calvo & Lundqvist, 2008; Exp. 4; Palermo & Coltheart, 2004). Thus, the apparent ease of identifying happy faces, possbily from simple features rather than configural analyses (Calvo & Nummenmaa, 2008) is likely to make the happy target a highly discriminable stimulus in a visual search task and, perhaps, also less likely to be confused with the neutral distractors, than the angry and fearful targets. The aim of Study II was to find out whether stimulus factors that might contribute to the happy advantage could be manipulated to produce an angry advantage.

In Experiment 5, the socially anxious participants' enhanced threat bias was manifest only in the presence of the critical observer. A closer look at the underlying interaction for this effect revealed that it probably was related more to difficulties in ignoring the threatening distractors while searching for a friendly target, than to improved detection for threatening targets among friendly distractors. In Study III our goal was to gain a better understanding of this anxiety-related threat-biased attention, with the specific aim to find out what type of attentional process that the present findings really signified; enhanced orienting towards threat or a problem with rejecting threatening distractors.

The results from Study I showed that the visual search outcome for emotional faces may be influenced by unforeseen differences in perceptual conditions relating to whether schematic or real faces are used. These facial materials differ in variability, from having or not having individual features. This fact led to differences in respect to distractor homogeneity. It might make a difference whether a visual search task used "cloned" copies of only one individual face, or if it used several different individuals, for a stimulus material. Apparently, studies reporting an angry visual search advantage with real faces had used designs with few stimulus persons and cloned distractors.

1.7 STUDY II FINDING THE FACE IN A CROWD

1.7.1 General background

In Experiment 1-3, the superior visual search performance for happy targets compared to both angry and fearful ones, and the strong influence from discrepant face-orientations between the target- and the distractors, suggested a largely perceptually driven visual search performance with photographed real faces. This interpretation is consistent with recent work with the visual search paradigm with faces as stimuli. Calvo and Nummenmaa (2008) demonstrated that happy faces were superiorly detected on the basis of identifying a single feature (i.e., the smile), implying that emotional processing may be superfluous to the happy advantage in visual search performance. They also demonstrated that detection of an angry face (in a neutral crowd) was significantly slowed when the face was inverted (up-side-down), compared to the performance with an angry face in the normal orientation. Calvo and Nummenmaa's (2008) findings that detecting a happy target only requires featural processing, whereas detection of an angry face seems to depend on more complex configural processing (see Farah, Tanaka, & Drain, 1995), might imply that there are differences in the amount of processing which is required for detecting an angry target compared to a happy one (Lavie, 1995, 2005).

Our next step was to look at possible design characteristics in common between studies showing the same emotional effects. Some studies using photographed real faces showed more rapid detection of angry than happy target faces among neutral distractors (Fox & Damjanovic, 2006; Horstman & Bauland, 2006), others find no difference (Williams, Moss, Bradshaw, & Mattingly, 2005), and yet others show faster detection of happy than angry targets (Calvo & Nummenmaa, 2008).

The mixed emotional effects among studies using photographed real faces, contrasted remarkably with the unanimous support for a social threat bias from visual search studies using schematic faces (e.g., Calvo, Avero, & Lundqvist, 2006; Esteves, 1999; Fox et al., 2000; Juth, Lundqvist, Karlsson, & Öhman, 2005, Exp. 5; Lundqvist & Öhman, 2005; Öhman, et al., 2001; Tipples, et al. , 2002).

The overall lack of consistency in the emotional findings among different visual search studies using different facial stimuli provided a starting point for further investigation of the perceptual principles that govern the search process. The results from Study I had shown the urgency of delineating the conditions that determined when happy or angry advantages in search performance were observed. One obvious factor was related to whether schematic or real faces were used. Another factor seemed to be related to whether homogeneous or heterogeneous crowds were used, that is, whether the distractors consisted in copies of a single cloned face or consisted in several different individual faces. Thus, as an initial step forward, adding a role for distractor homogeneity to the already important role for target discriminability, which was established by Calvo and Nummenmaa (2008), we aimed for delineating which perceptual conditions that reliably produced an angry advantage in a visual search with real faces.

1.7.2 Introduction

On the one hand, the visual search studies using photographed real faces which reported an angry advantage used distractor faces that were posed by the same individual (Fox & Damjanovic, 2006; Gilboa-Schechtman et al., 1999; Horstmann & Bauland, 2006). Their results seemed to revolve around the perceptual factor of distractor homogeneity. That is, they used perfectly homogeneous distractors, with "cloned" crowds consisting of several copies of a single individual face. Such an array of uniform distractors is the photographed-real-face version of the lack of individuality that is characteristic of schematic faces.

On the other hand, the visual search studies using photographed real faces which reported a happy advantage used distractors composed of different male and female individuals typically drawn from quite large sets of stimulus faces (Calvo & Nummenmaa, 2008; Byrne & Eysenck, 1995; Juth et al., 2005, Exp. 1-3). This latter factor, the size of the set of stimulus faces used in the entire task, provided another potential explanation for the different patterns of emotional effects in the reviewed visual search studies, including our own findings. Thus, it appears that the total number of individual faces used for the stimulus material was related to the emotional effects. While studies which had used many faces found a happy advantage, studies using only few faces found an angry advantage. This observation was difficult to fit with the underlying assumption that only the present stimuli and their visible characteristics (i.e., their discriminability) should determine the search outcome (Duncan & Humphreys, 1989). As discussed above, Rauschenberger and Yantis (2006) proposed *stimulus redundancy* as a central determinant of visual search performance. It appears that distractor homogeneity and stimulus set size both can be subsumed under the concept of stimulus redundancy. Thus, a fully homogeneous set of distractors is highly redundant because it is completely specified by one of its members (‘‘if you’ve seen one, you’ve seen them all’’). Complete specification of a fully heterogeneous set of different distractor faces, on the other hand, is more demanding, because knowing one of the set members does not generalize to other members of the set, thus giving minimal redundancy. This also applies to stimulus set size, as explained in paragraph xx).

Thus, in Experiment 6, we operationalized stimulus redundancy by varying distractor homogeneity versus heterogeneity, and, by varying the stimulus set size, respectively (note, that “stimulus set size” should not be confused with the number of distractors, it refers to the total number of individual stimulus faces used in the entire task). We manipulated both distractor homogeneity and stimulus set size, hypothesizing that these factors were the candidate sources of the amount of processing resources available for target processing. We assumed that stimulus redundancy indirectly was paving the way for the emotional effect, by permitting featural (non-emotional) or configural (emotional) face processing.
Highly redundant distractors (Duncan & Humphrey, 1989; Rauschenberger & Yantis, 2006), leave more perceptual resources to be allocated to target processing, because of their diminished perceptual load (Lavie, 1995, 2005). So, first, because angry faces need resources for configural processing, but happy faces can be detected on the basis of a single feature (Calvo & Nummenmaa, 2008), increased resources may at some point start benefitting the angry target, over the happy. Secondly, because configural

processing of the emotional expression of the target also will incorporate processing its gender, gender differences in relation to the encoding of angry and happy expressions will affect the search outcome.

Since anger is more quickly and accurately recognized in male faces than in female faces, and the reverse is true for happy faces (Becker, et al., 2007; Fabes & Martin, 1991; LaFrance, Hecht, & Levy Paluck, 2003; see Brody & Hall, 2008, for a review), we expected the detection of angry targets to be enhanced by male targets. Some other empirical findings that may suggest gender effects on attentional processes comes from aversive associative learning studies, which have shown that gender and age of the stimulus person also may affect how well it is associated with threat (Öhman & Dimberg, 1978). In fact, angry male faces are more effective conditioned stimuli (CS) than are angry female faces, and a grown man is also a more efficient CS than a boy (Mazurski, Bond, Siddle, & Lovibond, 1996).

1.7.3 Method

Sixty-four participants were randomly assigned to 4 sex-balanced experimental groups of 16 participants each. Distractor redundancy was manipulated in two factors: (1) distractor homogeneity, and (2) the total number of stimulus individuals that the research participants encountered in the experiment. Thus, the faces exposed to a participant on a given trial were selected from stimulus sets that either incorporated a small (6) or a large (60) number of stimulus individuals.

30 male and 30 female faces were selected from The Karolinska Directed Emotional Faces to constitute the large stimulus set in the experiment. For a given participant in the small stimulus set conditions the implicit stimulus set involved 6 individuals, which was randomly sampled from a subset of 12 individual stimulus persons (6 females) from the total set of 60 faces.

Six faces were arranged in a circular array. On half of the trials the display showed only neutral faces, and on the other half, one of the neutral faces was exchanged for a discrepant emotional target face. Half of the target trials showed a male and the other half a female target face. Targets displayed a happy or an angry expression. Distractors always showed a neutral expression.
Four between-subject conditions were created by varying the distractor homogeneity in the displays and the stimulus set size, i.e., the number of stimulus individuals used in the entire task. In the homogeneous distractors conditions all faces on a given trial were clones of the same person. In the heterogeneous distractors condition all faces were depicted by different individuals (see Figure 8). The small stimulus set size conditions involved 6 individual faces (3 females). Participants in the small/homogeneous group saw six versions of the same stimulus individual on every trial, but six different individuals across trials. Participants in the small/heterogeneous condition, on the other hand, saw the same set of six different individuals on every trials in the experiment.

1.7.4 Results and Discussion

According to the interaction between Target Emotion and Target Gender, the overall happy face advantage was limited to female faces. This result is consistent with our hypothesis that the happy advantage would be enhanced when the target was female and reduced when it was male. The basic interaction between Target Emotion and Target Gender was modified by both Stimulus Set Size and Distractor

Homogeneity, for two three-way interactions (see Figure 9). These, in turn, were subsumed in a five-way interaction between all the above variables and Block. To address our hypothesis we made separate analyses for male and female target genders (see Figure 10).

For male targets, a strong interaction between Emotion and Stimulus Set Size (Figure 9, left upper panel), showed that a small stimulus set (i.e., high redundancy) would favor an angry face advantage particularly for male targets, and that a large stimulus set (i.e., low redundancy) would favor a happy face advantage. Comparison between the upper and lower left panels of Figure 9 shows that a small stimulus set was more important than homogeneous distractors for producing the angry male target advantage. As confirmed by the three-way interaction between Emotion, Stimulus Set Size and Homogeneity for male target faces, the angry advantage that was apparent with the small stimulus set (collapsed over the homogeneous/heterogeneous condition; upper left panel) was not to be seen with the homogenous condition (collapsed over the two set sizes; lower left panel) For female targets (Figures 9 and 10, right panels), a happy face advantage was obvious from the beginning and remained across stimulus blocks (with one exception in the right panels of Figure 10).

The overall results showed that the visual search performance was strongly affected by our manipulations of stimulus redundancy, with much shorter target detection latencies in redundant than in non-redundant search conditions (Fig. 9). Importantly, an angry face advantage was observed, but only with male targets and redundant stimuli. These results were predicted from the combination of three theoretical concepts: (a) Rauschenberger and Yantis's (2006) theory of stimulus redundancy, (b) Lavie's concept of perceptual load, and (c) the differential effect of gender in recognition of facial emotion (Becker et al., 2007). First, more redundant distractors should leave more perceptual processing resources for finding the target stimulus (Lavie, 1995, 2005). Second, because recognition of angry faces is more perceptually demanding than recognition of happy faces (Calvo & Nummenmaa, 2008), recognition of angry faces should be more facilitated by low perceptual load than happy faces. Similarly, the facilitated recognition of anger in male faces may be more important than the facilitation of happiness in female faces (Becker et al., 2007) because the very efficient detection of happy faces may produce a ceiling effect. Finally, when a happy advantage was apparent (Figure 9) it decreased with increasing distractor redundancy. The right panels of Figure 9 show that, whereas emotional effects of male target faces depended on the size of the stimulus set, the female target faces provided a happy face advantage across all distractor conditions.

The angry face advantage was observed in the beginning of the experiment when the distractors were homogeneous, and was observed in the second half of the experiment when the distractors were heterogeneous (Figure 10, left panels). Thus, when the stimulus set size was small there was an advantage for angry (male) targets before happy (male) targets. Distractor homogeneity also influenced the angry advantage, but not in a critical way, since in the second trial-block an angry advantage was achieved even with heterogeneous distractors.

To sum up, our results demonstrated that two interacting conditions are required to obtain the angry face advantage: (a) a small stimulus set (i.e., they should be highly redundant); and (b) a male target face. In a sense, we found a way in Study 2 of exploiting the perceptual variability originating from the individuality inherent in real photographed faces, by using it to vary the perceptual load. When understood in terms of stimulus redundancy (Rauschenberger & Yantis, 2006), varying the distractor homogeneity and the stimulus set size seemed to alter the attentional 'set' and affect how the faces were processed in the search for a target. On the one hand, low redundancy enabled simple facial features to be selected as cues to target presence. Thus, with a high perceptual load, there will be a happy advantage because the smile is the most discriminable among the facial features that don't require configural processing. When, on the other hand, selective attention is set for configural face processing, both emotional and gender-related features were processed in the search for a target. Thus, low perceptual load provided enough room for configural processing, which permitted the angry advantage when the target was portrayed by a male individual.

1.8 STUDY III SOCIAL THREAT AND SOCIAL ANXIETY

1.8.1 General background

There is considerable empirical support from studies examining individuals diagnosed with different anxiety syndromes (see review by Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007) that selective attention to threatening stimuli is a factor contributing to the maintenance of anxiety symptoms (e.g., Eysenck, 1992; Mathews, 1990; Williams, Watts, MacLeod, & Mathews, 1997). However, for social anxiety the nature of this threat-biased attention still remains a controversial issue (see reviews by Bögels & Mansell, 2004; Hofmann, Heinrichs, & Moscovitch, 2004; Schultz & Heimberg, 2008).

One persistent issue revolves around the question of whether the socially anxious individual gives attentional priority to a socially threatening stimulus (e.g., Rapee & Heimberg, 1997) or avoids it (Clark, 1999; Clark & Wells, 1995). Empirical findings have generated support for both these opposing claims. A more recent conceptualization of the threat-biased attention in anxiety, questions whether it even concerns enhanced detection of threatening facial stimuli at all. Rather than involving enhancement of the shift component of attention (Posner & Pedersen, 1992), this alternative account proposes that the anxiety-related threat bias involves a problem with releasing attention once a threatening stimulus is focused in the mind's eye, that is, to say, rather than being attributable to rapid shifts of attention to threatening stimuli, the problem associated with anxiety may be slowed disengagement of attention.

1.8.2 Introduction Experiment 1 and 2

In Study I (Exp. 1-3), we compared low anxious control participants with participants selected either because of high self-reported social anxiety or a diagnosis of social phobia in three independent visual search experiments with photographed real faces. The visual search paradigm can be designed to measure attentional processes which are more closely associated with the shifting of attention. In contrast with the findings in the visual search study by Gilboa-Schechtman (et al., 1999), our series of (Exp. 1-3) found no evidence of an anxiety-related threat bias. Contrary to our predictions, we obtained an overall happy-advantage across all three experiments.

One possible factor behind these contrasting results could be that the enhanced threat-biased attention in relation to social anxiety that we were looking for may rests on an experimentally produced, stimulus-driven overall advantage for angry faces in search performance. Study II (i.e., Öhman, Juth, & Lundqvist, in press) showed that an angry advantage was apparent only in a set of narrowly defined perceptual conditions and, then, only for male target faces. Thus, our primary aim in Experiment 1 in Study III was to replicate the angry advantage from Study II and, on the premise of this stimulus-driven threat bias as a prerequisite for observing top-down effects from social anxiety, test our hypothesis of enhanced threat detection in socially anxious individuals.

1.8.3 Rationale and hypotheses for Experiment III

Experiment 5 in Study I found a threat advantage using schematic facial stimuli, and, in addition, also demonstrated that individuals with high levels of social anxiety were more threat-biased in their search, particularly if their social anxiety was elevated by the presence of a critical observer (i.e., fear induction procedure). However, this threat-bias effect among the socially anxious participants was limited to the search condition with emotional distractors. This limitation made it impossible to determine whether this enhanced effect actually involved enhanced threat detection or if, rather, it involved more threat-distraction from the threatening distractors in the contrasting condition of the search for a friendly target.

The purpose of Experiment 2 in the present study, therefore, was to examine individual differences in social threat distraction, in a paradigm designed to assess the disengagement component of attention (Posner, & Petersen, 1990) and used to investigate the slowed disengagement hypothesis of anxiety (Fox, 2004b). Several behavioral studies suggest that state/trait-anxious individuals may be more distracted by a threatening stimulus, as compared to healthy control, in an attentional process assumed to involve a prolonged dwelling of attention on threat (e.g., Fox, Russo, and Dutton, 2002; Fox, et al., 2001; Georgiou, et al., 2005; Yiend and Mathews, 2001). We formulated two major hypotheses involving different aspects of the predicted threat distraction effect on the socially anxious participants' task performance: (1) that, specifically, it would involve a socially threatening stimulus, rather than a merely emotionally negative stimulus, and (2) that it would involve relatively earlier, rather than later, attentional processing of a socially threatening stimulus.

To test Hypothesis 1, which stated that individual differences in level of social anxiety will be associated with a distraction effect from social threat on goal-directed attention processes, we first addressed the specificity of this effect. Specifically we hypothesized that it would involve a socially threatening stimulus (cf Mogg, Garner, and Bradley, 2007), rather than a merely emotionally negative stimulus (Martin, Williams, and Clark, 1991; Bradley, Mogg, White, Groom, and de Bono 1999). For this purpose, we contrasted trials were the central (task-irrelevant) face displayed an angry versus a fearful expression and varied their level of threat-value versus emotional negativity (valence) by manipulating their face-orientation. The critical test for the specificity hypothesis thus comprised trials where the central task-irrelevant face displayed *negatively valenced and threatening* combinations of expression and face-orientation (i.e., angry directed and fearful averted faces) which were contrasted with trials where the central face was *negatively valenced and non-threatening* (i.e., fearful directed and angry averted faces) (Adams, Gordon, Baird, Ambady, and Kleck, 2007; Adams and Kleck, 2003, 2005; Whalen, 1998; Whalen, Rauch, Etcoff, McInerney, Lee, and Jenike, 1998).

Hypothesis 2 predicted that the expected anxiety-related threat-distraction effect would involve relatively earlier attentional processing of a socially threatening stimulus, rather than later attentional processing (Mogg and Bradley, 1998). For this purpose, trials presenting a socially threatening (angry) face, were contrasted with trials presenting a socially non-threatening (happy) face, while manipulating the time interval between the onset of the face and the onset of the peripheral probe (600 or 1500 ms), to determine the time-course of the anxiety-related threat distraction effect. The SOAs afforded two "time-windows" for the threat-biased effect to appear in. The choice of SOA was bases on previous studies showing that, typically, a threat bias is present at around 500-600 ms post presentation, but that it disappears around 1000-3000 ms post presentation (Rohner?).

1.8.4 Method Experiment 1 and 2

The same psychometrically defined socially anxious and non-anxious participants performed a visual search task (Experiment 1) and a letter discrimination task (Experiment 2), in counterbalanced order between groups. In Experiment 1 a visual search task was designed based on our previous findings in Study II to optimize the chances to observe an overall threat advantage. Thus, we used photographically depicted male target faces and maximally redundant distractors composed of identical replications of the target individual showing a neutral facial expression, for completely homogeneous distractors.

In Experiment 2, a letter discrimination task (Fox et al. 2001; Georgiou et al. 2005) was used for testing the hypothesis that an attentional disengagement problem disrupts the socially anxious individuals' cognitive processing in the presence of socially threatening stimuli. In this task a central task-irrelevant face is continually presented focally while a peripheral letter-discrimination task is suddenly initiated. The participant's task is to identify the peripheral letter as quickly as possible. The time until response is used as an indirect measure of the ability to disengage attention from the central task-irrelevant face. A typical trial consists in a central fixation cross being replaced by a centrally located stimulus face, which remains visible throughout the entire trial. After a predefined delay (600 or 1500 ms), the letter P or X is presented in a peripheral location (9° in visual angles from the center of the screen) for a 60 ms exposure duration.

An essential aspect of our method was that the participants' eye-movements were recorded while they performed the two attention tasks. The eye-movements inherently relate to shifts in visual attention, because the eyes typically move to the location where attention is allocated (Deubel and Schneider, 1996; Hoffman and Subramaniam, 1995; Kowler, Anderson, Dosher, and Blaser, 1995). The purpose of recording the eye-movements was to assess whether the socially anxious visual search performance was influenced by avoidance behaviors (i.e., Horley, Williams, Gonsalvez, & Gordon, 2003; Horley, Williams, Gonsalvez, & Gordon, 2004) in Experiment 1, and to find out whether the expected anxiety-related threat distraction effect in Experiment 2 was associated with a prolonged dwelling with the focus on a central face displaying a socially threatening, as opposed to non-threatening, facial display (e.g., an angry, as compared to a happy, expression).

1.8.5 Results and Discussion Experiment 1

The results from the visual search task showed that although we obtained the expected threat bias, which was corroborated by eye-movement data, the level of social anxiety did not in any way influence the search performance. Thus, there were no behavioral differences relating the threat-biased search performance differentially to the participants' level of social anxiety (Figure 11). The lack of a further bias driven by social anxiety, therefore, seriously questions that social anxiety facilitates the process of orienting attention towards social threat.

1.8.6 Results and Discussion Experiment 2

The results showed that the socially anxious participants were relatively more distracted in their task performance by a threatening central task-irrelevant face, than by a merely emotionally negative display (Figure 12). The present results are consistent with anxiety-related effects which have been demonstrated in other studies that have combined emotional expressions and face-orientations in similar ways (Fox et al., 2007; Garner, Mogg, & Bradley, 2006). The results from testing hypothesis 2 showed a threat distraction effect appearing only among the socially anxious participants, in trials were the more intensely valenced angry and happy faces had been employed (see Figure 13).

In the visual search task (Exp. 1), we collected data about the first fixation on the target and the amount of target processing, because we expected attentional avoidance behaviors and, possibly, a post-detection interference from the socially threatening angry target face. In the letter discrimination task (Exp. 2), we hypothesized that a failure to disengage attention from the central task-irrelevant face would be obvious as a prolonged dwelling on the distracting (task-irrelevant) central face when it displayed an angry, as compared to a happy, emotional expression. Furthermore, we expected that this RT effect would be reflected in the eye-movement data, as less movement and fewer fixations on the computer screen when attention was dwelling on threat.

Because the time spent focusing on the face was similarly distributed between the angry or happy faces, a delayed disengagement account of the slowed RTs was challenged by our eye-movement data. Instead, the socially anxious participants' eye movement patterns indicated an *unstable* attentional focus (see Figure 14), but not a problem with delayed attentional disengagement from the angry face (Fox et al., 2001; Georgiou et al., 2005). Actually, the eye-movement findings in relation to the slowed RTs revealed that the anxiety-related distraction rather reflected a lack of focus than a focus rigidly locked to the threat. It is highly unlikely that attention was dwelling more on the angry face without any visible effects on eye movement measurements.

1.8.7 General Discussion

The visual search findings in experiment 1 showed that all participants prioritized threat, and that this threat advantage was unrelated to the observers' own level of social anxiety. The results from the attention task used in Experiment 2, on the other hand, showed that the socially anxious participants' task performance was distracted by a central task-irrelevant threatening face, particularly immediately after onset of the distracting face and in the beginning of the experiment. The eye-movement findings from Experiment 2 suggested that the anxious participants' early performance deficit (i.e., slowed RTs) was related to difficulties in maintaining a controlled focus in the presence of the threatening face, rather than to an attentional disengagement problem.

In Study III Experiment 2 we first addressed the question about stimulus specificity in relation to the hypothesized threat-distraction effects on the socially anxious individuals' task performance. By only manipulating the facial features that denote *social threat* (which was accomplished by varying the gaze-orientation of the central face), while keeping emotional valence constant (varying between angry and fearful facial expressions), we were able to isolate the threat value from mere emotional negativity. The results suggested that it was the facial features that denoted social threat, rather than merely emotionally negative features, that triggered the anxiety-related attentional threat bias. This evidence of a significant differentiation between threatening and negative facial expressions, first of all, suggests that there is a genuine *external* source for this attentional bias in social anxiety. That is, it can be triggered by the perception of an external social stimulus or situation. Some cognitive models for social anxiety propose (Clarke and Wells, 1995; Clarke, 1999) that socially anxious individuals' threat bias attention is only concerned with internal threats, generated by their negative self-image and by negative ruminations. Secondly, since the results demonstrated that only a facial display which denotes threat, but not one that simply denotes emotional negativity, will interfere with cognitive task performance, this suggests that the problem with attention control is not a generalized dysfunction but a circumscribed one (albeit, probably with far-reaching consequences).

Our findings relating to the second hypothesis in Experiment 2 suggested that social anxiety involves a disruption of attention control (Bishop 2007; Bishop et al., 2004; Eysenck and Calvo, 1992; Eysenck et al., 2007) in the presence of social threat. Thus, the findings showed that the socially anxious participants were more distracted by social threat than were the non-anxious controls, but their eye-movement patterns revealed a lack of focus, rather than a focus rigidly locked to the threat, which led us to question the attentional *disengagement* hypothesis (Fox et al., 2001; Georgiou et al., 2005).

Although the visual search results showed that the initial orienting process for socially threatening stimuli was prioritizing a social threatening face before a non-threatening face, there were no differences in this attentional threat bias from individual level of anxiety. Neither was the anxiety-related slowed RTs in the letter discrimination task differently related to the ability to disengage attention from a task-irrelevant socially threatening, as opposed to a non-threatening face. As shown by because the eye-movement data, the same amount of attention resources was dedicated to processing both the angry and the happy emotional expression. This anxiety-related effect in the task performance in Experiment 2 rather seemed to imply that attention resources for processing the cognitive task were reduced. That is, the attentional problem was one of controlling the deployment of attention in presence of social threat, even though the central face was irrelevant for attaining the goal of the task.

Rather than dwelling on the angry face, in a direct confrontation, the socially anxious participants' focus became unstable (Garner et al., 2006)The threat-biased attention appeared to be manifested in early attentional processes only, because it vanished when attention was probed later on (at 1500 ms) or in block 2, that is, after more practice with the task. In principle, this change in the direction of attentional behaviors resembles the predictions made about a vigilance-avoidance pattern of attention in high-anxious individuals which was proposed by Mogg and Bradley in their cognitive model of anxiety (1998).

1.8.8 The threat-biased attention and its' early effects

The interplay between different motivational states of the organism (Cannon, 1927; Gray, 1971) and the automatic orienting to threat may determine the behavioral outcome in complex ways. Specifically, in the case of anxiety, vigilance for threat may co-occur with a readiness to engage in defensive avoidant behavior (McNaughton & Corr, 2004). This may provide a basis for the vigilance-avoidance pattern of attentional bias (e.g., Mogg & Bradley, 1998; Williams et al., 1988), resulting in increased monitoring for minor threats in the environment, versus avoidance strategies that serve to reduce subjective discomfort and/or danger. This unstable focus of attention of anxious individuals, with a tendency to shift attention repeatedly towards and away from threat, may potentiate sensitization and interfere with habituation, and so maintain anxiety in the long term (Mogg & Bradley, 1998).

The early manifestation of the threat-related problems seems to suggest that it relies on an automatic stimulus process, implying the workings of the proposed fear-module (Öhman & Mineka, 2001). Such a fear-driven processing of the feared stimulus is largely an *encapsulated* process, which means that it is largely automatic and not easily interfered with by effort of voluntary control. The present findings of a time course of changed attentional behaviors in relation to the presence of a threatening stimulus, suggest that only with more exposure to the threat (or practice with the task) could goal-oriented control be regained. Thus, the disrupted cognitive task performance of the socially anxious participants early but not late in the experiment indicates that their problem with attention control is not a permanent control dysfunction, but a temporary effect (albeit, perhaps with far-reaching consequences).

1.8.9 Using eye-movements to interpret the RT-findings

The fact that the eyes typically follow attentional focus (Deubel and Schneider, 1996; Hoffman and Subramaniam, 1995; Kowler et al., 1995) provided the rationale behind using eye-movements to make interpretations about manual RTs. In the present scenario in Study III Experiment 2, we assumed that if attention was dwelling more on the angry face this should be confirmed by the eye movement measurements. This premise gives eye-movements a role in interpreting RT-findings. Specifically, three kinds of different behaviors could have caused similar effects (slowed RTs) on task performance in the present task (see Mogg, 2008, for a more general discussion about how to interpret slowed RTs). First, it could have been caused by dwelling on the threatening stimulus, second, it could have been caused by avoidance behaviors, and, thirdly, it could be related to more or less random eye-movements.

The basic logic of the task, rested on the idea that separate components of attention are involved in shifting attention towards a stimulus, engaging in it, and, releasing (disengaging) attention from it, to enable a new shift (Posner & Pedersen, 1992). Thus, to assess the relevant attention processes involved in task performance, the trial was divided into two time-episodes, on the basis of the SOA (the Stimulus Onset Asynchrony: 600/1500 ms). Each trial was divided into a pre-probe and a post-probe episode by the SOA condition, that is, in accordance with the onset of the letter probe. Pre-probe denotes the time before the probe onset and post-probe denotes the time after the probe onset. That the face was presented before the task begun and then remained visible during the remainder of the trial was the methodological procedure used to (first) promote an engagement of attention before the commencement of the task and (second) to promote a disengagement of attention after the commencement of the task.

This procedure for the eye-movement analysis allowed the assessment of how much focus was differentially allocated to the face both before the actual task had begun, as well as while performing it. Attentional avoidance behaviors were operationalized as (lesser) time being spent focusing the central *before* the task begun, since the face was visible right in focus even before the probe appeared. Attentional dwelling (denoting the problem with disengagement) was operationalized as (prolonged) time spent focusing the central face *after* the task had begun, since the face was continually visible after the probe appeared.

Both threat avoidance behavior (Clarke & Wells, 1995; Clarke, 1999) and prolonged dwelling on threat (e.g., Fox et al., 2001; Fox, 2004b) could be expected in the present context of investigating social anxiety. Thus, to investigate these hypotheses we employed various temporal and spatial eye-movement measurements to find out when and where the eyes were positioned on the central face during each trial. As it turned out, the socially anxious participants did not dwell more on threat, but, rather, their attention wandered quite randomly between a the faces and the screen background, which interfered with the detection of the task-relevant letters. The association between unstable eye movements and disrupted attentional performance, which is revealed in the socially anxious participants' non-emotional cognitive task performance in the presence of a task-irrelevant socially threatening stimulus, suggests a close relationship between eye focus and attention control functions in goal-directed behavior. Since in the archetypical social dominance conflict (Gilbert, 2001a, 2001b; de Waal, 1988, 2005) an averted eye gaze may be used to signal submissiveness, the lack of focus in the eye movements of the anxious individuals may have reflected fear activation. Their unstable focus may thus have resulted from the cognitive conflict between the need to control attention to optimize performance on the task at hand, and the fear-driven inclination to avert the gaze to the side to avoid the social confrontation (Clark and Wells, 1995; Clark, 1999).

1.9 FINAL DISCUSSION OF THE THESIS

Study I provided the questions to be answered in the present thesis: how do the low-level perceptual and the emotional processes together determine the visual search outcome and, how is social anxiety related to the attentional bias for socially threatening facial stimuli? The visual search experiment in Study II revealed that perceptual load determines whether emotional, or only low-level perceptual, information from faces influences the search outcome. Apparently, selective attention was being differently ‘set’ by the two levels of stimulus redundancy which we built into the task (by varying the distractor homogeneity and the size of the face material), for either a largely featural face analysis (which resulted in a happy advantage) or, for a more configural face analysis (resulting in the interaction between emotion and gender that resulted in an angry advantage for male target faces). Study II thus related both these constructs about perceptual load and stimulus redundancy to the emotional effects on selective attention in the visual search task, in showing how an angry target can be prioritized in search performance, depending on how the facial stimuli are analyzed.

Since the enhanced anxiety-related effects in Study I had been ambiguous as to which attentional process that was involved, we addressed this uncertainty by recruiting the same high or low socially anxious individuals to partake in two different attention tasks. Our experiments were designed to reveal an eventual association between social anxiety and (enhanced) attentional shift to a socially threatening stimulus, or the (dis-) ability to disengage attention from a socially threatening stimulus, respectively. Study III, Experiment 1, used a visual search task and, in building on the findings from Study II applied the conditions for achieving an angry advantage to investigate whether or not this initial bias for socially threatening stimuli would be potentiated in the highly socially anxious group of participants. The level of social anxiety did not affect the efficiency of social threat detection in the visual search in Experiment 1. In Experiment 2 of Study III, the socially anxious participants performed worse than the low-anxious control group in the letter discrimination task in trials where a socially threatening task-irrelevant facial stimulus was presented. However, rather than representing an inability to disengage attention from threat, the slowed RT may have reflected the draining of attentional resources available for the cognitive task, because the eye-movement data suggested that endogenous attentional control efforts were compromised. Thus, while not being preoccupied with the threatening stimulus in itself, their attentional focus seemed unstable (cf Mogg & Bradley, 1998).

The results from Study II suggested that it is possible for stimulus-driven emotional effects (i.e., from facial expression) to be selected early on by attentional processes, as long a there are perceptual resources for configural face processing. The resulting lack of top-down cognitive influences in the visual search task from fear-related processes (i.e., from social anxiety) suggested that the shared threat detection advantage which was common to all participants (although not independent on configural processing) in a functionally meaningful sense is an automatic threat bias. From this independence on anxious expectation or fear-potentiation we seem able to conclude that the social threat bias effect is driven by the threatening content of the stimulus, and its prioritized detection is an involuntary behavior (cf McNaughton & Corr, 2004). An outline has been offered by several researchers (e.g., Adolphs & Spezio, 2006; Morris et al., 1999; Öhman 2005; Vuilleumier, 2004) of the possible role for the amygdala in accomplishing such an early enough emotional influence on selective attention, to permit that face perception is affected in the a bottom-up fashion as we seem to observe here.

The central finding in Study III was that the presence of an angry face slowed the socially anxious individuals' cognitive task performance, even though processing this stimulus was completely irrelevant to performing the task. Thus, their failure to handle the threat distraction indicated a problem with attention control functions in social anxiety. In a recent version of the attentional control theory (2007), Eysenck and co-workers reasonably proposes that anxiety specifically *decreases* the influence of the goal-directed attentional system, while it *increases* the influence of the stimulus-driven attentional system (e.g., Corbetta & Shulman, 2002; Posner & Petersen, 1990). This presumed imbalance between goal- and stimulus-driven processes in anxiety is to the disadvantage of attentional control functions, were it can typically be observed as reduced performance efficiency for the current task at hand, unless it involves the threatening stimuli (Derryberry & Reed, 2002; Fox, 1994). Thus, from the perspective of the attentional control hypothesis (e.g., Eysenck et al., 2007), the functional attentional focus should be *broadened* when defensive mechanisms become activated, and attentional focus should not get stuck on the threatening stimulus. Rather, the functional deployment of attention resources lies in releasing focus from the threat, in order to have more processing resources available to finding out more about possible coping opportunities in the environment. In contrast, the dysfunctional response which is predicted to occur in anxiety, is driven by a stressed state of hypervigilance (overworking the fear systems), which in turn leads to a *narrowed* attentional focus that allocates too much attention to the threatening stimulus. This notion about an anxious preoccupation with threat is consistent with the hypothesized difficulty to disengage attention from threatening stimuli which has been observed in some studies (e.g., Fox, 2004b; Fox et al., 2001; Georgiou et al., 2005).

Defining the critical differences between functional and dysfunctional deployment of attention to threat like this (Eysenck et al., 2007), the eye-movement findings from Study III, Experiment 2, which showed that the socially anxious participants actually scanned more and made more frequent fixations all over the screen, in the presence of a task-irrelevant threatening stimulus, compared to when a non-threatening stimulus was present, appears to be only partially consistent with the expected scenario. The socially anxious participants' eye-movement patterns indicated that their slowed manual RTs were due to their *unstable* focus, not to a focus *narrowed* on threat. Therefore, the present findings about the way that a threat-biased attention in social anxiety disrupts cognitive task performance, doesn't seem to fit the role which is given to it in the above attentional control theory. Perhaps what happened is better explained by assuming some other underlying mechanism.

Noticing the temporal course of the threat distraction effect in the letter discrimination task - it only appeared when attention was probed early (at 600 ms) and in the first trial-block (see Figure 13). – might suggest that conflicting motivational forces promoted an initial attentional vigilance (evaluation), which was then followed by a subsequent attentional avoidance (escape) (Mogg & Bradley, 1998). Framed within Gray and McNaughton's (2000) and McNaughton and Corr's (2004) hierarchical concept of anxiety, these motivational forces are associated with the activation of different levels the defensive mechanism, which are manifest in two opposing behavioral action-tendencies, namely, fear and anxiety. Thus, the vigilance for threat is handled by lower level brain mechanisms and typically leads to avoidance behaviors (i.e., fear), while anxiety is controlled by higher level mechanisms in the brain that determine how the threat should be approached (by assessing the defensive distance) (e.g., McNaughton and Corr, 2004).

Perhaps we can assume that social anxiety is related to a heightened expectancy for social punishment, the absence of social support, and to failures to maintain or increase social status (i.e., common forms of negative evaluation) (Gilbert, 2001a; 2001b). According to the hierarchical model of anxiety (Gray and McNaughton, 2000; McNaughton and Corr, 2004), the defensive distance (cf threat imminence, Fanselow, 1994) is a more or less subjective construct, which is modulated by previous experience (one's personal learning history, or an inborn vulnerability, or a combination thereof). Such negative expectations might reduce the socially anxious individual's defensive distance to a socially threatening stimulus. This, in turn, should abort *approach* behaviors, and elicit *avoidance* behaviors instead. If this guess should be true, it could also explain the disrupted cognitive task performance in the presence of a socially threatening stimulus in the Experiment 2 (Study III). Then, the problem with the socially anxious participants' behavior was that they couldn't control their fear.

If too much fear leads to escape, then the socially anxious individual is in trouble. Social conflicts paradigmatically gain more from being approached than from being avoided (McNaughton & Corr, 2004). So, that same fear-driven avoidance behavior which is functional in relation to predator defense, is actually deeply dysfunctional in a social conflict were it hinders the important process of renegotiation in order to the "reconcile the hierarchy", to use the wordings of Franz de Waal (2005). If being socially anxious means feeling too much fear in the presence of a socially threatening stimulus, this might promote escape and avoidance (indeed, this is a cardinal symptom of social anxiety, Clark & Wells, 1995). The unstable attentional focus that we observed in Study III Experiment 2, which really did reflect a cognitive problem with goal-control, might not have been the only goal that failed.

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3 REFERENCES

Adams, R. B., Gordon, H. L., Baird, A. A., Ambady, N., and Kleck, R. E. (2003). Effects of gaze on amygdale sensitivity to anger and fear faces. *Science, 300*, June 6, pp.1536.

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science, 14*, 644-647.

Adams, R. B., & Kleck, R. E. (2005). Effects of direct and averted gaze on the perception of facially communicated emotion. *Emotion, 5*, 3-11.

Adophs, R. (2002). Neural systems for recognizing emotion. *Current Opinion in Neurobiology, 12*, 169-177.

Adolphs, R., & Spezio, M. (2006). Role of the amygdala in processing visual social stimuli. Progress in Brain Research, 156, 363-378.

Adolphs, R., Tranel, D., Hamann, S., Young, A.W., Calder, A.J., Phelps, E.A., Anderson, A., Lee, G.P. and Damasio, A.R. (1999b) Recognition of facial emotion in nine individuals with bilateral amygdala damage. *Neuropsychologia, 37*, 1111–1117.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology, 134*, 258-281.

Baron-Cohen, S. (1995). *Mindblindness: an essay on autism and theory of mind.* Cambridge MIT Press.

Bargh, J. A. (1992). The ecology of automaticity: toward establishing the conditions needed to produce automatic processing effects. *American Journal of Psychology, 105*, 181-199.

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

Becker, D. V., Kenrick, D. T., Neuberg, S. L., Blackwell, K. C., & Smith, D. M. (2007). The Confounded Nature of Angry Men and Happy Women. *Journal of Personality and Social Psychology, 92*, 179 –190.

Bishop, S. (2007). Neurocognitive mechanisms of anxiety: An integrative account. *Trends in Cognitive Sciences, 11*, 307-316.

Bishop, S., Duncan, J., Brett, M., & Lawrence, A.D. (2004). Prefrontal cortical function and anxiety: Controlling attention to threat-related stimuli. *Nature Neuroscience, 7*, 184-188.

Blanchard, D. C., & Blanchard, R.J. (1988). Ethoexperimental approaches to the biology of emotion. *Annu Rev Psychol, 39*, 43–68.

Bowlby J. *Attachment: attachment and loss*. Vol. 1. London: Hogarth, 1969.

Bond, N. W., & Siddle, D. A. T. (1996). The preparedness account of social phobia: Some data and alternative explanations. In R. M. Rapee (Ed.), *Current controversies in the anxiety disorders* (pp. 291–316). London: Guilford Press.

Bradley, B. P., Mogg, K., White, J., Groom, C., & de Bono, J. (1999). Attentional bias for emotional faces in generalized anxiety disorder. *British Journal of Clinical Psychology, 38*, 267–278.
Breiter, H. C., Etcoff, N. L., Whalen, P. J., Kennedy, W. A., Rauch, S. L., Strauss, M. M., Hyman, S. E., & Rosen, B. R. (1996). Response and habituation of the human amygdala during visual processing of facial expression. *Neuron, 17,* 875-887.
Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon.
Brody, L.R., & Hall, J.A. (2008). Gender and emotion in context. In In M. Lewis, J. M. Haviland, & L. Feldman Barrett (Eds.) *Handbook of emotions*, (3rd edition, pp. 395-408). New York: Guilford.
Byrne, A., & Eysenck, M. W. (1995). Trait anxiety, anxious mood, and threat detection. *Cognition & Emotion, 9,* 549-562.
Bögels, S. M., & Mansell, W. (2004). Attention processes in the maintenance and treatment of social phobia: hypervigilance, avoidance and self-focused attention. *Clinical Psychology Review, 24*, 827-856.
Calvo, M., & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): identification under different display-duration conditions. *Behavior Research Methods, 40*, 109-115.
Calvo, M. G., & Nummenmaa, L. (2008). Detection of emotional faces: Salient physical features guide effective visual search. *Journal of Experimental Psychology: General, 137*, 471-494.
Calvo, M. G., Avero, P., & Lundqvist, D. (2006). Facilitated detection of angry faces: Initial orienting and processing efficiency. *Cognition and Emotion, 20,* 785-811.
Cannon, W.D. (1927). The James-Lange theory of emotions: a critical examination and an alternative theory. *American Journal of Psychology, 39*, 106-124.
Cave, K. & Wolfe, J. (1990). Modelling the role of parallel processing in visual search. *Cognitive Psychology, 22*, 225-271.
Chance, M. R. A. (1988). Introduction. In M. R. A. Chance (Ed.), *Social fabrics of the mind* (pp. 1–35). London: Psychology Press.
Chen, E., Lewin, M. R., Craske, M. G. (1996). Effects of state anxiety onselective processing of threatening information. *Cognition & Emotion, 10,* 225–240.
Clark, D. M. (1999). Anxiety disorders: Why they persist and how to teat them. *Behavior Research & Therapy, 37*, 5-27.
Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F.R. Schneier (Eds.), *Social Phobia: Diagnosis, assessment, and treatment* (pp. 69–93). New York Guilford Press.
Corbetta, M., & Shulman, G.L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nat. Rev. Neurosci., 3*, 201-215.
de Waal, F. B. M. (1988). The reconciled hierarchy. In M. R. A. Chance (Ed.), *Social fabrics of the mind* (pp. 105–136). London: Psychology Press.
de Waal, F. B. M. (2005). *Our inner ape*. New York: Riverhead/Penguin Books, 2005.
Dennett, D. C. (2003). *Freedom evolves*. Viking Penguin.

Derryberry, D., & Reed, M. A. (2002). Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology*, 111, 225-236.
Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. Annu. Rev. Neurosci. 18, 193-222.
Deubel, H., & Schneider, W. (1996). Saccade target selection and object recognition: Evidence for a common attentional mechanism. *Vision Research, 36,* 1827-1837.
Dimberg, U. (1986). Facial expressions as excitatory and inhibitory stimuli for conditioned autonomic responses. *Biological Psychology, 22,* 37–57.
Dimberg, U., & Öhman, A. (1983). The effects of directional facial cues on electrodermal conditioning to facial stimuli. *Psychophysiology, 20,* 160–167.
Dimberg, U., & Öhman, A. (1996). Behold the wrath: Psychophysiological responses to facial stimuli. *Motivation and Emotion, 20,* 149–182.
Dimberg, U., Thunberg, M., & Elmehed, K., (2000). Unconscious facial reactions to emotional stimuli. *Psychological Science, 11*, 86-89.
Dimberg, U., Thunberg, M., Grunedal, S. (2002). Facial reactions to emotional stimuli: automatically controlled responses. *Cognition & Emotion, 16*, 449-472.
Driver, J., Davis, G., Russell, C., Turatto, M., & Freeman, E. (2001). Segmentation, attention and phenomenal visual objects. *Cognition, 80*, 61-95.
Duncan, J., & Humphreys, G. W. (1989). Visual-search and stimulus similarity. *Psychological Review, 96,* 433-458.
Eastwood, J. D., Smilek, D., & Merikle, P. M. (2001). Differential attentional guidance by unattended faces expressing positive and negative emotion. *Perception & Psychophysics, 63,* 1004–1013.
Eastwood, J., Smilek, D., & Merikle (2003). Negative facial expressions captures attention and disrupts performance. *Perception & Psychophysics, 65*, 352-358.
Eastwood, J. D., Frischen, A., Reynolds, M., Gerritsen, C. Dubins, M., & Smilek, D. (2008). Do emotionally expressive faces automatically capture attention? Evidence from global-local interference. Visual Cognition, 16, 248-261.
Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J.K. Cole (Ed.), *Nebraska Symposium on Motivation, 19*. Lincoln, NE: University of Nebraska Press.
Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect.* Palo Alto, CA: Consulting Psychologists Press.
Emery, N. J. (2000). The eyes have it: The neuroethology, function and evolution of social gaze. *Neuroscience & Biobehavioral Reviews, 24,* 581–604.
Esteves, F. (1999). Attentional bias to emotional facial expressions. *European Review of Applied Psychology, 49,* 91-96.
Esteves, F., & Öhman, A. (1993). Masking the face: Recognition of emotional facial expressions as a function of the parameters of backward masking. *Scandinavian Journal of Psychology, 34,* 1–18.
Esteves, F., Dimberg, U., & Öhman, A. ((1994). Automatically elicited fear: conditioned skin conductance to masked facial expressions. *Cognition & Emotion, 8*, 393-413.

Eysenck, M. W. (1992). *Anxiety: The cognitive perspective*. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.
Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion, 6*, 409-434.
Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and Cognitive Performance: Attentional control Theory. *Emotion, 7*, 336-353.
Fabes, R. A., & Martin, C. L. (1991). Gender and age stereotypes of emotionality. *Personality and Social Psychology Bulletin, 17,* 532–540.
Fanselow, M. S. (1994). Neural organization of the defensive behavior system responsible for fear. *Psychonomic Bulletin and Review, 1,* 429–438.
Farah, M. J., Tanaka, J. W., & Drain, H. M. (1995). What causes the face inversion effect? *Journal of Experimental Psychology: Human Perception and Performance, 21,* 628-634.
Findlay, J. M. & Walker, R. (1999). A model of saccade generation based on parallel processing and competitive inhibition. Behavioral and Brain Sciences, 22, 661-721.
Folk, C.L., Remington, R.W., & Johnston, J.C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance, 18*, 1030-1044.
Fox, E. (1994a). Attentional bias in anxiety: A defective inhibition hypothesis. *Cognition & Emotion*, 8, 165-195.
Fox, E. (2002). Processing emotional facial expressions: The role of anxiety and awareness. *Cognitive, Affective, & Behavioral Neuroscience, 2,* 52–63.
Fox, E. (2004b). Maintenance or capture of attention in anxiety-related biases? In J. Yiend (Ed.), *Cognition, emotion and psychopathology, Theoretical, empirical and clinical directions* (pp. 86-105). viii, 312 pp. New York, NY, US: Cambridge University press.
Fox, E., & Damjanovic, L. (2006). The eyes are sufficient to produce a threat superiority effect. *Emotion, 6,* 534-539.
Fox, E., & Georgiou, G. (2005). Anxiety modulates the degree of attentive resources required to process emotional faces. *Cognitive, Affective, & Behavioral Neuroscience, 5*, 396-404.
Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355-379.
Fox, E., Mathews, A., Calder, A., & Yiend, J. (2007). Anxiety and sensitivity to gaze direction in emotionally expressive faces. *Emotion, 7*, 478-486.
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 & Emotion, 14*, 61- 92.
Fox, E., Russo, R., Bowles, R. J., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety. *Journal of Experimental Psychology: General, 130*, 681-700.
Fox, E., Lester, V., Russo, R., Bowles, R. J., Pichler, A. and Dutton, K. (2000). Facial Expressions of Emotion: Are Angry Faces Detected More Efficiently?, *Cognition & Emotion, 14*, 61-92.

Fridlund, A. J. (1994). *Human facial expression: An evolutionary view.* London: Academic Press.

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115*, 760-770.

Furmark, T. (2002). Social phobia: overview of community surveys. *Acta Psychiatr Scand., 105*, 84–93.

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

Gilbert P. (1997). The evolution of social attractiveness and its role in shame, humiliation, guilt and therapy. *British Journal of Medical Psychology, 70*, 113-147.

Gilbert, P. (2001a). Evolution and social anxiety: The role of attraction, social competition, and social hierarchies. *Psychiatric Clinics of North America, 24,* 723–751.

Gilbert, P. (2001b). Evolutionary approaches to psychopathology: The role of natural defenses. *Australian and New Zealand Journal of Psychiatry, 35,* 17–27.

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.

Gray, J.A. (1971). *The psychology of fear and stress.* New York, NY, England: McGraw-Hill Book Company.

Gray, J. (1985). The neuropsychology of anxiety. *Issues in Mental Health Nursing, 7*, 201-228.

Gray, J.A., & McNaughton, N. (2000). *The Neuropsychology of anxiety: an enquiry into the functions of the septo-hippocampal system*, 2nd ed. Oxford: Oxford University Press.

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

Haxby, J.V., Hoffman, E. A., & Gobbini, M. I. (2000) The distributed human neural system for face perception. Trends in Cognitive Science, 4, 223-233.

Hofmann, S.G., Heinrichs, N., & Moscovitch, D.A. (2004). The nature and expression of social phobia: Toward a new classification. *Clinical Psychology Review, 24*, 769-797.

Hoffman, J., & Subramaniam, B. (1995). Saccadic eye movements and visual selective attention. *Perception & Psychophysics, 57*, 787-795.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2003). Social phobics do not see eye to eye: A visual scanning study of emotional expression processing. *Anxiety Disorders, 17*, 33-44.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: visual scanning evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research, 127*, 43-53.

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

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

Kastner, S., & Ungerleider, L. G. (2000). Mechanisms of visual attention in the human cortex. Annu. Rev. Neurosci., 23, 315-341.

Kanwisher, N., & Wojciulik, E., (2000). Visual attention: insights from brain imaging. *Neuroscience, 1*, 91-93.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: a module in human extrastriate cortex specialized for face perception. *The Journal of Neuroscience, 17*, 4302-4311.

Kirita, T., & Endo, M. (1995). Happy face advantage in recognizing facial expressions. *Acta Psychologica, 89,* 149–163.

Kowler, E., Anderson, E., Dosher, B., & Blaser, E. (1995). The role of attention in the programming of saccades. *Vision Research, 35*, 1897-1916.

LaBerge, D. (1998). Attentional emphasis in visual orienting and resolving. In R.D. Wright (Ed.), Visual Attention (pp. 417-454). New York: Oxford University Press.

LaFrance, M., Hecht, M. A., & Levy Paluck, E. (2003). The contingent smile: A meta-analysis of sex differences in smiling. *Psychological Bulletin, 129*, 305–334.

Langton, S. R. H., Watt, R. J., & Bruce, V. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends Cogn Sci, 4*, 50– 9.

Langton, S. R. H., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, 6, 541–567.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance, 21,* 451–468.

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General, 133*, 339-354.

Lavie, N. (2005). Distracted and confused? Selective attention under load. *Trends in Cognitive Sciences, 9*, 75-82.

LeDoux. J. (1996). *The emotional brain. The mysterious underpinnings of emotional life.* Simon and Schuster.

LeDoux, J. (2000). Emotion circuits in the brain. Annual Rev. Neurosci, 23, 155-184.

LeDoux, J. & Phelps, E. A. (2008). Emotional networks in the brain. Lewis, M., Haviland-Jones, J. M., Barrett, L. F. (Eds.), Handbook of emotions (3rd ed.) (pp. 159-179). New York, NY, US, Guilford Press.

Leppänen, J. L., & Hietanen, J. K. (2003). Affect and face perception: Odors modulate the recognition advantage of happy faces. *Emotion, 3,* 315–326.

Lundqvist, D., & Öhman, A. (2005). Emotion regulates attention: The relations between facial configurations, facial emotions, and visual attention. *Visual Cognition, 12,* 51–84.

Lundqvist, D., Esteves, F., & Öhman, A. (1999). The face of wrath: Critical features for conveying facial threat. *Cognition and Emotion, 13,* 691–711.

Lundqvist, D., Esteves, F., & Öhman, A. (2004). The face of wrath: The role of features and configurations in conveying social threat. *Cognition and Emotion, 18,* 161–182.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *Karolinska directed emotional faces*. CD, Section of Psychology, Karolinska Institutet, SE-171 77 Stockholm, Sweden. Available at http://www.facialstimuli.com/.
MacLeod, C., & Mathews, A. (1988). Anxiety and the allocation of attention to threat. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 40*, 653-670.
Mansell, W., Clark, D. M., Ehlers, A., & Chen, Y. (1999). Social anxiety and attention away from emotional faces. *Cognition and Emotion, 13,* 673–690.
Martin, M., Williams, R., & Clark, D. (1991). Does anxiety lead to selective processing of threat related information? *Behaviour Research and Therapy, 29*, 147–160.
Mathews, A. (1990). Why worry? The cognitive function of anxiety. *Behaviour Research and Therapy, 28*, 455-468.
Mathews, A. M., Fox, E., Yiend, J., & Calder, A. (2003). The face of fear: Effects of eye-gaze and emotion on visual attention. *Visual Cognition, 10,* 823–835.
Mazurski, E. J., Bond, N. W., Siddle, D. A. T., & Lovibond, P. F. (1996). Conditioning with facial expression of emotion: effects of CS sex and age. *Psychophysiology, 33*, 416-425.
Mayr, E. (1974). Behavior programs and evolutionary strategies. *American Scientist, 62*, 650-659.
McCarthy, G., Puce. A., Belger. A., Allison. T. (1999). Electrophysiological studies of human face perception. II. Response properties of face-specific potentials generated in occipitotemporal cortex. *Cerebral Cortex, 9*, 431-444.
McCarthy, G., Puce, A., Gore, J., & Truett, A. (1997). Face-specific processing in the human fusiform gyrus. *Journal of Cognitive Neuroscience, 9*, 605-610.
McNaughton, N., Corr, P. J. (2004). A two-dimensional neuropsychology of defense: fear/anxiety and defensive distance. *Neuroscience and Biobehavioral Reviews, 28*, 285–305.
Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behavior Research & Therapy, 36*, 809-848.
Mogg, K., & Bradley, B. P. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition & Emotion, 13*, 713-740.
Mogg, K., Garner, M., & Bradley, B. P. (2007). Anxiety and orienting of gaze to angry and fearful faces. *Biological Psychology, 76*, 163-169.
Mogg, K., Holmes, A., Garner, M., & Bradley, B.P. (2008). Effects of threat cues on attentional shifting, disengagement and response slowing in anxious individuals. *Behaviour Research and Therapy, 46*, 656-667.
Morris, J. S., Öhman, A., & Dolan, R. J. (1999). A subcortical pathway to the right amygdale mediating “unseen” fear. *Proceedings of the National Academy of Sciences, 96,* 1680-1685.
Morris, J. S., Friston, K. J., Büchel, C., Frith, C. D., Young, A. W., Calder, A. J., & Dolan, R. J. (1998). A neuromodulatory role for the human amygdala in processing emotional facial expressions. *Brain, 121*, 47-57.
Morris, J. S., Frith, C. D., Perrett, D. I., Rowland, D., Young, A. W., Calder, A. J., & Dolan, R. J. (1996). A differential neural response in the human

amygdala to fearful and happy facial expressions. *Nature, 383,* 812–815.
Musa, C.Z., & Lépine, J.P. (2000). Cognitive aspects of social phobia: a review of theories and experimental research. *European Psychiatry, 15*, 59-66.
Neisser, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Crofts.
Oatley, K., & Jenkins, J. M. (1996). *Understanding emotions.* London: Blackwell.
Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences, 9*, 242-249.
Ortony, A., & Turner, T. J. (1990). What's basic about basic emotions? *Psychological Review, 97*, 315-331.
Öhman, A. (1986). Face the beast and fear the face: animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology, 23*, 123-145.
Öhman, A. (1993). Fear and anxiety as emotional phenomenon : Clinical phenomenology , evolutionary perspectives, and information-processing mechanisms. In M. Lewis & J.M. Haviland (Eds.), *Handbook of Emotions* (pp. 511–536). New York: Guilford Press.
Öhman, A. (1996). Preferential preattentive processing of threat in anxiety: preparedness and attentional biases. In R. M. Rapee (Ed.) *Current controversies in the anxiety disorders*. Guilford Press, London.
Öhman, A. (2005). The role of the amygdala in human fear: automatic detection of threat. *Psychoneuroendocrinology, 30*, 953-958.
Öhman, A. (2009). Of snakes and faces: An evolutionary perspective on the psychology of fear. *Scandinavian Journal of Psychology, 50*, 543–552.
Öhman, A., & Dimberg, U. (1978). Facial expressions as conditioned stimuli for electrodermal responses: a case of "preparedness"? *Journal of Personality and Social Psychology, 36*, 1251-1258.
Öhman, A., & Dimberg, U. (1984). An evolutionary perspective on human behavior. In W. M. Waid (Ed.), *Sociophysiology* (pp. 47–86). New York: Springer-Verlag.
Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review, 108,* 483–522.
Öhman, A., & Rück, C. (2007). Four principles of fear and their implications for phobias. In Rottenberg, J. & Johnson, S. (Eds.), *Emotion and psychopatology: bridging affective and clinical science.* (pp. 167-189). Washington, DC, US: American Psychological Association.
Öhman, A., & Soares, J.F. (1993). On the automatic nature of phobic fear: Conditioned electrodermal responses to masked fear-relevant stimuli. *Journal of Abnormal Psychology*, *102*, 121–132.
Öhman, A., & Wiens, S. (2004). The concept of an evolved fear module and cognitive theories of anxiety. In Manstead, A., Fridja, N. Fischer, A. (Eds.), *Feelings and emotions: The Amsterdam symposium.* (pp. 58-80). New York, NY, US: Cambridge University Press.
Öhman, A., Dimberg, U., & Öst, L-G. (1985). Animal and social phobias: Biological constraints on learned fear responses. In S. Reiss & R. R. Bootzin (Eds.), *Theoretical issues in behavior therapy* (pp. 123–178). Orlando, FL: Academic Press.

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

Öhman, A., Flykt, A., & Lundqvist, D. (1996). Unconscious emotion: Evolutionary perspectives, psychophysiological data, and neuropsychological mechanisms. In R. Lane & L. Nadel (Eds.) *The Interface between emotion and cognitive neuroscience*. New York: Oxford University Press.

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

Öhman, A., Juth, P., & Lundqvist, D. (in press). Finding the face in a crowd: Relationships between distractor redundancy, target emotion, and target gender. Cognition and Emotion.

Palermo, R., & Coltheart, M. (2004). Photographs of facial expression: accuracy, response times, and ratings of intensity. *Behavior Research Methods, Instruments & Computers, 36,* 636-638.

Panksepp, J. (1998). Affective Neuroscience: the foundations of human and animal emotions. Oxford University Press.

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

Posner, M., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. S. Solso (Ed.), *Information processing and cognition: The Loyola Symposium* (pp. 55-85). Hillsdale, NJ: Lawrence and Erlbaum Associates, Inc.

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

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy, 35*, 741-756.

Rauschenberger, R., & Yantis, S. (2006). Perceptual encoding efficiency in visual search. *Journal of Experimental Psychology: General. 135,* 116-131.

Schore AN. (1994). *Affect regulation and the origin of the self: the neurobiology of emotional development*. Hillsdale: Lawrence Erlbaum.

Schultz, L. T. & Heimberg, R. G. (2008). Attentional focus in social anxiety disorder: Potential for interactive processes. *Clinical Psychology Review, 28*, 1206-1221.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review, 84,* 127–190.

Soares, S., Esteves, F., Lundqvist, D., & Öhman, A. (2009). Some animal specific fears are more specific than others: evidence from attention and emotion measures. *Behaviour Research and Therapy, 47*.

Suzuki, S., & Cavanagh, P. (1995). Facial organization blocks access to low-level fatures: an object inferiority effect. *Journal of Experimental Psychology: Human Perception and Performance, 21*, 901-913.

Theeuwes, J. (1993). Visual selective attention: a theoretical analysis. *Acta Psychologica, 83*, 93-154.

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

Tong, F., & Nakayama, K. (1999). Robust representations for faces: Evidence from visual search. *Journal of Experimental Psychology Human Perception and Performance, 25,* 1016–1035.

Tooby, J., & Cosmides, L. (1990). The past explains the present: Emotional adaptations and the structure of ancestral environments. *Etiology & Sociobiology, 11*, 375-424.

Treisman, A. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology, 12*, 242-248.

Treisman, A. (2006). How the deployment of attention determines what we see. *Visual Cognition, 14*, 411- 443.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12,* 97–136.

Trower, P., & Gilbert, P. (1989). New theoretical conceptions of social anxiety and social phobia. *Clinical Psychology Review, 9,* 19–36.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K.(1996). The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin, 119*, 488–531.

Vuilleumier, P., Richardson, M., Armony, J., Driver, J., & Dolan, R.J. (2004). Distant influences of amygdala lesion on visual cortical activation during emotional face processing. *Nat. Neurosci. 7*, 1271-1278.

Watson, D., & Friend, R. (1969). Measurement of social evaluative anxiety. *Journal of Consulting and Clinical Psychology, 33,* 448–457.

Whalen, P. (1998). Fear, vigilance, and ambiguity: Initial neuroimaging studies on the human amygdale. *Current Directions in Psychological Science, 7*, 177-188.

Whalen, P., Rauch, S., Etcoff, N., McInerney, S., Lee, M., and Jenike, M. (1998). Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. *The Journal of Neuroscience, January 1, 18*, 411-418.

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

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

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

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

Williams, J.M.G., Watts, F.N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders* (2nd ed.). Chichester, England: Wiley.

Wolfe, J. (1994). Guided Search 2.0 – a revised model of visual search. Psychonomics Bulletin and Review, 1, 202-238.

Wolfe, J. (1998). Visual search. Pashler, H. (Ed.), *Attention.* (pp.13-73). Hove, England: Psychology Press/Erlbaum (UK) Taylor & Francis.

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

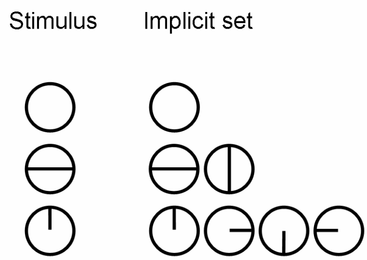

Figure 1. A larger implicit set of alternative stimuli with which a particular stimulus can be confused, the longer the list of attributes which have to be processed to distinguish it from the other members of its set.

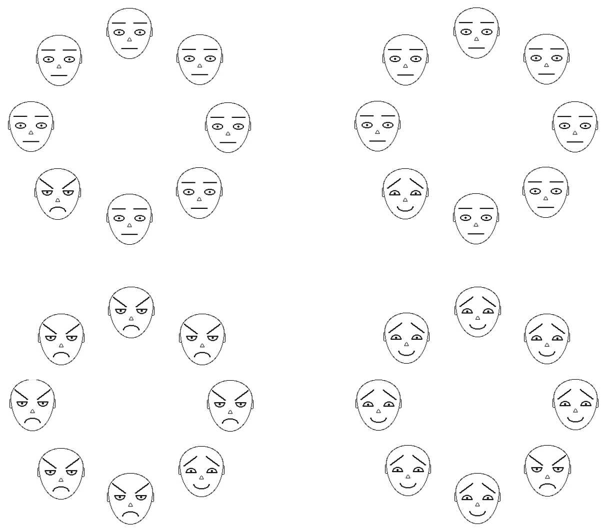

Figure 2. This illustration of schematic stimuli shows four examples of a target face in a crowd of distractor faces that were used as stimuli in Experiment 5. Note the identical physical differences between the threatening and the friendly faces, on the one hand, and the neutral face, on the other (Öhman, et al., 2001b).

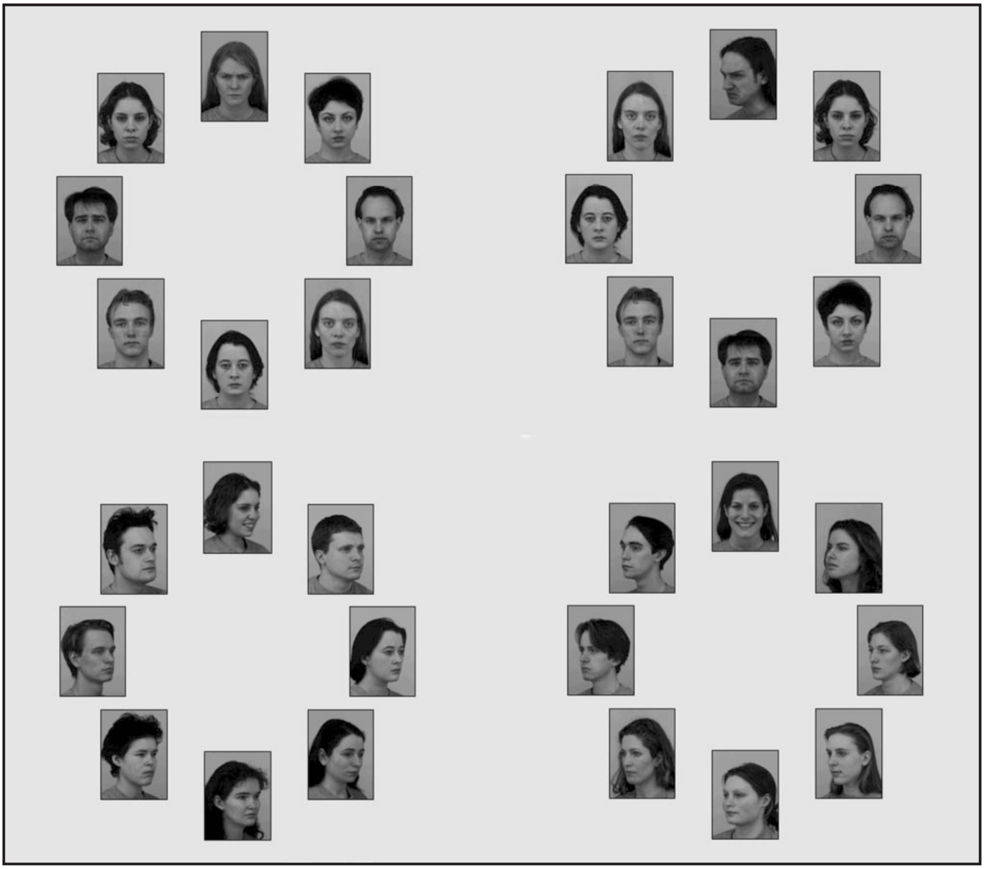

Figure 3. Examples of photographed real faces in crowds with a target, which were used in the visual search tasks in this thesis. In Experiment 1-3 of study I, the target and the distractors either shared face-directions (as in the two crowds to the left), or had different face-directions (as in the two crowds to the right) and were shown in color

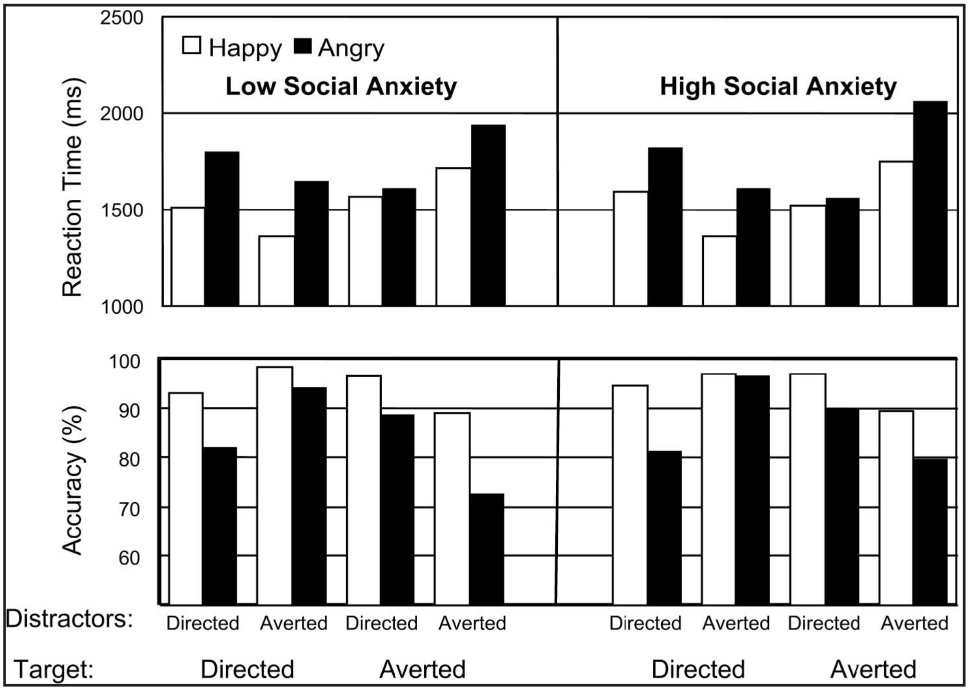

Figure 4. Visual search results from Experiment 1. The upper panels show reaction time and the lower panels show accuracy data for detection of directed or averted happy and angry targets among directed or averted neutral distractor stimuli. The right panels show data for highly socially anxious participants and the left panels show data from participants low in social anxiety.

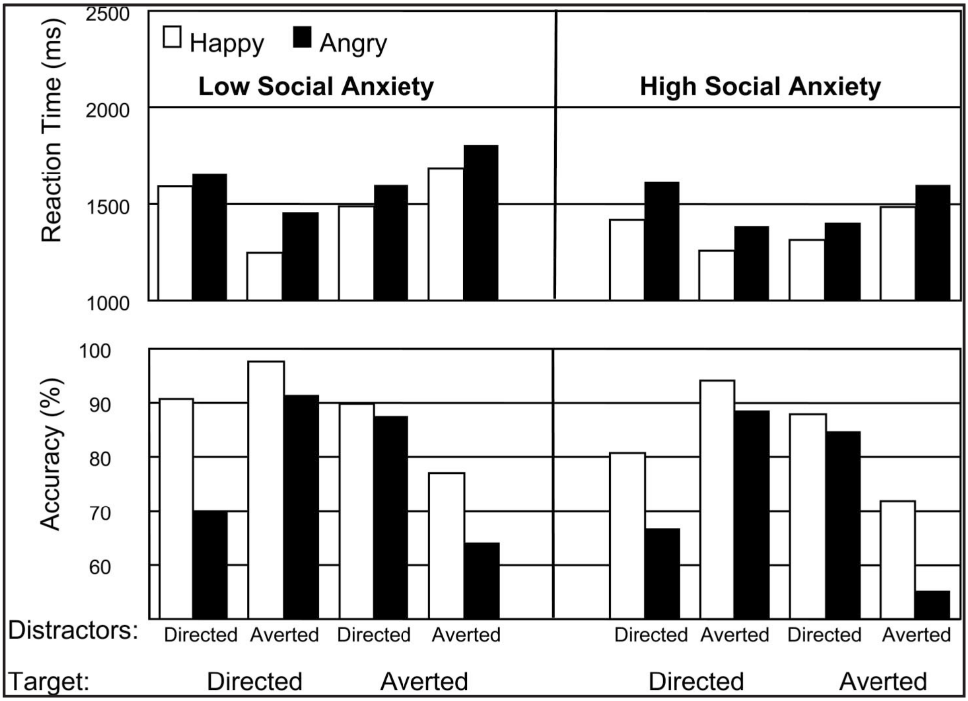

Figure 5. Visual search results from Experiment 2, which involved a social threat (a critical observer) for all participants. The upper panels show reaction time and the lower panels accuracy data for detection of directed or averted happy and angry targets among directed or averted neutral distractor stimuli. The right panels show data for highly socially anxious participants and the left panels show data from participants low in social anxiety.

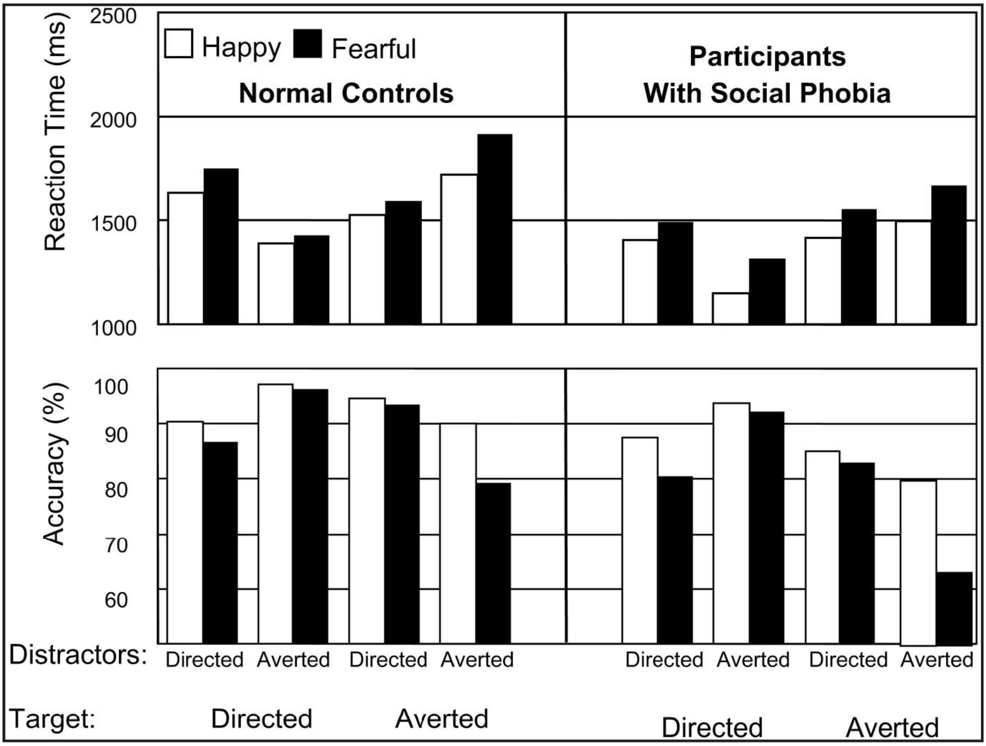

Figure 6. Visual search results from Experiment 3. The upper panels show reaction time and the lower panels accuracy data for detection of directed or averted happy and fear targets among directed or averted neutral distractor stimuli. The right panels show data for patients diagnosed with social phobia and the left panels show data from non-anxious control participants.

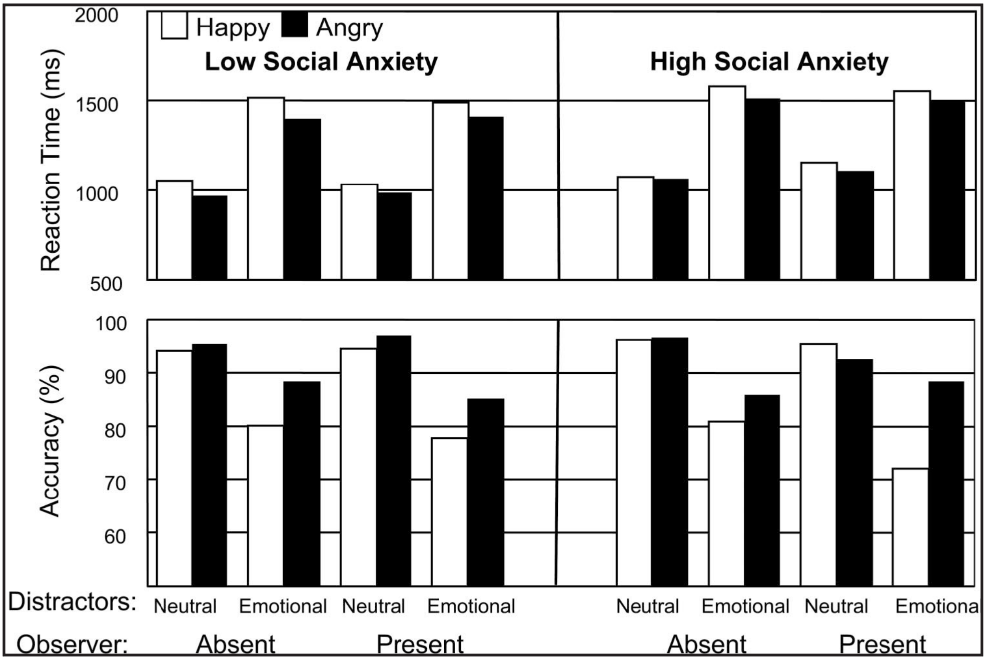

Figure 7. Visual search results with schematic stimuli in Experiment 5. The upper panels show reaction time and the lower panels accuracy data for detection of happy and angry targets among neutral or emotional (happy distractors for angry targets and vice versa) distractor stimuli with or without a critical observer. The right panels show data for highly socially anxious participants and the left panels show data from participants low in social anxiety.

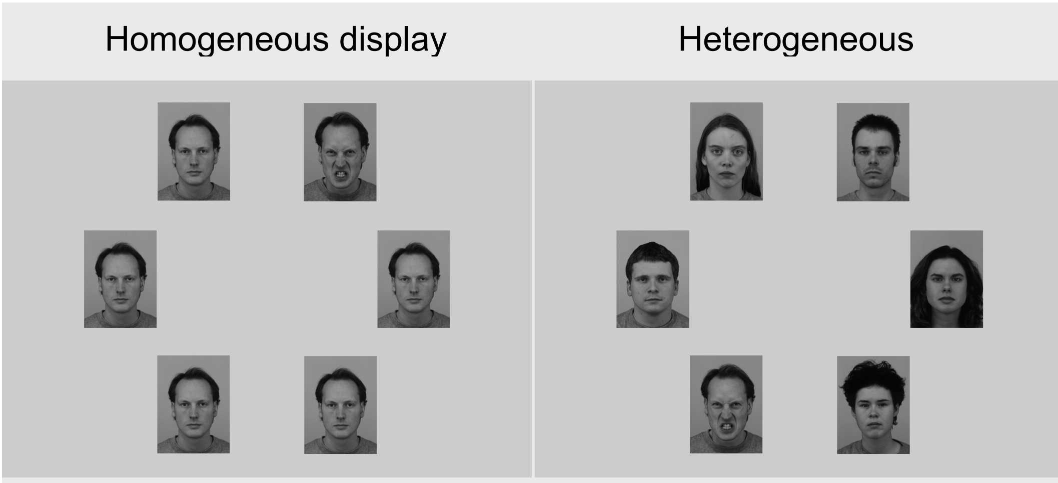

Figure 8. Participants in the experiment were exposed either to homogeneous distractors, in which the same individual posing different emotional expressions served both as target (the angry face to the upper right) or as distractors, or to heterogeneous distractors with different individuals serving as target and distractors.

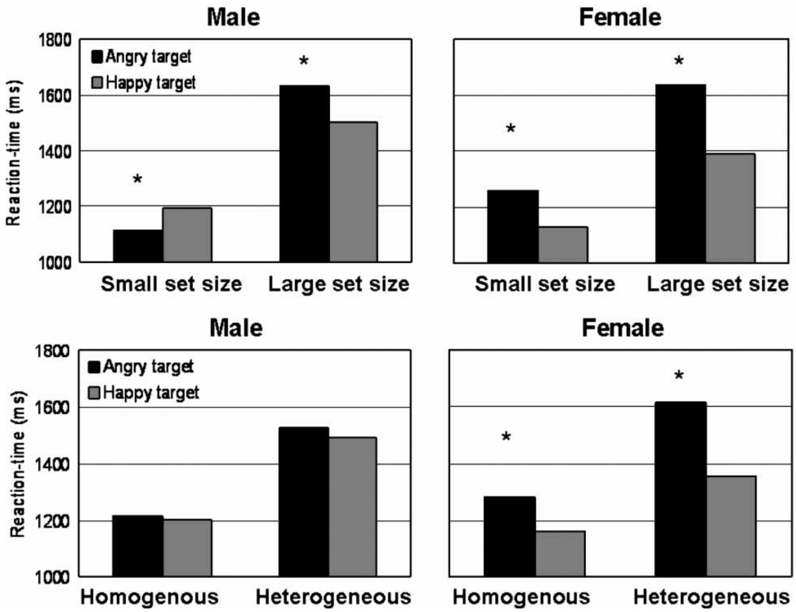

Figure 9. Upper panels: Reaction-time (RT) data for male and female target faces as a function of target emotion and stimulus set size (data collapsed over distractor homogeneity and blocks). Lower panels: Target trial RT data for male and female target faces as a function of target emotion and homogeneous versus heterogeneous distractors (data collapsed over stimulus set size and blocks). *Significant differences (p<.001) between angry and happy targets.

Figure 10. Reaction-time data for target trials for the first and second half of the experiment (Block 1 and Block 2, respectively) and for male and female targets. *Significant differences (p<.05) between angry and happy targets.

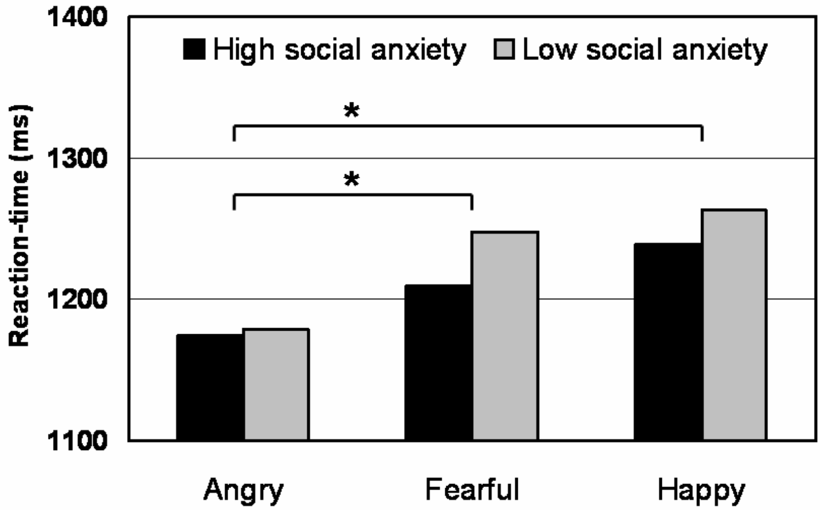

Figure 11. RT data for target trials were the deviant face displayed an angry, a fearful, or a happy expression, illustrated separately for the two groups of socially anxious and non-anxious participants. An angry target was detected more efficiently than both happy and fearful targets. * = $p < .0001$.

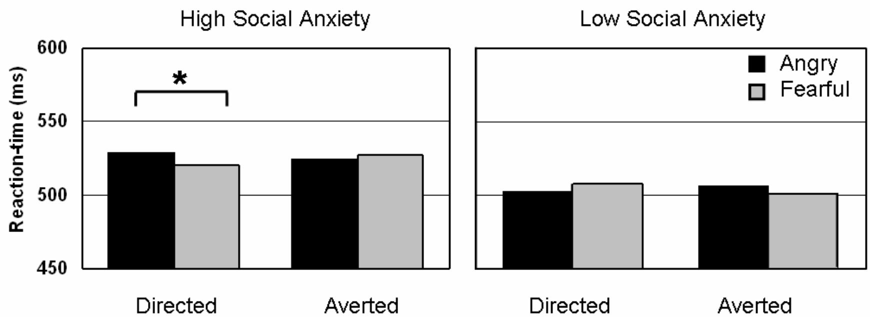

Figure 12. RT data for trials were the central face displayed an angry or a fearful expression in either a directed or an averted face-orientation, illustrating the significant three-way interaction between these facial factors and the participant's level of social anxiety. The socially anxious participants were more slowed by a directed angry face than by a directed fearful face, and, were more slowed by an averted fearful face than by an averted angry face, whereas the non-anxious controls showed the reverse RT pattern. * = p < .05.

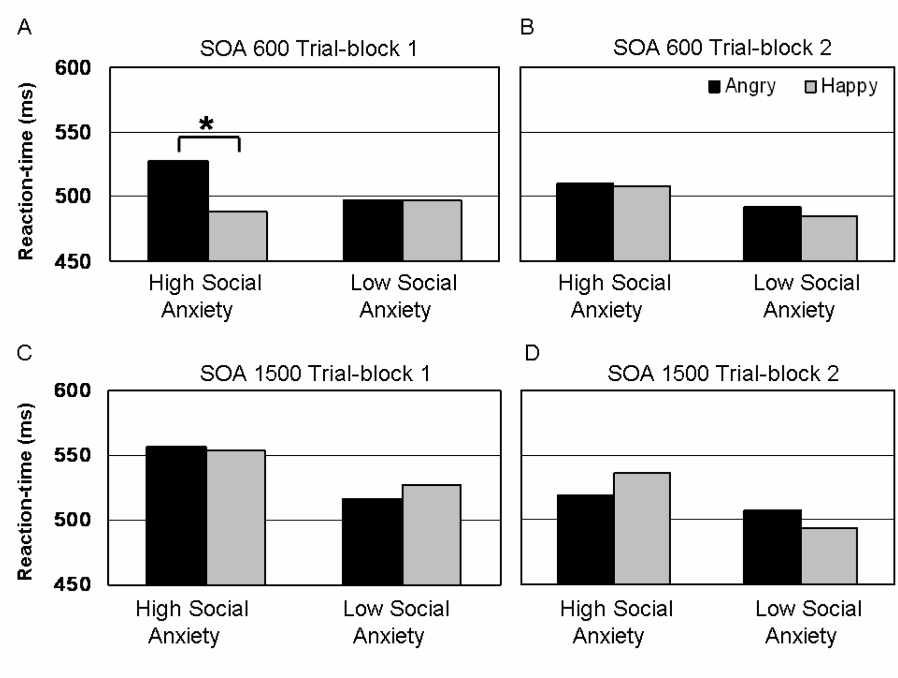

Figure 13. RT data for trials were the central face displayed an angry or a happy expression. Panels A-D illustrate the separate ANOVAs for the different SOA and block conditions. The significant interactions between group and expression in panel A shows that the group of socially anxious participants was more slowed by a central face displaying an angry than a happy expression, whereas the non-anxious control group did not differentiate between these emotional conditions. The significant two-way interaction in panel D shows that this emotional effect tends to be reversed with more time and training with the task. * = p < .02.

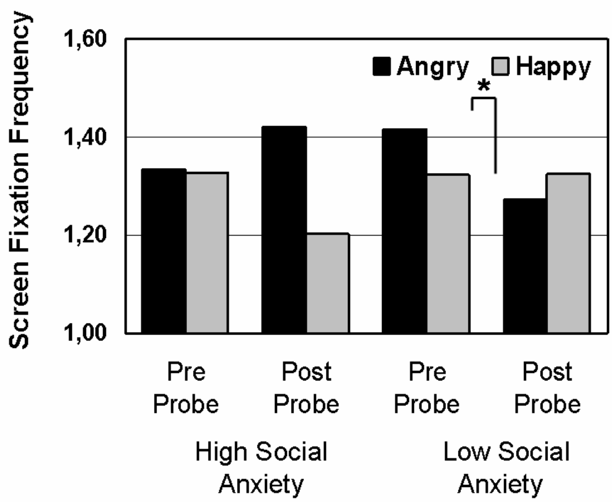

Figure 14. Screen fixation frequency before and after the probe onset, depending on whether the central face displayed an angry or a happy expression, *= $p < .05$ (t-test, one sided).