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Beyond the Dot-Probe: Investigating Attention Bias in Social Anxiety Using Novel Techniques

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Declarations.

1. The candidate has not previously submitted any of this work towards the award of a degree.
2. The material offered has not been part of solely or jointly-authored publications.
3. Length of the thesis: 31,575 words, excluding cover page, declarations, acknowledgements, abstract, list of contents, list of figures and tables, references, appendices and footnotes. 165 pages total.

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Abstract

The focus of this thesis is on attentional biases for emotional faces within trait social anxiety. There are two central aims. Firstly, to provide a theoretical expansion of what is known about attentional biases in social anxiety, especially regarding the theorised bias-components of facilitated attention toward threat, delayed disengagement away from threat, and attentional avoidance of threat. The second aim is to provide an experimental expansion by exploring paradigms that are relatively novel to the field, by using a mixed-method approach across four studies.

The first study presents adaptations of the attentional blink task. Between these tasks, processing stages and task-relevance of the emotional faces are manipulated. The second study investigates whether a child-version of the attentional blink task can be used to investigate attention bias in child social anxiety. Study three means to disentangle bias components by measuring eye-movements using a saccadic curvature paradigm and study four explores if anxiety-related sustained attention toward different emotions is reflected in neural activation with a steady-state visual evoked potential paradigm.

Ultimately, the findings and the existing literature are brought together under three themes. The first two map onto the thesis aims. Under the theme of components of attention bias, mixed support for facilitated attention, delayed disengagement and attentional avoidance in social anxiety is offered. The second theme evaluates that, with suggested adjustments, the presented novel techniques have the potential to explore attention bias in social anxiety. The third theme stems from the findings and focuses on how task-relevance of emotion might moderate social anxiety-attention links.

Taken together, this thesis extends knowledge of differential information processing in social anxiety and reveals the potential benefits of using novel techniques.

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1 Attentional Bias in Social Anxiety: A Literature Review

This first chapter provides an overview of the theory and the evidence relevant to the link between attentional bias and social anxiety. First, cognitive biases and anxiety in general will be discussed, before moving on to attentional biases and social anxiety more specifically. A summary of an influential model of attention processing will be provided to highlight how biases in attentional processing, such as facilitated attention toward threat, delayed disengagement away from threat, and attentional avoidance, might be underpinned by different components of attention. In conclusion, the strengths and limitations of experimental paradigms employed to study attentional biases in anxiety will be discussed. Overall, the aims of this chapter are to establish which aspects of attentional biases in social anxiety warrant further investigation; and which paradigms could best be employed to answer these remaining questions.

1.1 **Social anxiety**

Social anxiety is characterised by fear of situations in which an individual might be negatively evaluated by others (American Psychiatric Association, 2013). Symptoms include fear of negative evaluation, social avoidance, and physiological discomfort in social situations (Connor et al., 2000; de Vente, Majdandžić, Voncken, Beidel, & Bögels, 2013; La Greca & Stone, 1993). The Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) knows ten specific criteria of Social Anxiety Disorder. In summary, these deal with anxiety about social situations because of possible scrutiny by others and the fear of being negatively evaluated. Furthermore, social situations almost always provoke anxiety and are therefore often avoided, and this anxiety is disproportionate, persistent, distressing, and not explained by other medical conditions or mental disorders (American Psychiatric Association, 2013).

As opposed to the diagnostic criteria outlined in the DSM-V, some proposed that social anxiety lies on a spectrum as a dispositional trait (Schneier, Blanco, Antia, & Liebowitz, 2002; Stein, Ono, Tajima, & Muller, 2004). Schneier et al. (2002) argued that pathological categorisation relies on somewhat arbitrary criteria: thresholds are difficult to determine and prevalence depends strongly on how high this threshold is set. Furthermore, they provide evidence that some related subtypes such as shyness lie on the same social anxiety disorder spectrum. In similar fashion, Stein et al. (2004) hypothesised that social anxiety lies on various dimensions and proposed four different approaches, of which a spectrum of social fear and avoidance. Thus, regarding social anxiety as a spectrum rather than disorder-classification based on a set of boundaries is relevant for the work presented here. Individual differences in social anxiety can be regarded as a dispositional trait, and therefore throughout the experiments presented in this thesis analogue samples of participants will be used, rather than those diagnosed with social anxiety disorder.

Regardless of spectrum or classification, social anxiety causes interference with daily functioning and has an estimated prevalence of 5-7% in adolescence and adulthood, often with first onset during childhood (American Psychiatric Association, 2013, Broeren, Muris, Diamantopoulou, & Baker, 2013). Anxiety of any type can raise concern, having negative effects on school/academic performance as well as social and emotional functioning (Broeren et al., 2013). Significant progress has been made in delineating the cognitive underpinnings of social anxiety. However, a number of important questions remain.

1.2 **Cognitive biases and anxiety**

In recent years, research has focused on the role of cognition in anxiety (Puliafico & Kendall, 2006). Cognitive models suggest that anxiety stems from negatively biased information processing (Watts & Weems, 2006). The literature on these cognitive biases and anxiety provides evidence for several different biases that play a role in the development and maintenance of anxiety.

Biases relating to anxiety have been investigated for a number of cognitive processes. For example, memory bias refers to incorrect recollection of past events, resulting in remembering events as more negative. Whilst there is some evidence of correlations between memory biases and anxiety (e.g. Watts & Weems, 2006), these associations are not consistently found (e.g. Harrison & Turpin, 2003) and overall the evidence is not convincing. Another type of bias that has been investigated in relation to anxiety is judgement bias, which involves the negative perception of one's own ability to cope with negative information (Vassilopoulos & Banerjee, 2012).

The most convincing findings for cognitive biases in anxiety come from research examining interpretation and attentional biases. The first of these, interpretation bias, seems to be particularly relevant to social anxiety (Miers, Blöte, de Rooij, Bokhorst, & Westenberg, 2013). Interpretation bias corresponds to the negative interpretation of ambiguous or neutral information and specifically refers to the tendency to negatively interpret ambiguous cues in social situations (Clark & Wells, 1995; Miers, Blöte, Bögels, & Westenberg, 2008). In relation to social anxiety, there is a link between anxiety levels and more negative interpretations of ambiguous social events, as well as an overestimation of the likelihood of negative social outcomes (Beck, 1976). Interpretation bias is distinguishable from judgement bias in referring to negative interpretations of ambiguity situations/stimuli, whilst judgement bias is an overestimation of the emotional cost and probability of a negative event (Vassilopoulos & Banerjee, 2012). Previous research supports the view that socially anxious persons are more prone to interpretation bias (Mathews & Mackintosh, 2000). Child research has also indicated that a positive correlation exists between children's social anxiety symptoms and negative interpretations for ambiguous events (Hadwin, Frost, French, & Richards, 1997; Vassilopoulos & Banerjee, 2012).

Attention bias is the focus of the present thesis and refers to abnormalities in attentional processing of potential threats. There is substantial evidence that anxious adults exhibit biases in attention for threat-related stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), suggesting that the attentional system of anxious individuals is more sensitive to threat-related stimuli as compared with non-anxious individuals. These anxiety related attentional biases are found in child-populations as well (Bar-Haim et al., 2007; Dudeney, Sharpe, & Hunt, 2015; Puliafico & Kendall, 2006). The exact mechanisms that might underpin attentional biases have been described in a number of models, which will be described below (see Bar-Haim et al., 2007; Cisler & Koster, 2010).

1.3 Mechanisms underpinning attention bias

Schema theories describe that attention to information and interpretation and recollection thereof is guided by schemas, which are biased toward threat in anxious individuals (Bar-Haim et al., 2007). It is proposed that threat-related material is favoured at all stages of cognitive processing, including early attentional processing. For example, Beck and Clark's (1997) cognitive model proposes that anxiety is characterised by biases in the initial registration of a threat stimulus, the activation of what is called the primal threat mode -a state of alert- as well as later elaboration of the threat and reflection on it.

Other theories propose that attentional biases in anxiety occur only at specific stages of information processing. Anxious individuals may be prone to cognitive biases in early, automatic stages of processing (Williams, Watts, MacLeod, & Mathews, 1997. Williams et al.'s (1997) model suggests that attentional biases originate at the preconscious level of information processing. The threat value of incoming stimuli is assessed by an affective decision mechanism, which produces an initial decision; if the stimulus is perceived as highly threatening, a resource allocation mechanism is activated, allocating attentional resources to the threat.

Contrary to the theoretical position that biases manifest at early, automatic stages of processing, other theories suggest that biases occur at later stages: in anxiety there could be too much inhibition in elaborating threatening stimuli, which is reflected in threat avoidance strategies (Mogg, Bradley, de Bono, & Painter, 1997). Further, Wells and Matthews' (1994) model also argue against the idea that attention bias is automatic and explains it as a computational accident. This model emphasises the role of a top-down mechanism: attention bias occurs when stimuli are related to individual characteristics, such as knowledge and previous experience.

The conflicting views regarding the stage of cognitive processing at which biases occur, have led to theories that attempt to explain biases in both early and late processing (see Cisler & Koster, 2010). An example of this is Mogg & Bradley's (1998) cognitive-motivational model, which understands attention to threat as a normal and adaptive mechanism, determined by two systems; an initial appraisal of the stimuli followed by a goal-engagement system that determines the allocation of processing resources.

A slightly different model suggests that attentional bias is only predicted when threat has to compete with other stimuli or task-demands (Mathews & Mackintosh, 1998). Input is automatically evaluated, with its output feeding into a distractor/threat representation system. A final influential example of a model that attempts to explain biases at different processing stages is the attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007). This theory, which regards top-down as well as bottom-up processing, proposes that anxiety disrupts two executive functions of attentional control: inhibition of automatic responses and the ability to shift attention between tasks.

Only few of these models appear to describe their relation to all components of attentional bias. Whereas they all describe the stage of facilitated attention towards threat or vigilance, only Beck and Clark's (1997) and Eysenck et al.'s (2007) models emphasise difficulties in disengaging attention from threat. Avoidance of threat is only accounted for by Williams et al. (1988). An extensive meta-analysis of these models as well as others failed to demonstrate clear support for one particular theory over the other (Bar-Haim et al., 2007). The authors concluded that anxious individuals are likely to have a bias for preattentive detection to threat, as well as biases in later top-down processes. These findings led to a multistage model of attentional biases in anxiety (Bar-Haim et al., 2007) which proposes the following:

(1) A preattentive threat evaluation system scans the environment. (2) Stimuli tagged as threat feeds into a resource allocation system. This triggers a physiological state of alert. Ongoing activity is interrupted and processing resources are allocated to the threat stimulus, leading to a conscious anxious state. This alert state feeds into (3) a guided threat evaluation system, which carries out a set of strategic processes. The threat context is assessed, compared with memory and held up against the availability of coping resources and mechanisms. (4) This evaluation then reaches the goal engagement system. If the potential threat is consciously evaluated as being low, current goals are pursued, the stimuli will be ignored and the alert state will be relaxed. However, if there is a high conscious threat evaluation, a high state of anxiety is likely to be maintained.

Bar-Haim et al.'s (2007) model aptly explains how individual levels and types of anxiety could be characterised by biases in different stages of information processing. Anxious individuals may have a tendency to automatically evaluate the environment as more threatening; be more prone to allocate their resources to milder threat; may tend to consciously evaluate alert signals as more threatening, even despite context and memory indicating the opposite; and/or the overriding top-down mechanisms may have deficits, which explains how even conscious understanding of irrational anxiety is unable to override the anxious state.

1.4 Components of attention bias

Bar-Haim et al.'s (2007) proposed multi-stage model of attentional biases in anxiety, is favoured by Cisler and Koster's (2010) review of mechanisms of attentional biases towards threat in anxiety. This review confirms the notion that empirical evidence suggests that there are three components of attentional bias: facilitated attention for threat, delayed disengagement from threat and attentional avoidance of threat.

The facilitated attention to threat component of attention bias refers to the ease or speed of which attention is drawn to a threat stimulus (Cisler & Koster, 2010). Anxious persons may be more alert to potential threat, which could be the cause of their attention bias toward threatening stimuli. Past studies found inconsistent results, however, and this facilitation seems to be considerably moderated by high threat intensity and short stimulus durations, as Cisler and Koster (2010) pointed out.

Another component of attentional bias is delayed disengagement from threat, which refers to an impairment in the shifting of attention away from a threat stimulus to another stimulus (Cisler & Koster, 2010). Support that this component plays a significant role in anxiety has been confirmed in studies using spatial cueing tasks (e.g. Fox, Russo, Bowles, & Dutton, 2001; Koster, Crombez, Verschuere, & Houwer, 2006; Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006) and visual search tasks (e.g. Byrne & Eysenck, 1995; Lipp & Waters, 2007). The dot-probe task, which some argue can be used to disentangle facilitated attention to threat and difficulty in disengagement (Salemink, van den Hout, & Kindt, 2007), has provided more evidence for difficulty in disengagement as a major component of attentional biases in anxiety (Koster, Crombez, Verschuere, & De Houwer, 2006).

The third component of attentional bias is attentional avoidance (Cisler & Koster, 2010), which refers to the favourable allocation of attention to stimuli other than a present threat stimulus (Koster, Verschuere, Crombez, & Van Damme, 2005; Mogg, Bradley, Miles, & Dixon, 2004). Dot probe studies have demonstrated that anxious participants show attentional avoidance at long (1250 ms), but not at short (500 ms) presentation durations (e.g. Koster, Crombez, Verschuere, & Houwer, 2006; Koster et al., 2005; Mogg et al., 2004). Attentional avoidance has also been found looking at eye fixations of participants with spider phobia, after an initial phase of facilitated attention (Pflugshaupt et al., 2005).

1.5 **Networks of attention**

In order to arrive at a better understanding of biases arising during different stages of attentional processing, it is useful to discuss different functions and networks of attention. Posner (2012) has offered an influential model, which hypothesises that attention is composed of three functions: alerting, orienting, and executive functions (Posner, 2012). Support for this model came from imaging studies, among others, which indicated three separate networks carrying out each of these components of attention (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005).

Alerting is described as a state of higher sensitivity to incoming stimuli. Using warning signals prior to targets is an effective way to alter this state and results in shorter reaction times, as well as differences in physiological measurements such as heart rate and pupil dilation (Kahneman, 1973; Posner, 2012). The orienting network refers to shifting attention to sensory signals, such as a cue carrying information about a target; like its location. Whereas alerting relates to arousal -even when induced by warning signals-, the orienting network relies on specific and informative bottom-up cues, which facilitate shifting of attention. Finally, the network of executive control of attention is studied by tasks that involved conflict, such as various versions of the Stroop paradigm. Executive control involves self-regulation and is needed in planning, decision making, inhibition and error detection among others. This could be regarded as a bottleneck; the orienting network can be directed by any stimulus, but control can cause interference and inhibit orienting.

1.6 **Attentional biases in different stages of cognitive processing**

As it has been established that attention is composed of three functions (Posner, 2012), it is sensible to consider that attention biases could occur at each of these different stages of cognitive processing. The three components of attentional bias proposed by Cisler and Koster (2010), map well onto Posner's functions of attention. Taking first the facilitated attention component of bias, this aligns with the raised level of arousal in Posner's (2012) model, which prepares the individual to be ready for potential threat. In other words, their attention is facilitated towards that threat. Socially anxious individuals could have a higher bias toward threat, when their state of alertness to threat is higher than in non-anxious individuals, allowing for a quicker facilitation of attention toward potential threat stimuli.

Orienting could play a role in delayed disengagement from threat. Anxiety may be related to difficulties in task-switching for example, when biases do not allow for orienting attention away, or disengaging from threat stimuli. It should be clarified that different networks may overlap with multiple components and vice versa. Biases in the disengagement component of attentional processing could also be related to poorer executive control for instance. As illustrated in a study using rapid serial visual processing, poor executive control of attention related to difficulties in disengaging attention from emotional faces (Peers & Lawrence, 2009).

Another analogy could be drawn between the executive control network and the third component of attentional bias: attentional avoidance (Cisler & Koster, 2010). Attentional avoidance occurs when attention is favourably allocated away from a present threat stimulus (Koster et al., 2005; Mogg et al., 2004). Dot probe studies have demonstrated that anxious participants showed attentional avoidance at long (1250 ms), but not at short (500 ms) presentation durations (e.g. Koster, Crombez, Verschuere, & Houwer, 2006; Mogg et al., 2004). Attentional avoidance has also been found looking at eye fixations of participants with spider phobia, after an initial phase of facilitated attention (Pflugshaupt et al., 2005).

1.7 Evidence for cognitive biases in anxiety: overview of methods

Previous research into attention bias and anxiety has involved several experimental paradigms, including visual search, emotional stroop, emotional spatial cueing, and dot-probe. These have provided initial evidence for attention bias in anxiety and some insights into the mechanisms and processes that underpin attention bias. A brief overview of each task and its strengths and limitations is given below.

1.7.1 Visual search

Detection paradigms have been used primarily to study hypervigilance in anxiety. In the visual search task, a target stimulus is presented alongside an array of other distractor stimuli. Shorter reaction times for threat-related stimuli can be regarded as a straight-forward measure of heightened vigilance towards threat (Bögels & Mansell, 2004). In another variant of the visual search task, the participant is required to detect a non-threatening or neutral target stimulus in an array of threatening distractor stimuli. Slower response times here could reflect difficulties in disengaging attention from threat.

An example of enhanced detection of negative social cues in social anxiety is a study that found that persons with social anxiety showed preferential processing of faces; detecting an angry face in a neutral crowd more rapidly than a happy face (Gilboa-Schechtman, Foa, & Amir, 1999; Perowne & Mansell, 2002; Veljaca & Rapee, 1998). Whereas these studies demonstrated possible evidence for biases in preattentive mechanisms, or vigilance, other studies using visual search failed to find any evidence of such biases in social anxiety (Esteves, 1999; Pozo, Carver, Weflens, & Scheier, 1991; Winton, Clark, & Edelmann, 1995).

Whilst visual search paradigms suggest that social anxiety is associated with hypervigilance for social threat, they provide no insight into how attention biases are sustained over time. Visual search is response driven: a trial is presented until the participant finds the relevant target, which fails to allow for controlled timing. Due to these task-demands, detection paradigms may be informative about facilitated attention and delayed disengagement, but they fail to investigate avoidance of threat. The tasks described below are examples of paradigms in which presentation timing is determined by the task rather than the participants' performance, which allows for more accurate investigations into the time course of attentional biases.

1.7.2 Emotional stroop

Being an adaptation of the classic Stroop task (Stroop, 1935), the emotional Stroop involves manipulation of word valence rather than colour congruency. In a picture version, participants are instructed to name the colour of a schematic face, which displays either an angry or a neutral expression. A threat-related bias is implied when participants are slower to respond to threatening stimuli (e.g. angry faces) than neutral stimuli (MacLeod, 1991), suggesting avoidance of threatening stimuli.

Initially being a widely used tool to investigate attention bias in anxiety, the emotional stroop has later been subject to criticism (Bar-Haim et al., 2007); mostly with the argument that longer response latencies may result from late processes that are unrelated to attention. Both neutral and threat stimuli may be processed to the same degree, but a reaction time impairment for threat related stimuli could be a result of intensification of the negative affective state of anxious participants (MacLeod, Mathews, & Tata, 1986). Interference by threat stimuli in the emotional Stroop might also reflect effortful avoidance of processing threat cues rather than attentional capture by these cues (de Ruiter & Brosschot, 1994).

1.7.3 Spatial Cueing

The emotional spatial cueing paradigm was developed to study (biased) allocation of attention to emotionally valenced stimuli (Fox et al., 2001). In this paradigm, a target appears to the left or to the right of a fixation point. On the majority of trials (the valid-cue trials) a cue will appear briefly at the location the target will appear at. On the remainder of trials (the invalid-cue trials) the cue will appear at the opposite location. A validity effect can be measured by subtracting performance on valid-cue trials from performance on invalid-cue trials. The valence of the cue can be manipulated. For example, a neutral, happy, or angry face could be displayed as the cue. When validity effects are larger for threat-related cues than for neutral-cues, an attention bias is inferred. Furthermore, a valence-related modulation of performance on valid-cue trials indicates that the attentional bias occurs at the stage of initial orienting of attention, whereas such modulation on invalid-cue trials would reflect a difficulty in disengaging attention from threat-stimuli (Bar-Haim et al., 2007). In Fox et al. (2001), no evidence was found for an advantage for threat-related valid-cues, regardless of participants' anxiety levels; indicating that attentional biases did not occur at the stage of orienting. However, it took anxious participants longer to respond to targets after threat-related invalid-cues, suggesting difficulties in disengaging from threat.

The spatial cuing paradigm overcomes the participant-controlled presentation times in visual search. However, there are other limitations. For example, only one stimulus is present at a time, meaning that there is no direct competition between threat-related and neutral stimuli to measure attentional bias with. It is also possible that findings from this paradigm cannot be generalised, due to being contingent on the cue stimuli being task-relevant (Bar-Haim et al., 2007). In other words, regardless of valence, a single sudden-onset cue will strongly attract attention. This means that spatial cueing may not aptly measure the orienting component of attention, which could potentially explain the lack of evidence for anxiety related attentional biases occurring at this stage. Paradigms using multiple stimuli simultaneously, with task irrelevant valenced cues, may therefore be useful; such as the dot-probe task.

1.7.4 Dot-probe

Arguably the most frequently used experimental paradigm in research on attention bias and anxiety is the dot-probe task (Bar-Haim et al., 2007), which was designed to overcome the limitations of the emotional Stroop. In this task, two stimuli (usually words or faces) appear simultaneously on a screen, followed by a probe in the location of one of the stimuli. Participants are asked to respond to the location of the probe as fast as they can. In general, shorter response times to dots in the location preceded by a threat-related stimulus indicate attentional bias toward threat (Bar-Haim et al., 2007). Because participants are also required to respond to neutral stimuli, delayed response times cannot be explained by response bias or general arousal.

Manipulating the stimulus onset asynchrony in dot-probe tasks allows for the investigation of biases across the time course of attention. One of the main difficulties with the dot-probe task is that performance differences, and therefore apparent biases, could result either from faster engagement with the threat stimulus or from difficulty disengaging from the threat stimulus (Posner & Petersen, 1990; Posner, 2012). Furthermore, attention biases in the dot-probe task are possibly accounted for by poorer attentional control (Frewen, Dozois, Joanisse, & Neufeld, 2008). In a cueing task, employed by Derryberry and Reed (2002), targets appearing on one side of the screen were likely to result in negative feedback (thus threatening) and targets on the other side of the screen usually yielded positive feedback. The preceding cue's direction was manipulated, as was its duration. Besides assessing anxiety levels, self-reported attentional control was collected as well. Anxious participants revealed an early attention bias at 250 milliseconds. Only the anxious participants with low self-reported attentional control also showed an attention bias at 500 milliseconds presentation duration. This suggests that anxious people with skilled attentional control may be able to voluntary limit the impact of threat on their attention at longer presentation times.

Further difficulties with the dot-probe task include the fact that it is only able to provide a snapshot of attention and there is quite convincing evidence that stimulus presentation time affects the results, with a fairly consistent anxiety-related attention bias found when stimuli are displayed for 500 milliseconds (Shechner et al., 2012), but not at different display durations. For example, evidence for an attention bias to threat on the dot-probe task is less consistent when stimuli are presented for longer than 1,000 milliseconds (Frewen et al., 2008). Therefore it seems safe to say that modifying the display times on dot-probe tasks as a means to study biases in Posner's different stages of attention has provided important insights into attention biases in anxiety but the task has a number of limitations.

1.7.5 What these paradigms say about social anxiety

Compared with other anxiety disorders, social anxiety is a more recent topic of research (Rapee & Heimberg, 1997). Most recent social anxiety studies examining attention bias used faces rather than words as stimuli, as it has been found that social anxiety-related bias is more sensitive to faces than to words (Pishyar, Harris, & Menzies, 2004). Of the paradigms presented above, most attention bias research into subclinical social anxiety and Social Anxiety Disorder (SAD) has used the dot-probe task. A recent systematic review looked at facial dot-probe tasks in relation to social anxiety (Bantin, Stevens, Gerlach, & Hermann, 2016). The authors found 10 studies suitable for their systematic review, which indicates that relatively little has been done so far in the field. These studies revealed that individuals with SAD and individuals high in social anxiety display vigilance toward threat stimuli, especially at short stimulus presentation times. However, avoidance of threat was not found. This provides initial evidence for the role of early attentional processes in social anxiety related biases.

1.8 Exploring cognitive biases in social anxiety: suggested experimental paradigms

Visual search, emotional stroop, spatial cueing, and dot-probe paradigms have yielded mixed results regarding attentional biases in anxiety generally and social anxiety more specifically. More recently researchers have begun to use novel methods and techniques which could potentially further reveal the spatial and/or temporal characteristics of preferential threat processing in anxiety. Promising measures and tasks include the attentional blink paradigm, as well as eye-tracking and neuro-imaging measures such as electroencephalography (EEG). These are outlined below.

1.8.1 Attentional blink paradigm

The attentional blink reflects attentional capacity when two targets are presented shortly after one another in a rapid serial visual processing (RSVP) task (Ciesielski, Armstrong, Zald, & Olatunji, 2010; Raymond, Shapiro, & Arnell, 1992). Perceiving a first (T1) target results in an impairment of detecting the second (T2) target when it is presented only a few hundred milliseconds after T1. This effect is called the attentional blink (AB) and it is affected by the number of distractor stimuli presented between T1 and T2 (Lag) as well as the emotional salience of the target stimuli. The attentional blink is reduced when T2 is an emotional stimulus, whereas an emotional T1 results in a prolonged attentional blink (Schwabe et al., 2011) indicating that emotional information demand greater attentional resources.

In order to investigate attentional bias in anxiety, Fox, Russo, and Georgiou (2005) used the attentional blink paradigm manipulating the emotional salience of a T2 face target. Their main finding was that low anxious persons showed a strong emotional blink when T2 was a face expressing happiness or fear. In contrast, high anxious participants showed a significantly reduced attentional blink for fearful T2s. relative to low-anxious participants. Using a similar paradigm, de Jong and Martens (2007) failed to find an attentional blink for either happy or fearful faces in social anxiety. This discrepancy could be interpreted as attentional biases in social anxiety not conforming to those found in the anxiety more broadly (Fox et al., 2005).

The inconsistent findings might also be a result of task characteristics themselves. Often, a blink is absent when targets are faces compared to pictures of objects as distractors (Landau & Bentin, 2008); or when face targets are presented among a stream of digits (Awh et al., 2004). Compared with neutral faces, Stein, Zwickel, Ritter, Kitzmantel, and Schneider (2009) found a blink for fearful faces when the emotion had to be reported, but not when the gender of the face had to be reported or when the face was to be ignored. They proposed that the attentional blink depends on the attentional set of the observer and is modulated by task context. Consequently, a task needs to be developed with certain characteristics in order to assess modulations in the attentional blink effect to be accounted for by social anxiety rather than task properties and demands.

Taken together with the notion that emotional processing requires few attentional resources (Fox et al., 2005), the strengths of the attentional blink paradigm make it attractive for studying the temporal aspects of attentional biases in social anxiety more closely.

1.8.2 Eye-tracking measures

Gaze direction can be sampled by eye-tracking equipment. Therefore, whereas measures such as of reaction times and accuracy on behavioural tasks may provide a useful snapshot of attention, it is necessarily indirect. Eye-tracking technologies allow for a direct and continuous measure of overt attentional selection. Investigations of attention bias using eye-tracking suggested that anxiety-related biases are not always only *toward* threat, but also *away* from threat in later stages of processing, through attentional disengagement or possibly attentional avoidance (Koster, Verschuere, Crombez, & Van Damme, 2005).

Eye-tracking has been applied to a number of the paradigms described in this chapter to investigate anxiety-related facilitated attention and delayed disengagement. For example, a meta-analytic study investigating these mechanisms in visual search and free viewing suggested that anxiety appears to be related to vigilance toward threat in both free viewing and visual search tasks, but has only been found to be related to disengagement from threat on visual search tasks (Armstrong & Olatunji, 2012). Dot-probe tasks have found evidence of hypervigilance or facilitated attention in anxiety; early orienting toward threat compared with neutral faces is found in anxious participants relative to controls (Bradley, Mogg, & Millar, 2000; Mogg, Millar, & Bradley, 2000).

One difficulty with eyetracking as used in the previous work described is that participants were required to look at the emotional stimulus for attention to be inferred. Attention may also be covertly captured by emotional information in the environment. With saccade curvature paradigms the influence of salient or emotional task-irrelevant distractors on the saccade trajectory can be investigated (Schmidt, Belopolsky, & Theeuwes, 2012). Consequently, both initial vigilance toward and subsequent avoidance of emotionally relevant information in anxiety-related biases can be explored.

1.8.3 EEG

Attentional mechanisms are reflected in the electroencephalography (EEG) signal (Luck & Kappenman, 2011). In anxiety, EEG studies have revealed specific patterns related to resting-state frequency bands (Putman, 2011) and bias-related Event Related Potentials (ERPs; Bar-Haim, Lamy, & Glickman, 2005; Helfinstein, White, Bar-Haim, & Fox, 2008; Mueller et al., 2009), with the ERP research suggesting that differential attentional processing in anxiety is pronounced in the facilitated attention component of attention bias.

Another method to investigate emotional face processing in anxiety is through adaptation paradigms. In these paradigms, a stimulus is repeatedly presented. Increased repetition of the stimulus evokes a reduced neural response (Grill-Spector, Henson, & Martin, 2006). However, this reduction is found less for emotionally relevant information, such as threat-related emotional faces (Vuilleumier & Driver, 2007). Nevertheless, since effect sizes in adaptation paradigms are typically small (Rossion & Boremanse, 2011), using these to investigate how emotional faces are differently processed in low-anxious and high-anxious individuals would require a large amount of trials and participants.

Recently, a promising alternative to traditional adaptation paradigms has been proposed: the steady-state Visual Evoked Potential (ssVEP; Rossion, 2014). Repeatedly presenting images of faces at a fixed presentation-rate, evokes a strong neural response at the same firing-frequency as the presentation-rate. Much like adaptation studies, repetition of the same face evokes a reduced ssVEP compared with presenting different faces. As the signal-to-noise ratio of the ssVEP is large, this method may be more cost-and-time effective than adaptation paradigms to compare neural processing of emotionally relevant information between low-socially anxious high-socially anxious individuals. Finally, this method has yet to be used as a way to examine attention bias is anxiety.

1.9 **Conclusion**

The aim of this chapter was to review the existing evidence of attentional bias in social anxiety, to identify gaps in the literature, and to explore the potential of experimental paradigms that could investigate this further. Tasks like the visual search, emotional stroop, spatial cueing, and the dot-probe, confirm that attentional processes of threat-information act differently in high-anxious than in low-anxious individuals (Bar-Haim et al., 2007). These biases may be driven by separate facilitated attention toward threat, difficulty in disengaging attention away from threat, and/or attentional avoidance of threat (Cisler & Koster, 2010).

However, little is known about the role of these components in social anxiety specifically. Additionally, the frequently used paradigms may not prove sufficient for disentangling the role of these components in social-anxiety related attentional bias. Here, it is proposed that the attentional blink, saccadic curvature, and ssVEP paradigms could prove useful for investigating these components of social-anxiety related differential emotional processing further. Therefore in this thesis, these experimental paradigms will be utilised to examine attentional bias in association with self-reported social anxiety. The thesis will focus on two aims:

1) To provide a theoretical expansion of what is known about attentional biases in social anxiety, especially regarding the theorised bias-components of facilitated attention toward threat, delayed disengagement away from threat, and attentional avoidance of threat.

2) To provide an experimental expansion by exploring paradigms which are relatively novel to the field, by using a mixed-method approach across a series of four studies.

Firstly, in chapter two, an attentional blink paradigm using neutral and emotional stimuli as targets is presented. The hypothesised facilitated attention toward threat in social anxiety should lead to greater accuracy for emotional targets relative to low-socially anxious participants. In chapter three, an adaptation of this paradigm is presented to 11-year-olds, as so far, little is known about social-anxiety related attention bias in children. Chapter four employs a saccadic curvature paradigm, with emotional faces as task-irrelevant distractors. By recording whether eye-movements deviate toward or away from emotional distractors, accounts of respectively facilitated attention and attentional avoidance of threat in social anxiety can be tested. The final experimental chapter is chapter five, in which an ssVEP paradigm is utilised to examine whether high socially anxious participants remain more vigilant toward threat over time than low socially anxious participants, which would be demonstrated by a larger ssVEP response. Finally, the findings of these novel paradigms will be brought together and discussed in chapter six.

2 Facilitated Attention and Delayed Disengagement in Social Anxiety: the attentional Blink

This chapter will discuss a series of behavioural experiments in order to investigate components of facilitated attention and difficulties with disengagement in social anxiety related attentional biases. The paradigm presented here is an adaptation of the attentional blink. In the attentional blink paradigm, one or two targets are presented within a rapidly presented series of stimuli. When the second target (T2) is presented in quick succession of the first target (T1), people often have difficulties detecting it. In the first experiment, T1 is an emotional face, whereas T2 is a non-social neutral stimulus, an animal. If those high in social anxiety have difficulties in disengaging attention from threatening stimuli, this would result in an amplification of the attentional blink. In the second experiment, T1 is the animal and T2 is the emotional face. If attentional biases in social anxiety involve facilitated attention toward threat, performance of high-socially anxious participants should show an attenuation of the attentional blink. As both of these experiments ask participants to make a 2-alternative forced choice, it requires a certain alertness to the stimuli. Experiment 3 investigates whether these mechanisms of facilitated attention are also present in a more implicit design. Taken together, the experiments described in this chapter aim to disentangle components of vigilance and disengagement in social anxiety related attentional biases. It was found that, when the environment needs to be scanned for emotional information, those high in social anxiety process information efficiently regardless of valence, whereas those low in social anxiety showed preferential processing for threatening information only.

2.1 Background and rationale

2.1.1 The Attentional Blink and emotional processing

In the previous chapter, the potential of the Attentional Blink paradigm to investigate emotion related attentional biases in social anxiety was introduced. Specifically, the paradigm offers a promising approach to investigate components of facilitated attention toward threatening information and difficulty in disengaging attention away from threat in the temporal domain. The attentional blink will be summarised and elaborated in the current section.

When a stream of distractor stimuli is presented with two target stimuli in the stream, and the first target (T1) is detected, the second target (T2) is often missed when it closely follows T1 (Ciesielski, et al., 2010; Raymond et al., 1992). This attentional blink depends on how many distractor stimuli are presented between T1 and T2, but also on target salience. There is evidence to suggest that the attentional blink is reduced when T2 is an emotional stimulus, whereas an emotional T1 results in a prolonged attentional blink (Schwabe et al., 2011).

2.1.2 Emotional T1: disengagement from threat

Previous research suggests that attentional blink tasks using a negative emotional word as T1 and a neutral word at T2 results in a prolonged attentional blink (Schwabe et al. 2011), suggesting that attention is captured by threat. This attentional capture by negative information was illustrated in a study where T1 was a negative, neutral or scrambled scene and T2 was a rotated landscape (Most, Chun, Widders, & Zald, 2005). Participants were instructed to ignore all other stimuli except T2 and it was found that negative images resulted in a prolonged attentional blink, whereas scrambled and neutral scenes had no effect.

Interesting results have been reported with emotional faces as T1. Fearful faces resulted in a longer attentional blink than neutral faces, but only when the T1-emotion had to be reported as well as a neutral T2 (Stein, Zwickel, Ritter, Kitzmantel & Schneider, 2009). When T1-gender rather than emotion had to be reported, this effect of fearful faces disappeared. Furthermore, when participants did not have to report the face-T1 but only the neutral T2, the attentional blink disappeared altogether. This indicated that task demands play a role in the effect of fearful faces on the attentional blink. In other words, performance on the attentional blink is affected by the participant's attentional set.

Another study explored the effect of an emotional T1-face on detection of subsequent letter targets, in which it was found that angry faces resulted in a prolonged attentional blink compared with neutral or happy faces (de Jong, Koster, Van Wees, & Martens, 2010). However, the authors failed to find a link with social anxiety. On the other hand, a similar study where T2 was an emotional face as well yielded no emotional-T1 effects on the subsequent attentional blink (de Jong & Martens, 2007).

In conclusion, there is evidence for attentional capturing by an emotional T1 in an attentional blink task. However, previous research has focussed on strong emotional expressions such as anger or fear. Links to social anxiety-related attention bias for more subtle threat, such as disgusted faces, remain unclear. An enhanced blink is predicted when overinvestment of attentional resources in stimulus processing (Olivers & Nieuwenhuis, 2006) may prevent a neutral T2 from being detected when attentional resources are still captured by an emotionally salient T1. This predicts an enhanced blink when emotional information processing on T1 targets consumes additional capacity. If these attentional resources remain captured for a longer duration in high socially anxious participants relative to low socially anxious participants, then this prolonged blink would provide evidence that anxiety related attentional biases might be manifested in the component with disengagement from threat (Cisler & Koster, 2010).

2.1.3 Emotional T2: facilitated attention toward threat

In addition to investigating the effect of an emotional T1 on the attentional blink, T2-valence could be manipulated in an alternative adaptation of the paradigm. An emotional T2 is expected to command greater attentional resources, which would result in an attenuated, or shortened, attentional blink (Yiend, 2010). One example from the literature is a study by Maratos, Mogg, and Bradley (2008) which found a reduced attentional blink when T2 was an angry rather than a neutral or positive schematic face. If a positive relation between social anxiety and a reduced emotional blink for an emotional T2 is found, it potentially provides evidence for the facilitated attention to threat component of attention bias (Cisler & Koster, 2010). This in turn could relate to a more vigilant state of the alert network, as defined by Posner (2012), known as hyper-vigilance in the anxiety literature (Bögels & Mansell, 2004; Eysenck, 1992).

Experiments using emotional faces as T2 have yielded mixed results. For example in one study, a strong attentional blink for participants low on *general* anxiety was found for happy or fearful T2-expressions, compared with a significantly reduced attentional blink for high anxious participants for fearful T2s (Fox, Russo, & Georgiou, 2005). In contrast, de Jong and Martens (2007) failed to find a social-anxiety related effect in the attentional blink for either happy or fearful faces at T2. Potentially, attentional biases in social anxiety are different from those found in the anxiety disorders more generally (Fox et al., 2005). Therefore, investigating the attentional blink for emotional T2 stimuli may provide further evidence toward the facilitated attention account of attention bias in social anxiety specifically.

2.1.4 The experiments

One study which investigated the impact of faces as T1 *and* T2 found that the attentional blink is reduced when an angry face followed a happy face, but not the other way around (De Jong & Martens, 2007). This supports the assumption that attention is captured by threatening stimuli. In the experiments presented in this chapter disgusted rather than angry faces are used as potentially threatening stimuli for two main reasons. Firstly, in social anxiety disorder (SAD), the core concern is fear of negative evaluation from others (American Psychiatric Association, 2013). Socio-moral disgust is perhaps therefore at least as relevant to the concerns of socially anxious individuals as anger. Despite this, little research has examined attention bias to disgust in social anxiety. Second, there is evidence that an increased sensitivity to disgusted faces in social anxiety may exist along with that to angry faces. For example, when Montagne et al. (2006) presented neutral faces which morphed into emotional faces, SAD-patients were quicker to identify the displayed emotion when it was disgusted and angry, but not fearful, sad, happy or surprised, compared to healthy controls.

For the experiments that follow, T1-valence will be either a disgusted or happy face and T2 will be neutral in experiment 1. Experiment 2 will manipulate a face-T2 after presentation of a neutral T1-stimulus. Both of these experiments require participants to make a binary forced choice decision on T1 and T2 target identification. This will be compared to target identification on single-target trials, in which the respective T2 will act as the only target in a stream among distractors. Inconsistent findings from previous attentional blink paradigms with emotional faces in the anxiety literature might be a result of task characteristics (e.g. Most et al., 2005; Stein et al., 2009). Therefore, experiment 3 will utilise a more implicit paradigm: instead of presenting participants with a 2-alternative forced choice on the emotion on the face when it was present in the stream, participants will be asked whether they saw a face in a stream in which an emotional T2-face was not always present. These three experimental adaptations of the attentional blink paradigm, address the question of whether high levels in social anxiety are related to differential attentional capturing by happy and disgusted faces.

2.2 **Experiment 1: Emotional T1**

The first experiment aims to investigate whether presenting an emotional target (T1) affects the magnitude of the attentional blink when the second target (T2) is a non-social neutral stimulus. Previous research which used emotional faces for both targets, suggested that neutral non-facial T2 stimuli provides further insight into the effect of an emotional face-T1 (de Jong, Koster, van Wees, & Martens, 2009). In this experiment, T1 was a face with disgusted or happy expression, whereas T2 was an animal. The hypothesis assumes that social anxiety is related to difficulties in disengaging attention away from potential threat (Cisler & Koster, 2010), and therefore predicts that participants high in social anxiety will show lower performance than those low in social anxiety on correct T2 identification when T1 was a disgusted face. There will be no difference in performance between the group following a happy T1.

2.2.1 Method

Participants. From the sample of 35 undergraduate Psychology students, who participated in return for course credit, two outliers were removed, as they performed well below chance levels. Consequently, N = 33 (29 females); age range = 18.3 – 43.5 years; M (*S.D.*) = 20.6 (4.2). All participants reported normal or corrected-to-normal vision.

Apparatus and materials. T1 stimuli consisted of three male and three female faces from the Radboud Faces Database (RaFD; Langner et al, 2010). Disgusted and happy expressions were selected for each identity. T2 stimuli were six animals (retrieved from pics4learning.org) photographed *en profil*, which were non-threatening and not typically pet animals; a camel, elephant, fox, goat, kangaroo, and meerkat were selected. The head was cropped, a leftward looking and a rightward looking copy were made of each, and this target was superimposed over distractor stimuli. These distractor stimuli were scrambled neutral faces from the RaFD. All stimuli were in grayscale and luminosity was matched. Stimuli were presented at a size of 252 x 252 pixels on a black screen controlled by a standard desktop computer. Stimulus presentation was programmed using the Psychophysics toolbox-3 (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007) in Matlab. The edges of the distractor images and the animal images were blurred with a Gaussian mask to improve target-distractor similarity.[1]

SPIN. The Social Phobia Inventory (SPIN; Connor et al, 2000) comprised 17 items, with Likert scales 0-4. The SPIN is a self-rated questionnaire assessing the spectrum of fear, avoidance and psychological symptoms that are associated with social anxiety, providing a good internal consistency (alpha = .87 - .94; Connor et al., 2000; see Appendix A).

BFNE-S. The Brief version of Fear of Negative Evaluation -Straightforwardly worded (BFNE-S; Collins, Westra, Dozois, & Stewart, 2005; Rodebaugh et al., 2011; see Appendix B) is a self-report measure which assesses fear of negative evaluation, a characteristic feature of social anxiety disorders (Rapee & Heimberg, 1997). The questionnaire consists of 8 items rated on a 5-point Likert scale. Its internal consistency has shown to be high (alpha = .90, Collins et al, 2005).

Procedure. Participants sat in individual testing rooms at a distance of approximately 90cm from the screen. The experiment commenced after gaining participants' informed consent. The experiment comprised two tasks: a single-target task (T2 only) and a dual-target task (T1 and T2). Each trial started with a fixation cross with 1000ms duration. This was followed by a stream of 17 stimuli in total, displayed for approximately 67ms each (4 screen refreshes). Dual-target trials commenced with the presentation of 2, 4, or 6 distractor stimuli followed by the emotional face (T1). After T1 1, 4, or 7 distractor items appeared (lag-1, lag-4 and

[1] Pilot studies revealed that without masks, T2 detection was nearing 100%. T1 was presented without masks to increase its detection likelihood and consequently increase the number of trials suitable for analysis (T1-correct).

lag-7 at 67, 268 and 469 ms respectively), followed by the animal (T2). Finally, distractor stimuli were presented until the total of 17 stimuli was presented. Responses were self-paced and the next trial started after responses were gained. T1 position, lag, and target stimuli were presented with equal probability. Single-target trials followed the same presentation principles, but T1 was replaced by another distractor stimulus. See Figure 1 for the trial procedure.

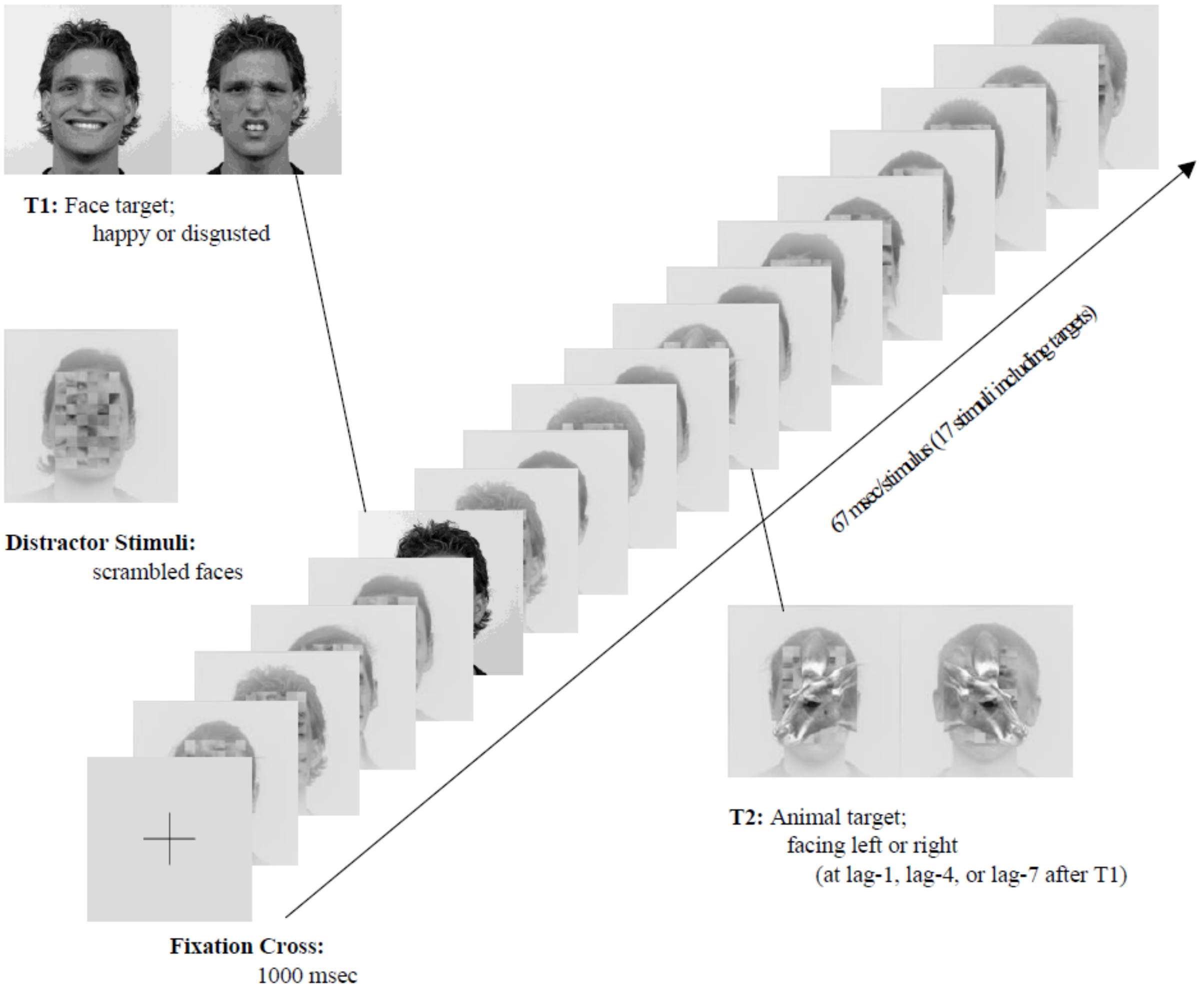

Figure 1. Example of a dual-target trial with T2 presented at lag 4. In single-target trials, a distractor was presented instead of T1. Participants were instructed to identify the emotion of the face and the direction in which the animal was looking using a 2AFC response after each trial.

After each single-target task trial, participants made a two-alternative forced choice response whether the animal was facing left or right. After each trial in the dual-target condition, this response dialog was preceded by the question whether the face was happy or disgusted. Responses were collected with a mouse.

Each task was presented in two blocks of 72 trials, thus the total experiment consisted of 288 trials across four blocks. Task order (Single-target block, dual-target block, single-target block, dual-target block; or dual-target block, single-target block, dual-target block, single-target block) was counter-balanced between participants. Between each block, there was a self-paced break.

Before the experiment, participants received instructions about the two tasks and practiced two trials for each task, which contained stimuli that were not used in the experiment itself. After the experiment, they completed the questionnaires and were debriefed.

Analysis. For single-target trials average correct target identification per participant was calculated in percentages. Mean target (animal) detection in the single-target trials was 94.8% (*S.D.* = 4.87); approximately 7 incorrect trials. For dual target trials, average correct T2-identification was calculated for trials on which participants correctly identified T1 (*M* = 96.4% across participants, *S.D.* = 3.18, approximately 5 incorrect trials).

Suggested cut-off scores for the SPIN and BFNE-S were used to bin participants into low and high social-anxiety groups. For the SPIN, the suggested cut-off is 19 (Connor et al., 2000). Mean SPIN-score in the current sample was 20.2, *S.D.*

= 11.3.[2] Using the cut-off score, 18 participants (54.5%) were classified as low-socially anxious and 15 (45.5%) were high-socially anxious. For the BFNE-S, a cut off score of 28 was used (Carleton, Collimore, McCabe, & Antony, 2011). Mean BFNE-S score in the current sample was 24.4, *S.D.* = 8.51, resulting into 22 participants (66.7%) in the low-scoring group and 11 (33.3%) in the high fear of negative evaluation group. Both of these questionnaires were subjected to individual ANOVAs.

Individual ANOVAs were conducted for each set of high/low groups as defined by the SPIN and BFNE respectively. The two main analyses of interest were mixed ANOVAs on T2 performance with SPIN group (Between-Subjects; low, high) × Emotion (Repeated Measures; disgust, happy) × Lag (Repeated Measures; lag-1, lag-4, lag-7) and BFNE-S group (Between-Subjects; low, high) × Emotion (Repeated Measures; disgust, happy) × Lag (Repeated Measures; lag-1, lag-4, lag-7); both 2 × 2 × 3. In addition, some exploratory analyses were conducted as detailed below.

2.2.2 Results

The data was negatively skewed due to a ceiling effect in target-detection performance. Nonetheless, the exploration of descriptive statistics suggested that participants had more difficulty in T2-detection after correct T1-identification at lag-1 than at lag-4 and lag-7. Greenhouse-Geisser degrees of freedom are reported where appropriate.

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[2] One participant missed one item in the SPIN as well as in the BFNE-S. These missing values were substituted with the average item-score on each questionnaire prior to calculating this participant's totals.

As expected, mean single-target detection was neither different between the low-SPIN and high-SPIN group; $t(31) = 1.32$, $p = .20$; nor between the low-BFNE-S and high-BFNE-S group; $t(31) = 0.14$, $p = .89$. For dual-target trials, both ANOVAs revealed a main effect of lag (SPIN ANOVA (lag effect): $F(1.46, 45.2) = 31.2$, $p < .001$; $\eta_p^2 = .502$; BFNE-S ANOVA (lag effect): $F(1.47, 45.5) = 27.5$, $p < .001$; $\eta_p^2 = .470$). Paired samples t-test revealed that T2-detection at lag-1 ($M = 83.3\%$, $S.D. = 9.75$) was poorer than at lag-4 ($M = 93.5\%$, $S.D. = 5.89$); $t(32) = 5.90$, $p < .001$. In addition, detection at lag-1was poorer than at lag-7 ($M = 94.3\%$, $S.D. = 5.89$); $t(32) = 6.26$, $p < .001$. The difference between lag-4 and lag-7 was not significant. Only T2-detection at lag-1 differed significantly from detection in single-target trials; $t(32) = 7.45$, $p < .001$. No main effects of emotions or social anxiety were found, nor was there an interaction effect between any of the variables; see Figure 2.

As a pop-out effect for T1 (face) was deliberately created, T1-detection performance in dual-target trials was high ($M = 96.4\%$, $S.D. = 3.18$). However, since the attentional blink is thought to be affected by T1, several exploratory analyses on T1 were carried out. A SPIN × T1-emotion × Lag ANOVA yielded a main effect of emotion on correct T1 identification when T2 was correctly identified; $F(1, 31) = 12.4$, $p = .001$, $\eta_p^2 = .285$. Mean accuracy for happy faces was poorer (94.7%, $SE = 1.0$) than for disgusted faces (98.2%, $SE = 0.3$). This was not moderated by SPIN group; SPIN group × Emotion interaction $F(1,31) = 0.646$, $p = .43$, $\eta_p^2 = .020$. Similar results were found regardless of whether T2 was correct. A SPIN × T1-emotion × Lag ANOVA showed only an effect of emotion in the same direction.

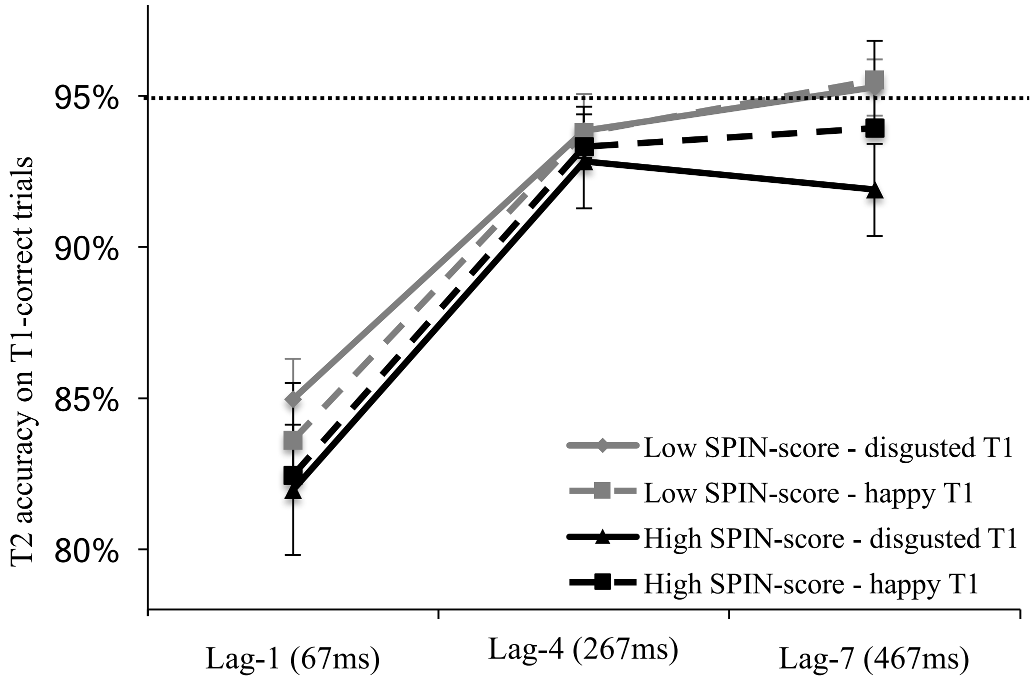

Figure 2. T2 accuracy when T1 was correct in experiment 1, where T1-valence was manipulated (face) and T2 was neutral (animal). The horizontal dotted line reflects accuracy on single-target trials (animal). An attentional blink was present: accuracy at lag-1 was lower than at lag-4, at lag-7, and for single-target trials. Error bars represent +/- 1 within-subjects standard error.[3]

Similarly, for T2-correct dual-target trials, a BFNE-S group × T1-emotion × Lag ANOVA yielded a main a main effect of emotion; $F(1, 32) = 8.45$, $p = .007$, $\eta_p^2 = .214$; as well as a main effect of fear of negative evaluation; $F(1, 31) = 4.73$, $p = .045$, $\eta_p^2 = .124$. Participants below the BFNE-S cut-off performed better on disgusted faces ($M = 98.1\%$, $S.D. = 1.69$) compared to happy faces ($M = 93.1\%$, $S.D. = 5.92$); $t(21) = 3.99$, $p = .002$. There was no difference in performance on disgusted and happy faces for participants above the cut-off, see Figure 3. However, it should be

[3] For future reference, figures in this thesis are displayed with within-subjects standard errors (Franz & Loftus, 2012; Loftus & Masson, 1994).

noted that only 11 participants fell into this group. This analysis also revealed marginally significant BFNE-S group × T1-emotion interaction; $F(1, 31) = 12.4$, $p = .052$, $\eta_p^2 = .116$.

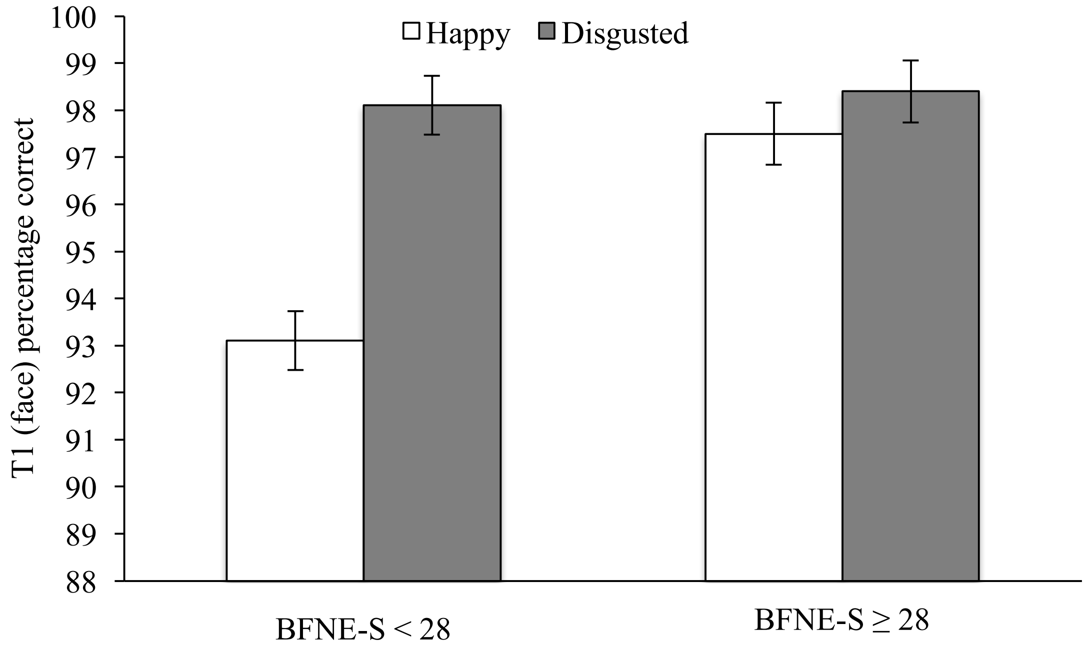

Figure 3. Mean T1 (face) detection when T2 (animal) was correct (dual target trials) for the low and high fear of negative evaluation groups. in percentages. Error bars = +/- 1 within-subject SE.

2.2.3 Discussion

Investigating the attentional blink for emotional T1s and neutral T2s allowed an exploration of difficulties in disengaging from threatening information in social anxiety. It was hypothesised that if social anxiety is related to difficulties in disengaging attention from potential threat (Cisler & Koster, 2010), those participants high in social anxiety would show poorer performance on T2 identification when T1 was a disgusted face than those low in social anxiety. The results presented above, suggest that that is not the case. A short attentional blink was found (at lag-1 only), but there were no social anxiety related effects on T2 performance.

However, exploratory analyses showed that those low in social anxiety, specifically those with low fear of negative evaluation, had more difficulty correctly identifying happy T1 faces compared with their performance on disgusted faces and compared with those high in fear of negative evaluation. This result should be considered with caution given that the effect was not replicated with SPIN score and was not anticipated.

2.3 Experiment 2: Emotional T2

Whereas the previous experiment, with an emotional T1 and neutral T2, investigated difficulty with disengaging attention away from emotional information, the experiment described in the current section explores *facilitated* attention toward threat in social anxiety using the same paradigm but with the targets switched; here T1 is an animal, and T2 is an emotional face. It is hypothesised that socially relevant information "breaks through" the attentional blink more for socially anxious individuals than for those lower in social anxiety. In other words, even when attentional processes are dedicated toward other resources, orienting attention toward emotional stimuli will be facilitated for those participants with higher levels of social anxiety as measures using the SPIN and BFNE-S.

2.3.1 Method

This study comprised a new sample of 35 Undergraduate Psychology students (28 female). Mean age was 20.9 years (*S.D.* = 5.17; range = 17.9 – 48.0). Except for the target order, with T1 being the animal and T2 the emotional face, this experiment followed the same apparatus, materials and procedure as experiment 1.

2.3.2 Results

Mean accuracy on single-target (face) trials was 98.8% (*S.D.* = 1.49). For dual-target trials, overall mean T1 (animal) correct was 89.9% (*S.D.* = 13.3) and T2 (face) correct was 97.0% (*S.D.* = 2.32), indicating a negatively skewed distribution driven by a ceiling effect.

Mean score for the SPIN questionnaire was 21.9 (*S.D.* = 9.62; Cronbach's alpha for internal consistency = .86). Using the cut-off score of 19, 20 participants (57%) were in the high-socially anxious group.

Analyses were carried out on T2 (face) identification when T1 (animal) was correct (Figure 4). A SPIN group × T2-Emotion × Lag ANOVA yielded a three-way interaction effect; $F(2, 66) = 5.08$, $p = .009$; $\eta_p^2 = .133$. Subsequent analyses for the high and low social anxiety groups separately showed that, for the High-Social Anxiety group only a main effect for Lag was found, $p = .007$; mainly between Lag-1 and Lag-7 ($p = .040$, Lag-1 – Lag-4 $p = .06$, Lag-4 – Lag-7 *n.s.*). However, for the Low-Socially Anxious group, a T2-Emotion × Lag two-way interaction effect was found; p = .001. Examining the effect of lag for each emotion separately within the low socially anxious group showed no effect of Lag for disgusted faces, whilst for happy faces all three Lags yielded different accuracy, with improved performance over increases in lag (largest $p = .002$). Finally, comparing performance on happy and disgusted faces at each lag (for the low socially anxious group only), a significant difference was only found at Lag-1; low-Socially Anxious participants had poorer performance for happy faces compared with disgusted faces; $t(14) = 3.58$, $p = .006$. All p-values are Bonferroni-corrected.

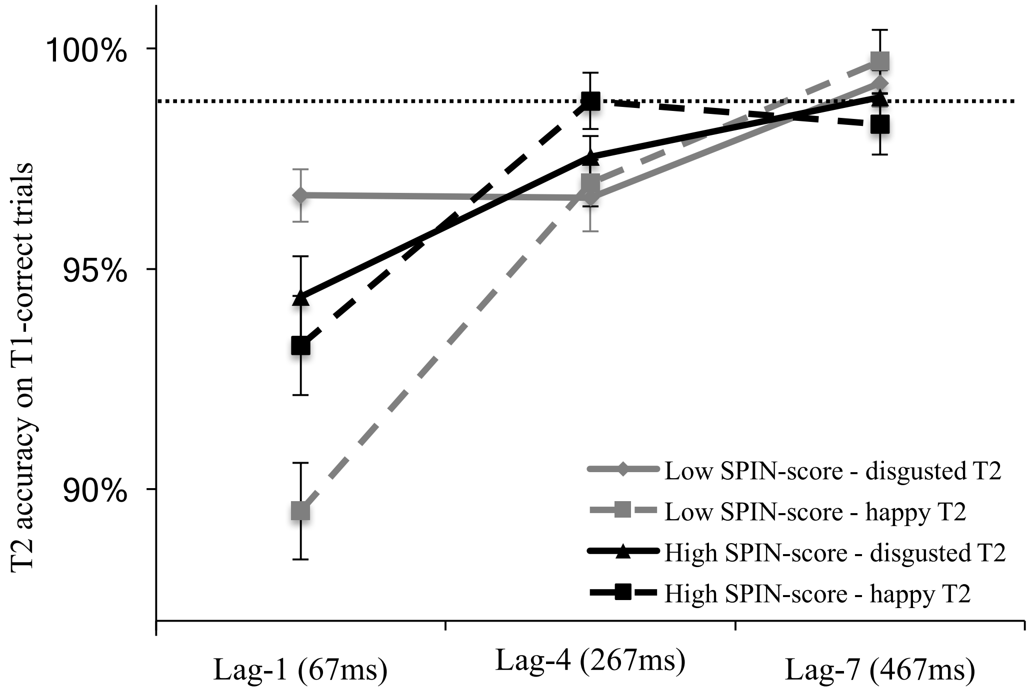

Figure 4. T2 accuracy when T1 was correct in experiment 2, where T1 was neutral (animal) and T2-valence was manipulated (face) for both social anxiety groups (SPIN). The horizontal dotted line reflects accuracy on single-target trials (animal). At lag one, accuracy of happy face detection in the low-social anxiety group was significantly lower than in the high anxiety groups, as well as accuracy on disgusted faces in both groups. Error bars represent +/- 1 within-subjects standard error.

In order to further explore this T2-emotion effect at Lag-1 a between-groups t-test indicated that performance on happy faces was significantly poorer in the low social anxiety group than the high social anxiety group ($t(33) = 2.08$, $p = .045$) but no difference was found in performance on disgusted faces ($t(33) = 0.83$, $p = .414$). Further, a correlation between SPIN scores and accuracy difference for each emotion (disgusted-happy) at lag-1 was found; r =.39, p = .021 indicating that lower social anxiety is associated with relatively poor performance on happy trials.

Finally, accuracy for each emotion between dual-target trials and single-target trials was compared for each social-anxiety group using paired-samples t-tests, which revealed the following. In the low-social anxiety group, only accuracy for happy faces at lag-1 in dual target trials was worse than accuracy for happy faces in dual-target trials; $t(14) = 5.03$, $p < .006$, adjusted for multiple comparisons. There was no statistical difference in the low-social anxiety group between accuracy for happy faces in single target trials and accuracy for happy faces in dual-target trials at lag-4 or lag-7 and similarly not between accuracy for disgusted faces in single target-trials and those at lag-1, lag-3, or lag-7 in dual target trials. For the high social anxiety group, no differences were found for accuracy for happy or disgusted faces in single-target trials compared with any of the lags in dual-target trials.

Mean score on the BFNE-S in this sample was 22.7 (*S.D.* = 7.20; Cronbach's alpha for internal consistency = .90) with a normal distribution. Using the same cut-off score of 28 and higher, only 9 participants 25.7% were classified as high-socially anxious. Nonetheless, the results, though not always significant, appeared to be in the same direction as the above results for SPIN score[4], see Figure 5. For example, a significant main effect for Lag was found; $F(1.41, 48.2) = 13.8$, $p < .001$, $\eta_p^2 = .295$. The BFNE-S group × Emotion × Lag three-way interaction effect was only marginally significant; $F(1.46, 48.2) = 3.42$, $p = .055$, $\eta_p^2 = .094$. This effect appeared to be underlined by a trending Emotion × Lag interaction; $F(1.41, 46.7) = 2.89$, $p = .082$, $\eta_p^2 = .081$, as well as by the Lag main effect reported above.[5]

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[4] The correlation between SPIN and BFNE-S was $r = .61$, $p < .001$.
[5] In the context of the BFNE-S results largely following the patterns found in the SPIN analyses throughout the current work, additional analyses from this questionnaire will be summarised in footnotes from this point. Low BFNE-S group: main effect Lag ($p < .001$); trend Emotion ($p = .068$). Interaction Emotion X Lag ($p < .001$) - poorer detection of happy faces (95.9%) than disgusted faces (97.3%; $t(25) = 3.25$, $p = .003$). High BFNE-S group: no significant effects. Numerically, the results in the high BFNE-S group appears to reflect the findings from the high SPIN-group, but this failed to reach significance, which can most likely be attributed to the small number of participants in high BFNE-S group.

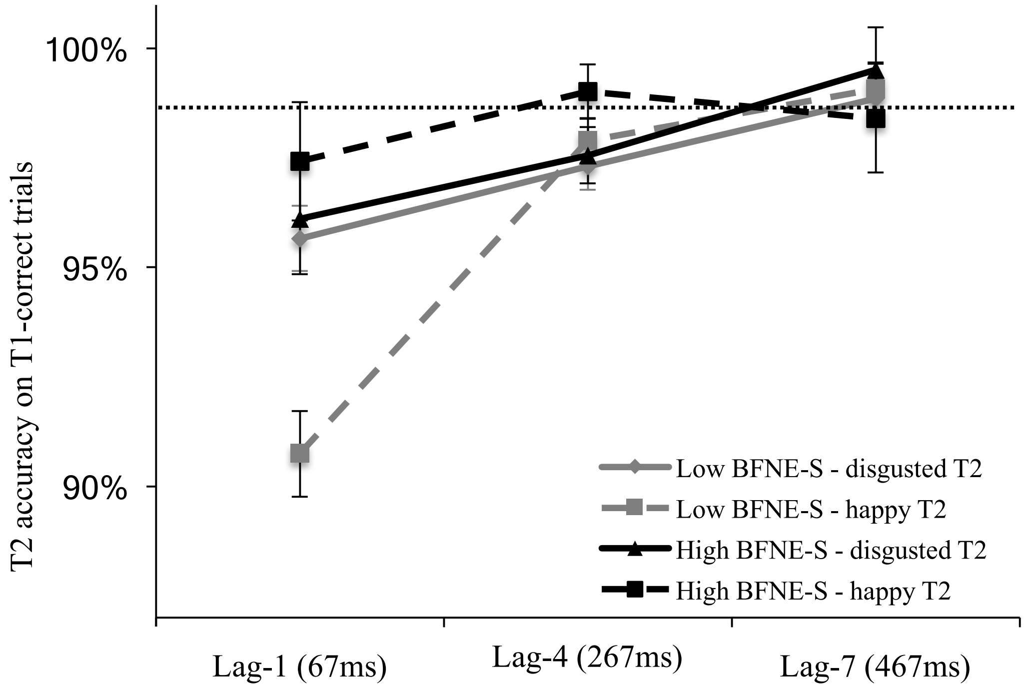

Figure 5. T2 accuracy when T1 was correct in experiment 2, where T1 was neutral (animal) and T2-valence was manipulated (face) for both Fear of Negative Evaluation groups (BFNE-S). The horizontal dotted line reflects accuracy on single-target trials (animal). At lag one, accuracy of happy face detection in the low-social anxiety group was significantly lower than in the high anxiety groups, as well as accuracy on disgusted faces in both groups, but this interpretation is based on only a marginally significant three-way interaction. Error bars represent +/- 1 within-subjects standard error.

2.3.3 Discussion

In this experiment, where T1 was an animal and T2 an emotional face, an attentional blink effect was found. The closer T2 followed T1-presentation, the less often participants correctly identified it. Perhaps most interestingly, the magnitude of this attentional blink when T2 follows T1 most closely – at lag-1-, was modulated by emotion of the face and by social anxiety. Specifically, at lag-1 those who are low in social anxiety made more errors in correctly identifying happy faces compared to both their own performance for disgusted faces and when compared to those high in social anxiety.

This effect is similar to the T1-effect in experiment 1, where happy T1s were more often incorrectly identified than disgusted T1-face targets in the low socially anxious groups. One explanation for this is that negative or threat-related expressions are salient and command attentional resources even when social anxiety is low (Eysenck, Derakshan, Santos, & Calvo, 2007). However, happy faces may not be salient to low-socially anxious participants, meaning that they are less likely to break through the attentional blink for them than for high-socially anxious participants, who may allocate resources toward facial expressions generally. This would explain equal and high performance for participants high in social anxiety regardless on valence. However, the tasks used in experiments 1 and 2 required participants to make a 2-alternative forced choice response on the emotion of the face and this face was always present. It is possible therefore that the attentional set of scanning the environment for emotional information plays a role in emotion detection.

2.4 Experiment 3: Implicit Emotion Detection

2.4.1 Rationale

Study two involved an explicit 2-alternative forced choice emotion-judgement task on the face-T2. It was found that the most important effect involving social anxiety was that low-socially anxious individuals were worse at correctly identifying happy faces at lag-1, whilst their accuracy regarding disgusted faces was as high as for both emotions in the high-socially anxious group. It is not clear from the results of experiments 1 and 2 whether the low anxious participants were simply not seeing the happy faces at lag-1 or whether they were seeing the face but misjudging it as being a disgusted face. Further, experiment 2 required participants to pay attention to the emotion of the second target. Due to its blocked design, participants knew that an emotional face would always be present in the dual-target blocks. These task-demands could have given rise to hypervigilance toward emotional faces due to expectations and alertness. However, it does not provide any information as to whether such biases still exist if the environment is to be scanned without prior expectations. Therefore, for Experiment 3 a number of changes were made to the design, including the use of a more implicit paradigm.

The emotion judgement task from experiment 2 was replaced with a detection task, i.e. “Did you see a face?” with “yes/no” response alternatives. Single-target trials were randomised, rather than the block design followed in experiment one and two. This allowed for a target-detection rather than a target identification task, i.e.: “Was there a face?” instead of “What was the emotion of the face?” Consequently, accuracy could be measured as an implicit function of emotion. An additional advantage of this change is that it allowed for signal detection analysis. The randomisation of single-target trials also lowered response biases related to expectancy, which could partially have accounted for the ceiling effect found in the previous experiment.

In order to further avoid ceiling effects, a number of presentation characteristics were amended. The Gaussian blur was removed from the distractor stimuli, to improve target-distractor similarity (Müsch, Engel, & Schneider, 2012). Presentation rates were kept the same, but backwards masking was used on the face target.

If the low socially anxious group’s larger amount of errors in detecting happy faces was driven by a response bias toward disgusted faces, these effects would disappear using a paradigm with implicit yes/no judgements (H1). Furthermore, it was predicted that an emotion-effect would be more apparent, given that ceiling-effects should be absent with increased task-difficulty (H2). Finally, in line with anxiety-related facilitated attention toward threat, those high in social anxiety should show a higher detection rate for disgusted T2s compared with low-socially anxious participants (H3).

2.4.2 Method

Participants. Participants were a new sample 32 (6 males) undergraduate students at the University of East Anglia who participated in return for course credit. Mean age was 19.7 years (*S.D.* = 0.76; range = 18.6 – 22.7).

Materials. The same materials were used as were used in experiments one and two. The blurring Gaussian mask was removed from the distractor stimuli. Backward masks for T2-faces were created by scrambling the face area of the face-targets, in similar fashion to distractor items.

Procedure. The procedure followed the same basic principles as in experiments one and two, with a few differences.

Instead of four, eight practice trials were offered, using one animal-target (left/right-looking) and one face-target (neutral). Practice stimuli were not used throughout the actual experiment. If participants (n = 4) failed to correctly detect at least one presented face during the practice trials, the practice was run again.

Furthermore, the presentation time of 6 frames (67ms) per stimulus was unchanged. However, T2 (faces) were presented for 3 frames, immediately followed by its unique mask for 3 frames, so T2+mask presentation made up an identical duration as the other stimuli in the RSVP stream. This backward masking was implemented to increase task difficulty in an attempt to reduce the ceiling effect of performance in experiments 1 and 2. It was reasoned that emotional information in faces is processed after an even shorter presentation duration, however, it was decided that the overall rate of 67ms per stimulus should remain consistent. These backward masks were comprised of a scrambled neutral face with the same identity as the preceding T2.

Analysis. As in the previous experiments, T2-accuracy was calculated for each participant. Only T1-correct trials were included, to ensure T1-processing was apparent. Two separate 2 × 2 × 3 ANOVAs were carried out: one for the SPIN (Social Anxiety; High, Low × Emotion; Happy, Disgusted × Lag; Lag-1, Lag-4, Lag-7) and one for the BFNE-S (Fear of Negative Evaluation; High, Low × Emotion; Happy, Disgusted × Lag; Lag-1, Lag-4, Lag-7).

2.4.3 Results

Mean SPIN score was 21.6 (*S.D.* = 11.7). Using the cut-off score of 19, 12 participants (37.5%) were in the low-socially anxious group, and 20 (62.5%) were in the high-social anxiety group. As expected, the data was normally distributed across conditions (except for happy-lag7 and T2-absent correctness, both expected). A 2 (SPIN-score; low, high) x 2 (T2-emotion; disgusted, happy) x 3 (Lag; 1, 4, 7) ANOVA yielded a main effect for emotion, with less accuracy on detection of disgusted faces (M = 59.4%, SE = 3.5) than happy faces (M = 68.6%, SE = 3.5); $F(1, 30) = 16.62$, $p < .001$, $\eta^2 = .36$. Furthermore, a main effect of lag, $F(2, 30) = 29.93$, $p < .001$, $\eta^2 = .50$, illustrated that the attentional blink was present. Accuracy on lag-1 (M = 49.5%, SE = 4.9) was lower than on lag-4 (M = 72.0%, SE = 3.1) and lag-7 (M = 70.2%, SE = 3.2), both $p < .001$. Lag-4 accuracy and lag-7 accuracy were not statistically different, $p > .5$. No effect for SPIN group was found. No other effects, including interactions were found, see Figure 6.[6]

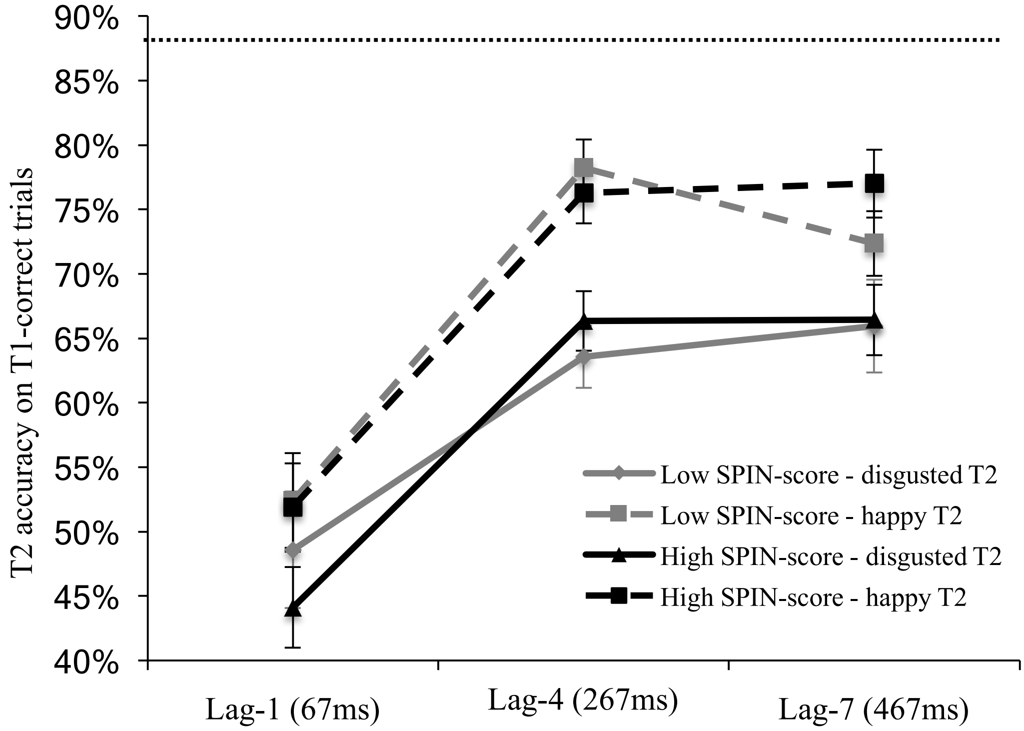

Figure 6. T2-present accuracy when T1 was correct in experiment 3, where T1 was neutral (animal) and T2-valence was manipulated (face) and present or absent for both social anxiety groups (SPIN). Participants made a judgement whether a face (T2) was present or absent, thus T2-emotion was task-irrelevant. The horizontal dotted line reflects accuracy on T2-absent trials ($M = 88.2\%$, $S.D. = 9.6$). No social anxiety-related effects were found, but accuracy on disgusted faces was poorer than when the face was happy across all participants. Error bars represent +/- 1 within-subjects standard error.

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[6] In the introduction of this experiment, it was explained that this paradigm allowed for signal detection analysis. Consequently, d' was calculated as a function of $Z_{(\text{hit rate})}$ and $Z_{(\text{false alarm rate})}$. However, there were no statistical differences between these sensitivity indexes and the reported accuracy percentage, rendering reporting signal detection statistics redundant.

Mean BFNE-S score was 23.1 (*S.D.* = 7.57). Applying the cut-off of 28 results in 19 (59.4%) participants in the low-fear of negative evaluation group and 13 (40.6%) with high-fear of negative evaluation. The findings were similar to the SPIN results[7], see Figure 7.

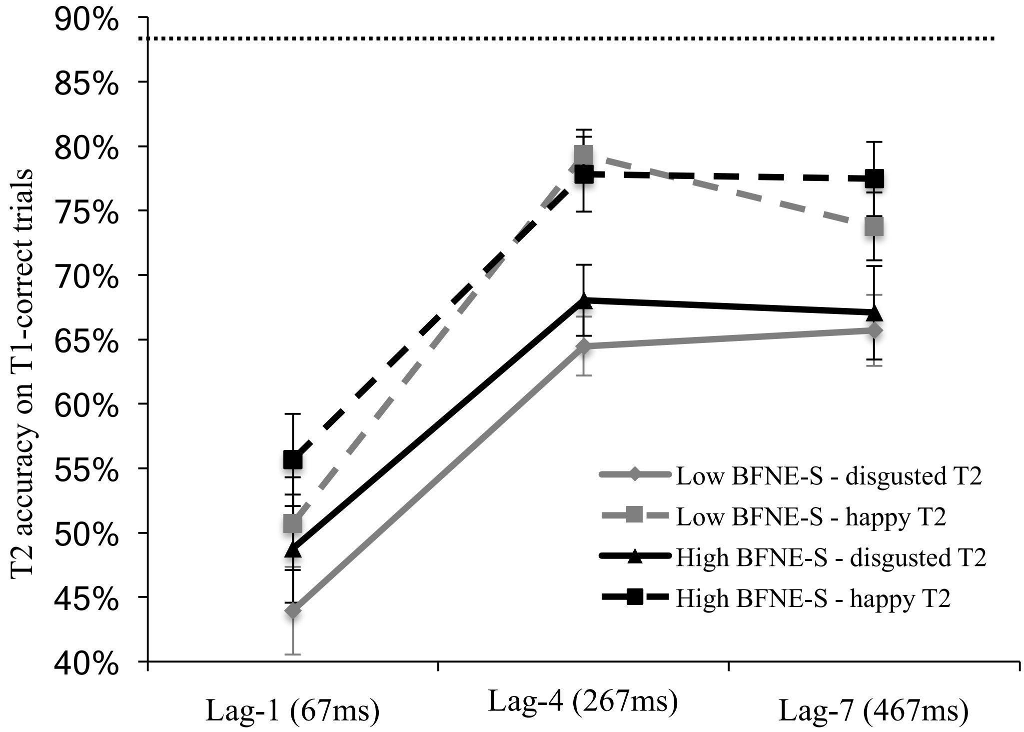

Figure 7. T2-present accuracy when T1 was correct in experiment 3, where T1 was neutral (animal) and T2-valence was manipulated (face) and present or absent for both fear of negative evaluation groups (BFNE-S). Participants made a judgement whether a face (T2) was present or absent, thus T2-emotion was task-irrelevant. The horizontal dotted line reflects accuracy on T2-absent trials (*M* = 88.2%, *S.D.* = 9.6). No fear of negative evaluation-related effects were found, but accuracy on disgusted faces was poorer than when the face was happy across all participants. Error bars represent +/- 1 within-subjects standard error.

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[7] Main effects Emotion* and Lag*, no other effects. Pairwise comparisons Emotion: detection disgusted (59.7%) < happy (69.1%)*. Lag: lag-1 (49.8%) < lag-4 (72.4%)*; lag-1 < lag-7 (71.0%)*; lag-4 ≈ lag-7 (*n.s.*). * All *p*s < .001.

2.4.4 Discussion

Firstly, If the low socially anxious group's larger amount of errors in detecting happy faces was driven by a response bias toward disgusted faces, these effects would disappear using a paradigm with implicit yes/no judgements (H1). Furthermore, it was predicted that an emotion-effect would be more apparent, given that ceiling-effects should be absent with increased task-difficulty (H2). Finally, in line with anxiety-related facilitated attention toward threat, those high in social anxiety should show a higher detection rate for disgusted T2s compared with low-socially anxious participants (H3).

Taken together, the results of experiment 3 show that there is an attentional blink for emotional faces. Furthermore, a clear emotion effect was found: across participants, faces were more often detected when they had a happy compared to a disgusted expression. As this effect is not related to lag, it cannot be concluded that either emotion "breaks through" the attentional blink more easily. Experiment 3 found no effects of social anxiety.

Finally, the task was difficult enough to solve the ceiling effect which was found in the previous experiment, where detection was nearly 100%. In this third experiment, detection rates were normally distributed. With performance lower at lag-1 (chance levels), a strong and reliable attentional blink effect was found on a paradigm employing emotional faces as targets, which forms an inviting foundation for designing future studies with similar paradigms.

2.5 General Discussion

The aim of these experiments was to examine social anxiety related facilitated attention toward threat as well as difficulty in disengagement. Experiment 1 explored whether presenting an emotional target (T1) affects the attentional blink when the second target (T2) is a non-social neutral stimulus. If social anxiety is related to difficulties in disengaging attention away from potential threat (Cisler & Koster, 2010), those participants high in social anxiety would have lower accuracy for T2 identification when T1 was a disgusted face. For experiment 2, target-order was reversed, so that T1 was neutral and T2 emotional. Specifically, it was investigated whether socially relevant information “breaks through” the attentional blink more for socially anxious individuals than for those lower in social anxiety, which would provide evidence for accounts of anxiety-related facilitated orienting toward threat. Finally, experiment 3 saw a modulation of task demands. Again, T1 was neutral and T2 emotional, but this emotional T2 was not always present in the stream. Participants did not make an emotion-decision, but were asked whether they saw a face. If anxiety is related to vigilant scanning of the environment, it should result in higher detection rates for socially anxious than for non-socially anxious participants for socially anxious participants.

Experiment 1, where T1 valence was manipulated, no social anxiety related differences in T2 performance emerged. However, in experiment 2, which used an emotional T2, happy faces did not attenuate the attentional blink for those low in social anxiety. This pattern of poor performance for happy faces in low socially anxious participants is confirmed in T1 analysis of experiment one: those low in social anxiety appear to have more difficulty identifying happy faces when they are scanning the environment for emotion judgements. On the other hand, experiment 3 showed that performance on disgusted faces was poorer than for happy faces in both groups when the presence of a face was task-relevant, but its emotional expression was not.

Whereas low-socially anxious participants were poorer at detection of happy faces in experiment one (where the face was shown at T1) and at lag-1 in experiment two (where the face was shown at T2), which employed explicit 2-alternative forced choice emotion judgements, the findings of experiment 3 were in the opposite direction, suggesting that when emotion search goals are not activated, happy faces are easier to detect than disgusted faces for all participants. This suggests that previous results were not driven by a general impairment in the detection of happy faces in participants with lower social anxiety but rather that task goals affect attention allocation to emotional expressions differentially for low and high socially anxious participants. The results suggest that when an emotion-relevant task goal is given, both happy and disgusted faces command attentional resources in high socially anxious participants. In comparison, for low socially anxious participants, when an emotion-relevant task goal is given, only disgusted faces command attentional resources.

These results do not directly provide support for the previous findings in the literature, which, nonetheless, have been inconsistent. For example, an attentional blink may not be found when targets were faces compared to pictures of objects as distractors (Landau & Bentin, 2008); or when face targets were presented among a stream of digits (Awh et al., 2004). Task-irrelevant emotional stimuli, such as scenes, found an attentional blink in a number of studies (McHugo, Olatunji, & Zald, 2013; Most, et al., 2005). However, when targets were emotional faces, the attentional blink effect across the literature is less evident. For example, an attentional blink has been found for fearful faces compared with neutral faces when participants were instructed to report the emotion (such as in experiment 1 and 2 in the current chapter); but not when they had to report the gender or when the face was to be ignored (Stein et al., 2009). The current study provides further evidence that the attentional blink depends on task characteristics modulating the attentional set of participants (Stein et al., 2009).

Besides availability of resources, perceptual salience of faces within distractors could also account for the absence of a blink for faces (Landau & Bentin, 2008). This corresponds with another study that attempted to systematically investigate the influence of target-distractor similarity in attentional blink paradigms with faces (Müsch et al., 2012). When targets could be easily discriminated from each other, as well as from distractors (by either insufficient backwards masking or target-distractor similarity), the attentional blink was minimal or absent for emotional faces. The authors suggested that target-distractor similarity is a more important consideration than attentional task demands for eliciting an attentional blink. Consequently, a task needs to be developed with certain characteristics in order to assess modulations in the attentional blink effect to be accounted for by social anxiety rather than task properties and demands.

The implicit nature of experiment 3 may also provide a further indication that emotional modulation of the attentional blink is not driven by response bias, which confirms the findings by Tibboel, Bockstaele, and Houwer (2011). It is thought that emotional processing requires only few attentional resources (Fox et al., 2005). It could be possible that emotional information from faces is processed using different channels than other information (Ahw et al., 2004), which may explain the lack of strong attentional blink effects compared to traditional studies having used, for example, digits and numbers.

Taken together, a few social anxiety related effects emerged from the current experiments. When scanning the environment for emotional information, as required in experiments 1 and 2, those high in social anxiety process this information accurately, regardless of valence. Positive information may not be salient for those low in social anxiety, explaining the difficulties in happy face-detection. When environmental scanning does not require explicit emotional vigilance, happy faces elicited preferential processing compared to threatening information, regardless of social anxiety. In conclusion, the attentional blink paradigm shows some promise for the study of temporal aspects of attentional biases in social anxiety. However, tasks with different demands and better target-distractor similarity need to be employed to utilise the attentional blink paradigm to its fullest potential as a means to disentangle biases related to facilitated attention and difficulty in attentional disengagement.

3 Temporal Attentional Biases in Child Social Anxiety: the Attentional Blink

Attentional biases are suggested to play a role in maintaining social anxiety in adults. Chapter 2 explored this using the emotional attentional blink paradigm. However, relatively little is known about the role of biases in childhood social anxiety. In the present study, 67 participants aged 10-11 years completed an attentional blink task designed to explore facilitated attention toward threatening stimuli in the temporal domain. A neutral, non-social first target (T1) was followed by a disgusted or happy face (T2) at lag-1, lag-4 or lag-7, with stimuli being presented at a rate of 67ms per image. Participants made forced choice judgements on T1 and on the emotion of the T2 face. Participants completed the social anxiety scale for children-revised (SASC-R; LaGreca & Stone, 1993). Social anxiety levels were negatively related to emotion detection, irrespective of valence and lag. This could indicate that the association between social anxiety and threat-related attentional biases may not emerge until later in life.

3.1 **Background and Rationale**

3.1.1 Attention bias in anxiety

The literature review in this thesis (chapter 1) and the attentional blink experiments (chapter 2) saw that social anxiety is believed to be maintained by attentional biases in emotional processing (e.g. Bar-Haim et al., 2007; Mathews & MacLeod, 1994). Attentional biases toward threat relate to differential allocation of attention when processing threatening stimuli compared with non-threatening stimuli (Bar Haim et al., 2007; Cisler & Koster, 2010; MacLeod, et al., 1986; Mogg & Bradley, 1998). It is thought that an attentional bias can be underpinned by various components, namely facilitated attention toward threat, difficulties disengaging attention away from threat and/or attentional avoidance of threat (see Cisler and Koster (2010) for a review). Facilitated attention toward threat involves faster orientation toward threatening stimuli. Difficulty with disengaging occurs when attention is captured by threat and switching attention to another stimulus is impaired. Finally, when both threatening and non-threatening stimuli are presented and attention is preferably allocated to the non-threat, it indicates attentional avoidance of threat. Attentional biases for threat-relevant stimuli are typically more pronounced in anxious individuals than non-anxious individuals, and are not consistently displayed by non-anxious individuals (Bar-Haim et al., 2007; Mogg & Bradley, 1998; Williams, Mathews, & MacLeod, 1996). Biases have been observed in a range of anxiety disorders (Shechner et al., 2012). In the present study the focus is on attentional bias in child social anxiety.

3.1.2 Child Social Anxiety

Difficulties with social anxiety often originate in childhood (e.g. Gamble and Rapee, 2009; Puliafico & Kendall, 2006) and it is believed that between 2.5% and 15% of children and adolescents suffer from an anxiety disorder (Rapee, Schniering & Hudson, 2009). However, there is a lack of research examining attentional biases in childhood social anxiety (Seefeldt, Krämer, Tuschen-Caffier & Heinrichs, 2014). In contrast, a number of studies examined attentional biases in adult social anxiety. Overall, the findings have been somewhat mixed. For example, in one study employing a visual search paradigm, high socially anxious adults showed a bias toward threat when angry faces were presented, compared with neutral or happy faces (Esteves, 1999). Using a dot-probe task, Sposari and Rapee (2007) found that those high in social anxiety attended to emotional faces over household items, regardless of the valence of the face suggesting a more general bias toward social stimuli. This study was a replication of a study by Mansell, Clark, Ehlers and Chen (1999), who reported contradictory findings; in their dot-probe tasks (also with emotional faces and household items) participants with social anxiety were faster to respond to targets that were not on the location of the face, regardless of valence, indicating avoidance of potential threat from social stimuli. In sum, many questions about the nature of attentional bias toward emotional faces in social anxiety remain (Yiend, 2010).

As previously indicated, only a few studies have investigated attentional biases in child social anxiety. One example is an eyetracking study which found social anxiety related hypervigilance toward angry faces in a free viewing task when angry-neutral stimulus pairs were presented, but only if social fears were induced prior with a stressor task (Seefeldt et al., 2014). Regarding other types of childhood anxiety, studies have demonstrated that children who are high in anxiety more generally, display preferential processing of threatening stimuli, such as angry faces (Bar-Haim et al., 2007; Waters, Henry, Mogg, Bradley, & Pine, 2010). For example, research using the dot-probe task has shown that anxious children and adolescents display threat biases toward angry faces compared with neutral faces (Shechner et al., 2012; Waters et al., 2010). Furthermore, there is some evidence that children with higher levels of anxiety have faster reaction times for angry faces in visual search tasks (Hadwin et al, 2003). A recent meta-analysis on attention bias in child anxiety confirms that anxious children show a greater bias toward threat than non-anxious children; however, differences between anxious and control participants appear to increase with age (Dudeney et al., 2015). Taken together, these studies suggest that child social anxiety is related to preferential processing of angry faces in the spatial domain.

Dot-probe tasks and visual search paradigms are informative in regards with attentional biases in spatial visual processing. However, they tell us little about attentional biases in the temporal domain. Therefore, exploring these components under conditions of temporal, serial processing, could provide new insights into anxiety-related attention. Toward this objective, the present study employs an emotional adaptation of the attentional blink paradigm to examine whether children who are high in social anxiety show facilitated orientation toward perceived threat compared with children low in social anxiety, or whether they display attentional avoidance of threatening stimuli.

To provide a brief review of the attentional blink paradigm, as discussed in chapters 1 and 2: detecting a first (T1) target leads to an impairment of detecting the second (T2) target when it is presented briefly after T1 (Ciesielski et al.,, 2010; Raymond et al., 1992). However, emotional faces as T2 reduce this impairment relative to neutral faces (De Jong et al, 2009; Maratos et al., 2008), which indicates facilitated processing of emotional faces. Examining how this impairment in detecting an emotional T2 is affected by social anxiety would be in keeping with the facilitated attention to threat component of attention bias (Cisler & Koster, 2010).

To date, limited research has examined the association between social anxiety and attentional bias using face stimuli with children and to our knowledge, no studies have used the attentional blink paradigm. The attentional blink has however been used with children in other areas of research such as reading research. In these tasks letters, words, or geometrical shapes were used (e.g. Bar-Haim et al., 2007; McLean, Castles, Coltheart, & Stuart, 2010; Mclean, Stuart, Visser, & Castles, 2009). One exception is a paper by Yerys et al. (2013), which used an attentional blink paradigm with angry and neutral faces to investigate attentional differences between children with Autism Spectrum Disorders and typically developing children. Overall, an attentional blink was found where angry T2 faces were detected more accurately than neutral faces. However, no group differences were found, which led the researchers to conclude that early visual attention to emotional facial expressions was preserved in children with ASD. It is suggested that children and adolescents who are high on the autism spectrum often have higher levels of social anxiety (Kuusikko et al., 2008) but this was not examined by Yerys and colleagues. Therefore there appears to be a gap in the literature regarding the attentional blink for emotional faces in child social anxiety.

3.1.3 The current experiment

This chapter aims to investigate whether children with higher social anxiety display attentional biases toward emotional stimuli when attentional capacities are limited relative to children with lower social anxiety, and in doing so, to explore whether the attentional blink task could prove a useful paradigm for examining attentional biases in child anxiety. An attentional blink task with neutral T1 and emotional T2 is used, with the emotional T2 being disgusted or happy faces. Expressions of happiness are emotionally relevant, but not threatening. In contrast, disgust relates to interpersonal conflict and/or disapproval (Phillipott et al., 1999) and may reflect a negative social judgement (Rossignol, Anselme, Vermeulen, Philippot, & Campanella, 2007). This emotional expression may be particularly relevant for individuals high in social anxiety, a characteristic of which is a fear is of being negatively evaluated by others (Bögels & Mansell, 2004; Clark & Wells, 1995; Rapee & Heimberg, 1997). In line with the literature that suggests that anxiety is related to threat related attention bias, the following is hypothesised. In dual-target trials, when available attentional resources for T2 are competing with the processing of a neutral T1, socially anxious children have a higher accuracy for disgusted compared with happy T2s compared with non-socially anxious children. This would indicate anxiety-related facilitated attention toward threat. However, when attentional resources are more available to process an emotional face, in single-target trials, there will be no anxiety related differences in accuracy for disgusted and for happy faces. Due to the exploratory nature of the present study, an additional research question is whether the emotional attentional blink has the potential to be a suitable method for investigating attention bias in child social anxiety.

3.2 **Method**

3.2.1 Participants

Participants were 67 children (34 female) in year-6 of a local primary school (Age: *M* = 11.4 years, *S.D.* = 0.50). Parental opt-out consent was sought as well as child verbal assent. Participation was voluntary and children were free to withdraw at any time. Ethical approval was granted by the Research Ethics Committee at the University of East-Anglia. In coordination with the relevant class teachers, it was ensured that none of the participants had any learning disabilities or developmental disorders, such as autism.

3.2.2 Stimuli and apparatus

Twelve emotional images from the Radboud Faces Database's children subset (RaFD; Langner et al., 2010) were used in the attentional blink task: a happy and a disgusted expression for each of six child actors (three female, three male). Distractor stimuli consisted of nine different child actors from the same dataset, with neutral expressions. The face areas of these images were scrambled. For the non-social, neutral targets, the same animal images from chapter 2 were used.

All images were grayscale and were edited in Adobe Photoshop CS4. Faces were matched on size and position, by positioning the center of the pupils on the same coordinates. Overall grayness value was equalized between images.

The experiment was programmed and presented using the PsychoPhysics Toolbox-3 (Brainard, 1997) in Matlab 2013a. The task was presented on a 13" MacBook (OS X 10.8). Responses were collected using a USB mouse.

Social anxiety symptoms were assessed using the Social Anxiety Scale for Children - Revised (SASC-r; La Greca & Stone, 1993; see Appendix C). This questionnaire asks children to agree or disagree with 22 items by circling the respective number (1 = not at all to 5 = all of the time; example item: "I'm afraid that other kids will not like me"). Higher total scores reflect higher social anxiety, whilst subscales provide scores of Fear of Negative Evaluation From Peers (FNE), Social Avoidance and Distress Specific to New Situations (SAD-New), and Generalized Social Avoidance and Distress (SAD-G). Internal consistency for this measure in the present sample was $\alpha = .88$.

3.2.3 Design

The presentation parameters of the Attentional Blink task, such as number and order of stimuli and blocks was identical to the studies in chapter 2. However, the two-alternative forced choice response, asked the participant whether the animal was looking left or right with symbols rather than words ("<--" or "-->"). Furthermore, this child version consisted of 4 blocks of 36 trials instead of 72.

3.2.4 Procedure

Children were tested individually in a private room and sat approximately 60 centimeters from the screen. The task was explained in the following manner. Children were told that they would play a game on the computer and that they would see pictures flash up quickly on the screen. Their job was to look for animals and faces, which would be hidden between the other pictures. They were told that they would go through some questions too after the game. Next, the single-target task was explained in more detail. Children were told that there would be jumbled-up faces, but also a normal one, and they had to think about whether the normal face was feeling happy or discussed. They were then asked whether they could show the experimenter a happy face, and a disgusted face. Next, they were shown an example of each emotion and were asked to guess whether the example was looking happy or disgusted, after which they practiced four practice single-target trials with the same example face, which was a different stimulus than in the experimental trials.

The dual-target task was explained next. Children were told that besides the face, they would also look for an animal and had to remember whether it was looking left or right. They then looked at an example that was not used in the experiment and practiced four dual-target trials with the examples. After practicing both tasks, they were shown all six animals that would appear in the task and were asked to name them. They were told that there would be four blocks of about four minutes each and that they could take breaks between blocks if they liked.

After these task instructions and practice trials, the attentional blink task was completed. In total, the attentional blink task took approximately 15 minutes. After completing the attentional blink task, children completed the questionnaire before being debriefed.

3.2.5 Analysis

Accuracy scores for target detection in single-target trials were collected, as were correct T1 and T2 judgments in the dual-target trials. For dual-target trials, the dependent variable T2-detection was analysed if T1 was correct. This data was found to be considerably negatively skewed due to a ceiling-effect in task performance: even with images presented at a rate of 67ms per stimuli, children were remarkably accurate in their judgments. Therefore only participants who displayed a performance of less than 100% on lag-1 detection were selected for further analysis (N = 39) and included in the results that follow. The included sample did not differ on age, gender, and social anxiety from participants that were excluded. To analyse this data, first, the single-target task was analysed to examine whether social anxiety affected basic emotion recognition on an RSVP task. Second, a 2 (emotion; happy, disgusted) × 3 (lag; lag-1, lag-4, lag-7) GLM was carried out without social anxiety included to clarify whether an attentional blink effect was present. Finally, an identical GLM was conducted including total scores on the SASC-R as a covariate. As there are no known clinical cut-off scores for the SASC-R, as opposed to the questionnaires used in chapter 2, maintaining the continuous nature of the scores was preferred to a median split. Follow-up GLM analyses were also conducted using SASC-R subscales. Descriptive statistics are shown in Table 1.

3.3 **Results**

Mean score on the SASC-R was 39.6, *S.D.* = 14.7. Tests of normality revealed that these scores were not normally distributed (Kolmogorov-Smirnov $p = .003$; Shapiro-Wilk $p < .001$), but positively skewed.

Where the data failed to meet assumptions of sphericity, Greenhouse-Geisser corrected values are reported with the original degrees of freedom to favour legibility.

In the single target task, social anxiety did not affect performance on emotion identification; $F(1, 36) = 1.25$, $p = .276$, $\eta_p^2 = .033$. There was no main effect of emotion; $F(1, 36) = 0.24$, $p = .624$, $\eta_p^2 = .007$. Neither was an emotion × social anxiety interaction found; $F(1, 36) = 0.04$, $p = .841$, $\eta_p^2 = .001$.

In dual-target trials, mean T1 (animal) identification was 78.0% (*S.D.* = 14.5). Without social anxiety as a covariate, examining T2 (emotion) identification on correct-T1 trials indicated that there was an attentional blink effect (main effect for lag; $F(2, 76) = 6.65$, $p = .004$, $\eta_p^2 = .149$). Pairwise comparisons showed that T2 accuracy at lag-1 ($M = 75.4\%$, $SE = 2.1$) was less accurate than at lag-4 ($M = 81.8$, $SE = 2.3$) and at lag-7 ($M = 82.2$, $SE = 2.7$); $p = .001$ and $p = .013$ respectively. No significant differences were found between lag-4 and lag-7. Neither a main effect of emotion or an emotion × lag interaction effect was found.

When including SASC-R total scores as a covariate in the above analysis, a main effect of social anxiety was found; $F(1, 37) = 4.28$, $p = .046$, $\eta_p^2 = .104$; higher total scores on the SASC-R were related to poorer emotion-identification performance. There were no main effects for either emotion or lag and no two-way interactions for social anxiety × emotion and social anxiety × lag; ps > .249, η_p^2s < .037

Table 1.

Correct T2-emotion detection (%) without social anxiety as a covariate.

	Mean (S.E.) [95% C.I.]			
	Single-target trials	Lag-1 (67ms)	Lag-4 (268ms)	Lag-7 (469ms)
Happy	92.6 (1.5)	76.7 (2.2)	83.7 (2.3)	82.2 (3.0)
	[89.6 – 95.7]	[72.2 – 81.2]	[79.0 – 88.3]	[76.2 – 88.2]
Disgusted	90.0 (2.3)	74.1 (2.4)	79.9 (2.8)	82.2 (3.2)
	[85.3 – 94.6]	[69.2 – 79.0]	[74.2 – 85.7]	[75.7 – 88.7]

Table 1 and Figure 8 illustrate the lack of interaction effects when social anxiety was included as a covariate. In other words, when adjusted for social anxiety, T2 performance was similar across all three lags, indicating the absence of an emotional attentional blink. To illustrate this pattern in Figure 8, SASC-r scores were binned into a low-social anxiety group (*Z-score* $< -.80$; $N = 8$) and a high-social anxiety group (*Z-score* $> .80$; $N = 6$). For Figure 8, a 2 (Social anxiety; low, high) × 2 (emotion; happy, disgusted) × 3 (lag; lag-1, lag-4, lag-7) ANOVA was carried out. Due to the low number of participants in each group, this ANOVA yielded no significant results, including a main effect for social anxiety; $F(1, 12) = 2.12$, $p = .17$, $\eta_p^2 = .150$. The effect size indicates that there is not enough power due to the low number of participants (observed power = .27).

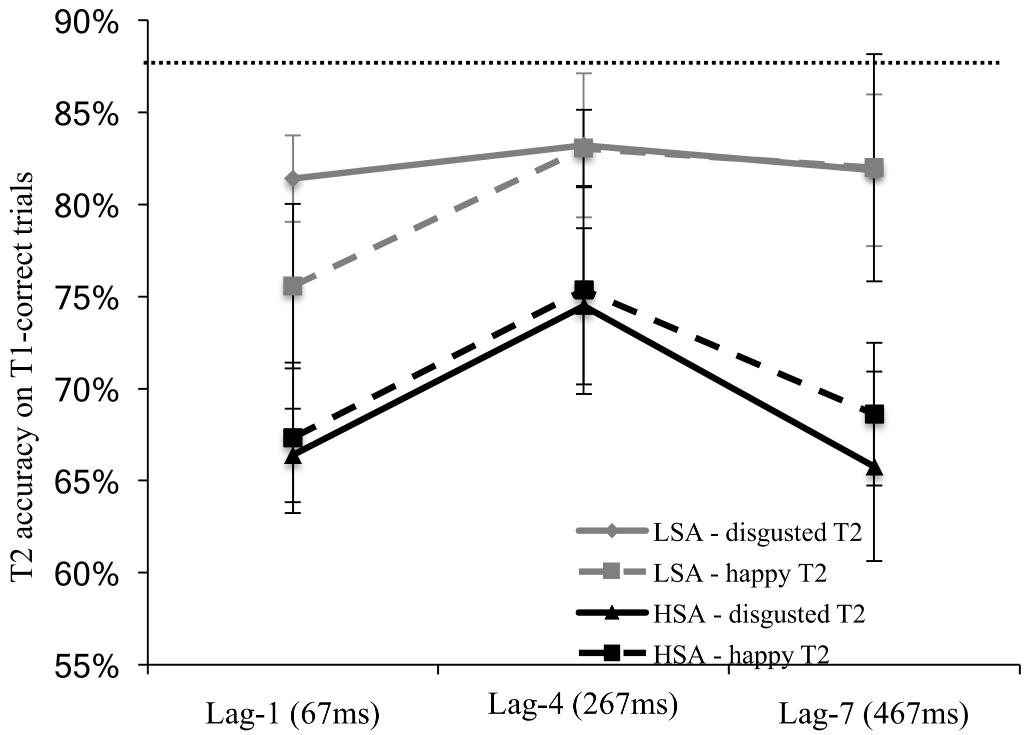

Figure 8. Performance on each T2-emotion across lags. Normalised SASC-R scores were binned into low social anxiety (LSA; < -.80 SD from the mean) and high social anxiety (HSA; > .80 SD from the mean) groups. The horizontal dotted line reflects accuracy on single-target trials in this sample (M = 87.9%, S.D. = 16.3). Emotion recognition was poorer in de HSA group relative to the LSA group, regardless of valence. Error bars represent +/- 1 within-subjects standard error.

3.4 **Discussion**

This study aimed to explore attentional biases in child social anxiety and consider the utility of the attentional blink paradigm for this purpose. It was hypothesised that those children with higher social anxiety would show biases toward threatening stimuli relative to children lower on this trait. An additional aim was to explore whether these biases manifest as avoidance of threat or facilitated orientation toward threat when attentional capacity is limited. It was found that participants with higher social anxiety scores more frequently failed to identify disgusted as well as happy faces when processing a neutral T1 target compared with those lower in social anxiety. These results do not therefore support the hypothesised attentional bias for negative emotions in child social anxiety.

This main effect for social anxiety was particularly pronounced in the Fear of Negative Evaluation subscale, followed by a marginally significant main effect for Generalised Avoidance and Distress subscale. Interestingly these main effects were not echoed for the subscale measuring Social Avoidance and Distress Specific to New Situations.

On the single target trials, no effect of social anxiety on emotion identification was found. This indicates that social anxiety symptoms in children were not linked to poor emotion identification per se. Rather, the results suggest that higher social anxiety may be linked to difficulties in emotional processing when attentional capacity is limited. Potentially such difficulties may increase or maintain social anxiety: socially anxious children have been found to be poorer at emotion recognition than non-socially anxious controls (Simonian, Beidel, Turner, Berkes, & Long, 2001). Therefore emotion recognition requires more attentional resources, which may lead them to avoid processing faces. If socially anxious children then 'learn' to process emotions differently, it would be in line with the finding that anxiety-related biases are more pronounced with age (Dudeney et al., 2015). To tease apart some of these explanations, in future studies, a present/absent condition analogous to experiment 3 of chapter 2 would permit investigation into whether children do not see the face at all in dual-target trials, or whether they cannot process the emotion as suggested.

Another potential explanation for poorer performance of those children with higher social anxiety in the dual-target, but not in the single-target task, lies in processing efficiency theory (Eysenck & Calvo, 1992). This theory proposes that anxiety disrupts two executive functions of attentional control: inhibition of automatic responses and the ability to shift attention between tasks (Eysenck, Derakshan, Santos, & Calvo, 2007), resulting in impaired attention on complex and attentionally demanding tasks relative to simpler tasks (Derakshan & Eysenck, 2009). Following on from processing efficiency theory, Derakshan and Eysenck's (2009) attentional control theory predicts that anxiety affects performance via its disadvantageous effects on attentional control. In line with this, it could be reasoned that the nature of the testing situation in the current experiment elevated participants' state anxiety and therefore reduced their processing efficiency/attentional control. It is reasonable to expect that the testing situation may have a more pronounced effect on state anxiety, and in turn processing efficiency/attentional control, for participants with high social anxiety. As the present study did not include a control T2 task that was not emotional, it is not possible to evaluate this possibility with the current data. However, one recent paper found that individuals with social anxiety disorder and current comorbid depression showed poorer performance on T2 number targets in a stream of letters compared with healthy controls (Morrison et al, 2016), which is consistent with this explanation of the present findings.

Whereas the Attentional Blink is robust for targets such as letters and symbols (Raymond et al., 1992), tasks with faces have yielded mixed results (Eagles & Murphy, 2016). For example, Awh et al. (2004) found no attentional blink when T1 was a letter and T2 was a neutral face. With regard to emotional faces, these appear to have a lower detection threshold at T2 than neutral faces (de Jong et al, 2009; Maratos et al., 2008), which would indicate facilitated processing of emotional facial expressions. In the present study there was some evidence of an attentional blink in preliminary analyses that did not include social anxiety as a covariate. This was not robust however, with the effect of lag no longer significant once social anxiety was included as a covariate. These results are in line with evidence that salient emotional information is accessible even when limited attentional resources are available (De Martino, Kalisch, Rees, & Dolan, 2009).

There are some reasons to be cautious when interpreting the present results. Most notably, there was a ceiling effect in performance with 40% of participants achieving 100% in T2 at lag 1. Thus, the current design may not be very sensitive for assessing individual differences. A more difficult task could be implemented in order to achieve a more typical performance distribution. For example, a briefer target presentation followed by a backward mask could potentially decrease mean accuracy. Another possibility is varying the task-demands. In the current experiment, participants knew when they were doing a block of dual-target trials and when they were doing only single-target trials. Perhaps this allowed them to tune in their attentional set toward task characteristics. Trial types could be randomised across trials. Instead of trial-type information offered before each trial, task demands would only become clear during each trial, or potentially after, when the participants see the question(s) they are asked. Nevertheless, this study provides new insights into potential deficiencies in emotional attention in child social anxiety and provides a useful foundation for future work using the attentional blink task to examine attentional biases in childhood anxiety.

In conclusion, the current findings suggest that those children higher in social anxiety show poorer emotion recognition than those with lower social anxiety when attentional capacity is limited. However, it is recommended that the attentional blink task design is refined before further use, perhaps in clinical samples is considered.

4 Fast eye-movements move toward emotional faces whereas slow ones deviate away: an eye-tracking study

Emotional faces convey social information, and their processing may occur without top-down attention. Saccade trajectories of eye movements are thought to be driven by stimulus properties as well as goal-directed control, which explains deviations toward versus deviations away from distractors in the visual field. In this study participants' eye movements were recorded whilst faces were presented as task-irrelevant distractors. It was found that, for fast saccades, saccade trajectory curved towards emotional faces relative to neutral faces. However, slow saccades deviated away from these, likely driven by top-down control. Furthermore, effects of social anxiety were explored. The results indicated that those higher in social anxiety, may initiate their saccades towards emotional faces, regardless of response time. These findings demonstrate that attention is captured by social information, and support the hypervigilance/avoidance accounts of attentional biases in social anxiety.

4.1 Background and rationale

4.1.1 Eye-tracking and emotional attention

As outlined in the previous chapters, some behavioural studies suggested that emotional information affects attentional processing. Evidence for this comes, for example, from visual search tasks, in which participants were more efficient at searching for emotional than neutral stimuli (Eastwood, Smilek, & Merikle, 2003; Öhman, Lundqvist, & Esteves, 2001). It is thought that the prioritised perception of emotional stimuli occurs through a fast-acting subcortical pathway (LeDoux, 2000). Given that that the superior colliculus and the pulvinar within this pathway are involved in saccadic motor generation, thus underlining the role of these visuomotor regions on emotional processing (West, Al-Aidroos, Susskind, & Pratt, 2011), eye-tracking may provide novel insights into emotion processing and attention.

4.1.2 Saccade curvature; studies and theories

When people redirect their eyes from one location to another, these saccades are rarely in a straight line (Viviani, Berthos, & Tracey, 1977; Yarbus, 1967). This saccadic curvature is a sensitive measure of the influence of distractors on attention (Ludwig & Gilchrist, 2002) and can either be directed away or toward elements in the visual field. In a typical saccadic curvature task, emotional images are used as task-irrelevant distractors. This method can therefore be used to ascertain whether emotional stimuli are a*utomatically* prioritised in visual selection (Schmidt, et al., 2012). Belopolsky and Theeuwes (2009) suggested that the mechanisms responsible for covert attention are the same mechanisms responsible for saccade generation. Furthermore, it is argued that deviations *toward* stem from competition between elements in the oculomotor system, whereas deviations away are associated with top-down control (Van der Stigchel, Meeter, & Theeuwes, 2006). In other words, saccade trajectories are thought to be affected by both stimulus-driven features and goal-directed control (Van Zoest & Donk, 2006). Related to this are findings that saccades deviate away more strongly from stimuli if they are more salient (Belopolsky & Theeuwes, 2009; Doyle & Walker, 2001; Godijn & Theeuwes, 2002; Ludwig & Gilchrist, 2003).

A few studies have examined the effect of affective stimuli on saccade deviation to indicate the salient nature of emotional information, but their findings have been mixed. Some studies have used paradigms where only one distractor was present. In one study it was found that saccade trajectories deviated away from angry faces (Petrova & Wentura, 2012). In line with this, when emotional faces were paired with objects it was found that eyes curved more away from angry faces than from happy or neutral faces (Schmidt et al., 2012). Socially relevant distractors resulted in greater deviations away from these distractors, with no difference between upright or inverted faces (Laidlaw, Badiudeen, Zhu, & Kingstone, 2015) and saccade trajectory was no more affected by participants' own faces than those of unfamiliar strangers (Qian, Gao, & Wang, 2015). On the other hand, a study that presented a negative and positive scene simultaneously as distractor items, found that saccade endpoints were pulled toward distractors comprised of negative scenes (McSorley & Van Reekum, 2013).

4.1.3 Influence of saccade latencies.

Much eye movement research with emotional stimuli has investigated effects of task-driven stimulus onset asynchrony (SOA) and has indicated that the timing of saccade onset may be important. For example, saccades were found to be directed toward salient distractors when the saccade onset latency was short, whereas more slowly initiated saccades deviate away from salient distractors (Van Zoest & Donk, 2006). Similarly, exploratory findings from McSorley and Van Reekum (2013) suggested that early saccades result in more deviation toward images depicting unpleasant scenes than later saccades. These timing-associated differences in findings may reflect the relative influence of stimulus-driven properties and top down control, with the latter having less influence on early saccades.

4.1.4 Social anxiety and saccadic curvature

To summarise the previous chapters: anxiety is thought to be related to cognitive biases for threatening stimuli, including an attentional bias (e.g. see Bar-Haim et al., 2007). As discussed, three underlying mechanisms of these attentional biases have been identified; facilitated attention toward threat, delayed disengagement from threat, and attentional avoidance (Cisler & Koster, 2010). More specifically, the hypervigilance-avoidance account of anxiety suggests that those with higher anxiety levels are initially hyper-vigilant toward threat, followed by attentional avoidance (e.g. Mogg et al., 1997; 2004). Eyetracking studies of visual attention are ideal for studying the time-course and mechanisms underpinning these cognitive biases. For example, support for the hypervigilance-avoidance hypothesis in social anxiety comes from a free-viewing paradigm, during which participants with more fear of negative evaluation initially looked more at emotional faces, followed by avoidance of these faces (Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009). In their meta-analytic review of eye-tracking in affective disorders, Armstrong and Olatunji (2012) found support for the vigilance hypothesis of anxiety; anxious individuals demonstrated facilitated orienting towards threat in free viewing tasks and facilitated detection of threat during visual search tasks. Furthermore, it has been shown that low-anxious individuals showed slower saccade onsets in response to positive stimuli relative to high-anxious individuals, which indicates that anxiety could also be associated with facilitated processing of positive information (Chen, Clarke, Watson, MacLeod, & Guastella, 2014).

4.1.5 Research questions and hypotheses

In the study presented within this chapter, the role of emotional faces and social anxiety on saccade trajectory is investigated. The hypervigilance-avoidance hypothesis of attentional biases in social anxiety is explored, by classifying each participant's saccades into two SOA-bins: fast saccades, defined by saccades with onsets below each participant's median, versus slow saccades, those above their median. Participants made eye movements from cues to targets which consisted of typographic characters, whilst emotional and neutral faces were presented as peripheral distractors. It is predicted that individual fast eye movements deviate toward the emotional faces (relative to neutral faces) faces, whereas slower saccades deviate away. Furthermore, effects of social anxiety on saccade trajectory are explored, in order to contribute to theoretical models of hypervigilance and avoidance in the social anxiety literature: the results for high-socially anxious participants compared to participants who are low in social anxiety will show a general tendency of saccades to deviate toward emotional stimuli as a marker of hypervigilance or away from emotional stimuli as a marker of avoidance, regardless of onset-latency.

4.2 **Method**

4.2.1 Participants

37 undergraduate students took part in exchange for course credit, of which 6 failed to reach the criterion of minimum 70% of correctly tracked trials; $N = 31$ (5 males), Mean age = 20.0 years, *S. D.* = 1.21. Participants reported normal or corrected-to-normal vision.

4.2.2 Materials

Stimulus presentation was controlled by a desktop computer with a 46cm screen (1024 x 768 pixels). Eye position was recorded with a desktop mount Eyelink 1000 eye-tracker (SR Research, Ontario, Canada); using a spatial resolution of 0.1° and sampling rate of 1000 Hz. Recordings were made tracking the right eye.

The Social Phobia Inventory (SPIN; Conner et al., 2000) was used to measure social anxiety. The SPIN is a 17-item, self-rated questionnaire assessing the spectrum of fear, avoidance and psychological symptoms that are associated with social anxiety, providing a good internal consistency (see Appendix A). In addition, participants completed the Brief Fear of Negative Evaluation-Straightforwardly Worded (BFNE-S; Collins et al., 2005; Rodebaugh et al., 2011; see Appendix B). However only 5 out of 31 participants scored above the suggested cut-off of 28 points. Consequently, this questionnaire was not used in the subsequent analyses. In this sample, there was a large, positive correlation between SPIN and BFNE-S; $r = .50$, $p = .005$.

4.2.3 Stimuli

Two female and two male identities with neutral, angry, disgusted and happy expressions were selected from the NimStim dataset (Tottenham et al., 2009). Greyscale images were resized to 180w x 240h pixels and luminosity was equalised between all images.

4.2.4 Procedure

The experimental session took place in a well-lit room. Participants were positioned comfortably in a chin-rest, approximately 70 cm away from the screen. Each trial started with a 1500 ms blank screen, followed by a white fixation cross at the bottom of the screen (Courier New "+", 36pt, centre at 653 y-px) for a random duration between 800 and 1200 ms, of which the last 100 ms was gaze contingent. The fixation cross would then change into a cue; either an upward arrow (Wingdings3 "h", 36pt), or a red cross (Webdings "r", 36pt). Simultaneously, two faces appeared to the left (centre at 287 x-pixels) or the right (centre at 737 x-pixels) of the screen, as well as a white target cross at the top of the screen (Courier New "+", 36pt, centre at 115 y-pixels). One of the faces was always neutral, whereas the other had a neutral, angry, happy, or disgusted expression. Participants were instructed to fixate on the lower cross, and then respond to the cue. For go-trials, the cross would turn into an arrow, upon which the participants had to fixate as quickly as they could on the target at the top of the screen, which would turn green upon successful fixation. No go-trials were included, to avoid automaticity of responses. On these no-go trials, the bottom cross would turn into a red X. In this case, participants had to stay fixated on this position, or look back there as quickly as they could. Upon successful fixation, this cross turned green. See Figure 9 for a trial example. After instructions, participants did a practice session consisting of six trials in fixed order, with unique, neutral faces appearing on the screen. The experiment was divided into four blocks with a self-paced break between them. A standard 9-point calibration took place before the practice session, prior to each block, or after time-outs in gaze contingency. After the eye-tracking session, participants then filled out the questionnaires on the screen[8]. The whole session took approximately 45 minutes.

fixation (700 - 1100 ms + 100 ms gaze contingent) → Cue + target + distractors appear

Figure 9. Typical go-trial in the saccade curvature task with an angry face opposing a neutral face. The target turned green upon successful fixation, after which the next trial commenced. In no-go trials, a red X appeared instead of the arrow, which turned green upon successful fixation.

4.2.5 Analysis

Only Go-trials were included in the analysis. Saccades that happened around eye-blinks were removed. Saccades with latencies faster than 100ms from cue-onset were classified as anticipatory saccades and rejected. Furthermore, saccades larger than 2.5 standard deviations from individual means were defined as slow outliers and removed from the data. In order to exclude micro-saccades, undershoots and overshoots, valid saccades were those that started from within 2.5° from the centre of the cue and landed within 2.5° from the target's centre. For each participant, median

[8] Participants also completed the Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). This was not analysed in this chapter to keep within the theoretical scope of the thesis.

latency was then calculated as the interval between cue presentation and saccade onset, to allow classification of fast and slow saccades into two individual latency bins. Mean fast latency was 216 ms (*S.D.* = 27.5), mean slow latency was 305 ms (*S.D.* = 49.8).

The following measures of saccade trajectory were used: saccade angle, maximum deviation, curve area, and the quadratic coefficient of the curve. The saccade angle is defined as the angle in degrees from the start point of the saccade to its endpoint, with 0° being vertically upwards, providing an indication of relative saccade endpoint. Maximum deviation refers to the maximum distance of the saccade signature from a straight line drawn between the start point and the endpoint of the saccade (Smit & Van Gisbergen, 1990), with curve area being measured as the surface between these two lines (Ludwig & Gilchrist, 2002). Quadratic coefficient is based on a quadratic polynomial curve fitting approach, which is less susceptible to noise, such as double-curved saccades (Ludwig & Gilchrist, 2002). In the reported results, negative values on these measures indicate movement toward the emotional distractor and positive values represent movement away from it. Trials in which two neutral faces were presented were used as baseline. Mean values on these trials were subtracted from means on each type of emotion.

To investigate if the results replicated findings in the literature, the data were subjected to individual Latency × Emotion ANOVAs for each measure; angle, maximum deviation, and quadratic coefficient. In addition, the influence of social anxiety levels of participants on emotional saccades was explored. In the current sample, mean SPIN-score = 19.1 (*S.D.* = 11.0). A suggested clinical cut-off score of 19 (Connor et al., 2000) was used to group participants into Low-Socially Anxious (<19, $N = 19$) and High-Socially Anxious (≥ 19, $N = 12$) categories. These data were explored with Social Anxiety × Latency × Emotion ANOVAs for each measures of saccade deviation.

In order to investigate hyper-vigilance toward emotion in social anxiety, it was deemed interesting to explore the initial average saccade direction as well. Initial average deviation is derived from the deviation of each sample point in the first 10 milliseconds of the saccade (Sheliga, Riggio, Craighero, & Rizzolatti, 1995; Sheliga, Riggio, & Rizzolatti, 1995). The initial saccades data were subjected to a Social Anxiety × Latency × Emotion ANOVA.

4.3 **Results**

The Latency × Emotion ANOVAs yielded no significant main effects or interactions for angle. However, maximum deviation, curve area and quadratic coefficients all yielded significant main effects for latency (Figure 10a-d). Fast-onset saccades were made towards emotional faces, whereas the trajectory of slow-onset saccades curved away, see Table 2 for each measure individually. No valence effects (emotion main effects; ps ≥ .44; effect sizes: $.005 \leq \eta_p^2 \leq .027$) or interactions between latency and emotion (ps ≥ .80; $.003 \leq \eta_p^2 \leq .008$) were found.

Table 2

Latency main effects for each measure of saccade trajectory

Measure	Mean Difference (slow-fast)	$F(1, 30)$	p	Effect size (η_p^2)	95% Confidence intervals of difference
Angle	-0.102	0.33	.573	.011	[-0.47 – 0.26]
Maximum deviation	1.275	9.25	.005	.236	[0.41 – 2.12]
Curve area	403.5	10.1	.003	.251	[114 – 663]
Quadratic coefficient	2.185	6.73	.015	.183	[1.04 – 8.74]

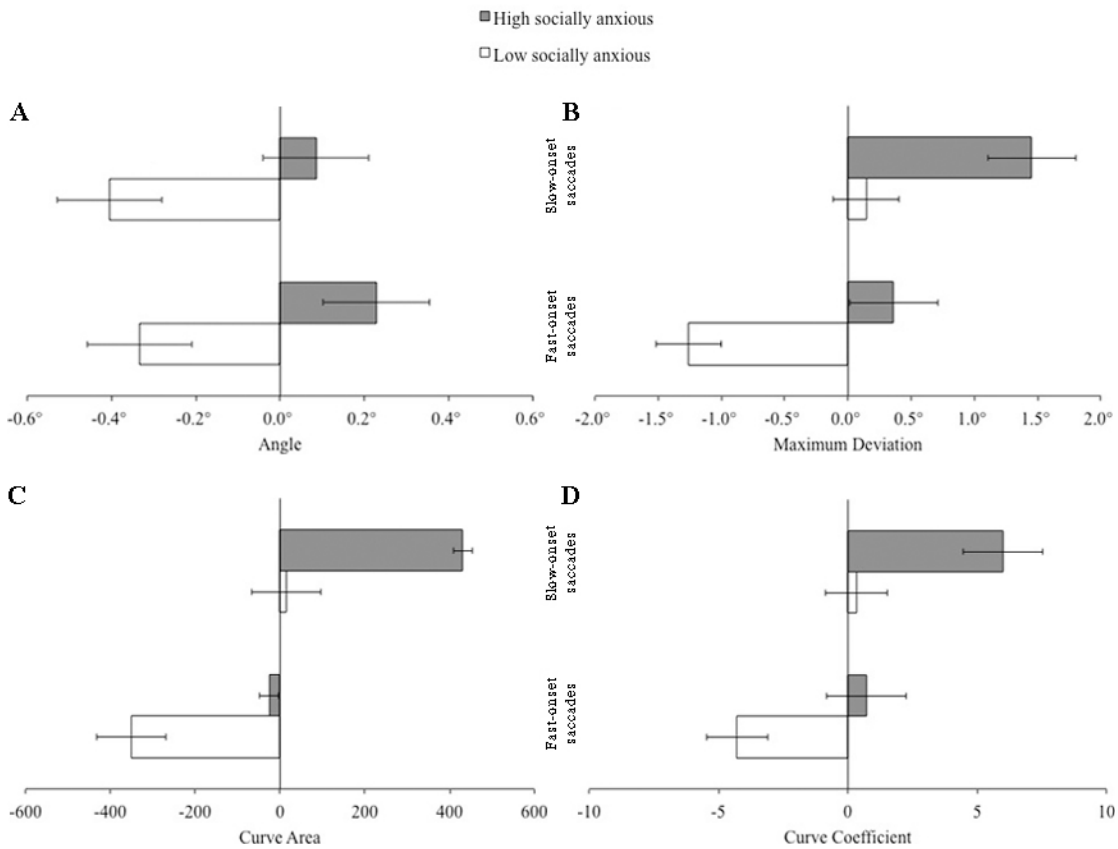

Figure 10. Mean saccadic metrics on fast-onset saccades (bottom pairs of bars) and slow-onset saccades (top pairs of bars) relative to emotional faces. No valence effects were found, thus the results are collapsed across angry, disgusted and happy. Negative values indicate eye-movements toward the emotion, positive values away. A: Angle, B: maximum deviation, C: curve area, and D: quadratic coefficient. All metrics except angle yielded main effects for latency. Error bars represent +/- 1 within-subjects standard error.

Next, effects of social anxiety were explored using Social Anxiety × Latency × Emotion ANOVAs for each measure of saccade deviation. For saccade angle, no main effect of Social Anxiety was found; $F(1, 29) = 2.75$; $p = .11$, $\eta_p^2 = .087$. There was a Social Anxiety × Latency × Emotion interaction-effect; $F(2, 58) = 4.97$, $p = .01$, $\eta_p^2 = .146$. Independent t-tests for each emotion (angry, disgusted, happy) on each onset-latency (fast-onset, slow-onset) indicated that this interaction was driven by fast saccade behaviour on angry faces; $t(29) = -2.62$, $p = .028$; corrected for multiple comparisons (all other *p*s ≥ .14). When participants low in social anxiety had a fast saccade reaction time, they looked toward angry faces (*M* = -0.40°, *S.D.* = 0.92), compared with those high in social anxiety who looked away (*M* = 0.48°, *S.D.* = 0.91). This three-way interaction is illustrated in Figure 11.

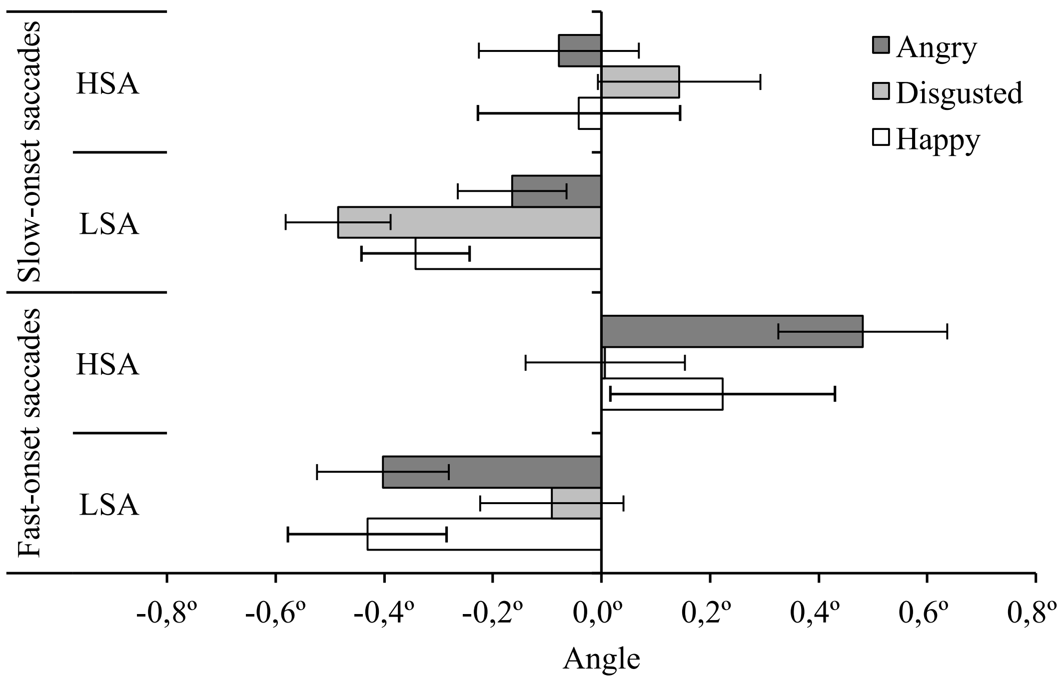

Figure 11. Mean saccade angle (º) of high socially anxious (HSA) and low socially anxious (LSA) participants on fast-onset saccades (bottom) and slow-onset saccades (top) relative to angry, happy and disgusted faces. Negative values indicate eye-movements toward the emotion, positive values away. The significant Social Anxiety × Latency × Emotion was driven by angry faces on fast-onset saccades, from which high-socially anxious participants looked away. Low socially anxious participants looked toward angry faces on fast saccades. Other pairwise comparisons $p \geq .14$. Error bars represent +/- 1 within-subjects standard error.

For maximum deviation, there was a marginal main effect of social anxiety; $F(1, 29) = 3.20$, $p = .084$, $\eta_p^2 = .099$; indicating that those low in social anxiety looked toward emotional faces (*M* = -0.43°, *SE* = 0.44) and participants who scored above the cut-off looked away from emotional faces (*M* = 0.83°, *SE* = 0.55). The direction of this main effect was replicated in the curve area and coefficient measures of saccade deviation, but failed to reach significance (curve area: $p = .10$, $\eta_p^2 = .091$; coefficient: $p = .11$, $\eta_p^2 = .087$.). Other than the main effect for latency described above, none of the Social Anxiety × Latency × Emotion ANOVAs for maximum deviation, curve area, and coefficient revealed main effects for emotion or significant interactions (Social Anxiety X Emotion; Social Anxiety X Latency; Emotion X Latency). *p*-values ranged between .22 and .97; effect sizes η_p^2 were between <.001 and .050. The Social Anxiety X Emotion X Latency interaction that was found for angle, was not present in the measures of maximum deviation, curve area, and coefficient ($.65 \leq p \leq .88$; $.004 \leq \eta_p^2 \leq .015$).

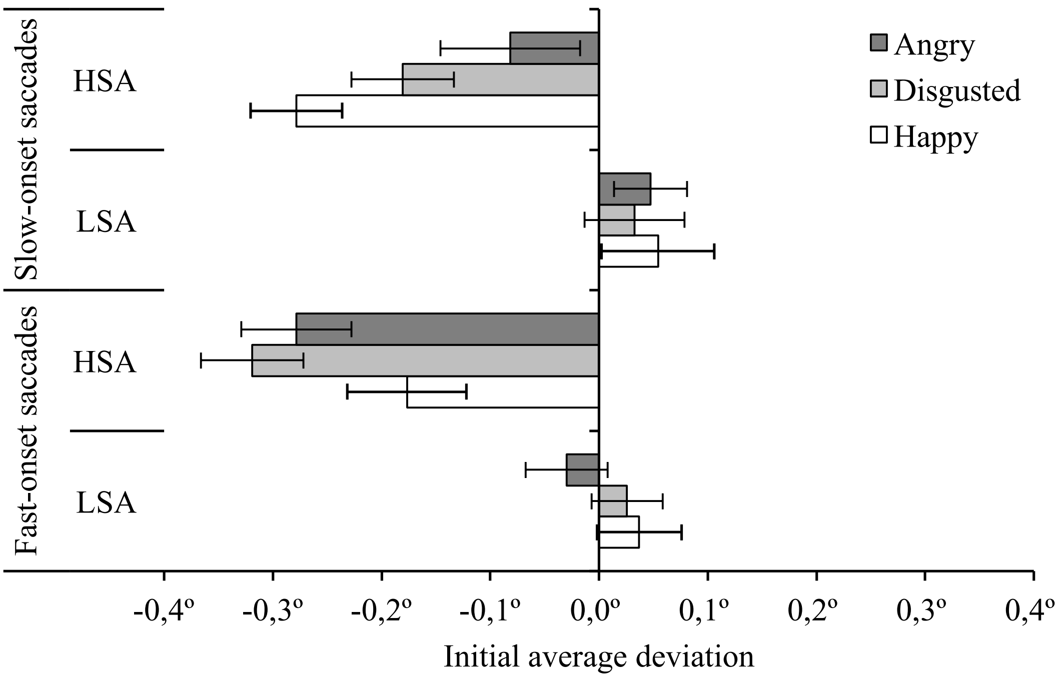

Figure 12. Mean initial average deviation (º) of high socially anxious (HSA) and low socially anxious (LSA) participants on fast-onset saccades (bottom) and slow-onset saccades (top) relative to angry, happy and disgusted faces. Negative values indicate eye-movements toward the emotion, positive values away. High socially anxious participants initiated their gaze toward emotional faces relative to neutral faces. Low socially anxious participants initiated their saccades more straightforwardly through the centre of the screen. Error bars represent +/- 1 within-subjects standard error.

Finally, the exploration of initial average saccade deviation was carried out. In the Social Anxiety × Latency × Emotion ANOVA there was a main effect of social anxiety on the direction of the initial average saccade deviation; $F(1,29) = 7.38$, $p = .011$, $\eta_p^2 = .203$ (Figure 12). Whereas the low socially anxious group initiated their saccades straightforwardly through the centre of the screen, the high socially anxious participants initially diverted their gaze toward the emotional face (One-Sample $t(11)$ from 0° = -2.73, $p = .02$). No other main effects or interactions for this analysis were significant; $ps \geq .10$, $\eta_p^2\text{s} \leq .078$.[9]

4.4 Discussion

4.4.1 Interpretation of results

The aims of this study were, firstly, to investigate whether emotional information acts the same as salient distractors do in previous studies on saccade curvature, in which fast-onset saccades deviated toward salient distractors and slow-onset saccades deviated away. In the current study, fast-onset saccades deviated toward emotional faces relative to neutral faces, whereas slow-onset saccades deviated away. This effect was consistent across different measures of saccade trajectory and provides evidence of the salient nature of emotional expressions. Secondly, this study explored whether saccade curvature was modulated by social anxiety. There was some evidence that this is the case.

[9] These values were found for the Latency × Emotion interaction, but its follow-up comparisons yielded no significant results. All other effects; $ps \geq .24$, $\eta_p^2\text{s} \leq .049$.

Overall, the findings suggest that fast saccades deviate towards emotional faces, whereas saccades that have a slower onset deviate away from emotional distractors. This is in line with findings from salient distractors in visual search tasks with eye-tracking (Van Zoest & Donk, 2006) and with studies investigating the influence of task-irrelevant social or emotional distractors on saccadic curvature (Petrova & Wentura, 2012; Laidlaw et al., 2015; McSorley & Van Reekum, 2013; Schmidt et al., 2012). Furthermore, previous studies used paradigms where fast-onset and slow-onset saccades were decided by task demands. In other words, in overlap-conditions measuring fast-onset saccades, distractor items appeared before the saccade target was presented and in gap conditions measuring slow-onset saccades, the target appeared after the distractors were presented. The current study appears to be the first one in the literature using emotional faces as task-irrelevant distractors, as well as employing a paradigm in which target and distractors appeared simultaneously, allowing for a look at individual SOAs. Therefore, the confirmation of findings from previous studies provides a basis on which to investigate saccade modulation by individual differences such as, in the present case, social anxiety.

Nevertheless, in the current experiments, the overall saccade trajectory was not convincingly related to social anxiety but numerical differences indicate that those high in social anxiety may avoid emotional faces more than those with low social anxiety. All measures; angle, maximum deviation, curve area, and quadratic coefficient, indicated that participants who were high in social anxiety looked away from emotional faces, whereas those low in social anxiety, looked toward emotional faces, irrespective of valence or latency (note that these did not reach statistical significance).

Additionally, the three-way interaction effect of social anxiety X latency X emotion on angle revealed that fast-onset saccades differed between low- socially anxious and high-socially anxious participants when an angry face serves as a distractor. When low socially anxious participants generated fast-onset saccades during the presence of an angry face, their response was similar than to fast-onset saccades for other emotional faces: they tended to deviate toward the emotional expression. On the other hand, high socially anxious participants showed a different saccade angle for fast-onset saccades during the presence of an angry face relative to low-socially anxious participants as well as relative to their fast-onset saccades for other emotions: they deviated away from angry faces.

These results suggest that top-down driven avoidance of threat may be accelerated in socially anxious individuals. However, it is important to note that this interaction was not replicated across the other curvature measures. Furthermore, the difference was only .88° and angle is only an indication of landing position, not the complete trajectory. This result should therefore be interpreted with caution.

Finally, exploratory analyses with initial average deviation elicited a strong group effect. High socially anxious participants initially showed saccades toward emotions, regardless of latency. Low socially anxious participants initiated their eye movements more vertically. This effect is interesting in light of the marginal social anxiety main effects on the overall saccade measures, where those high in social anxiety appeared to look *away* from emotional faces. Firstly, as the high socially anxious initially shifted toward the emotion, this could potentially explain why their overall effect of looking away failed to reach significance. But moreover, this fits in with hyper-vigilance/avoidance theories of attentional biases in anxiety (Wieser et al., 2009). For example, dot-probe paradigms have often shown stronger evidence for early vigilance than late avoidance (e.g. Miskovic & Schmidt, 2012). Furthermore, most tasks of visual attention with threatening faces engage perceptual processes in socially anxious individuals mostly when exposure times are short (Staugaard, 2010). Nevertheless, the reliability of initial deviations is unknown (Ludwig & Gilchrist, 2002), but this finding is interesting considering the currently reported strong findings for hyper-vigilance compared to the weak trend of social anxiety related avoidance.

4.4.2 Limitations and implications

Patterns of social-anxiety related facilitated orienting toward threat followed by avoidance remain unclear. One potential explanation of the findings presented above is that the deviation away from emotion seen in higher social anxiety failed to reach a large effect size because the initial deviation in high socially anxious participants was always toward the emotion regardless of saccade onset. On the other hand, low-socially anxious participants' direction of initial deviation matched the direction of the other deviation measures: fast-onset saccades deviated toward emotional distractors and slow-onset saccades deviated away. In other words, social anxiety may be characterised by a bottom-up mechanism of emotionally relevant information drawing attention. When this is then followed by avoidance, this top-down mechanism may not be able to correct the trajectory enough to yield larger differences. A study with more power, or a higher number of trials specifically, will lead to more insight into the potentially dual attentional mechanism at play.

The attentional capture of emotional faces also appears to be driven by stimulus properties and experimental design. For example, in McSorley and Van Reekum (2013), the distractor images were larger and closer to the path between cue and target than in the present study. A pilot version of the study presented in this chapter used smaller images that were more peripherally located on the screen, and the currently presented systematic pattern of deviation toward emotion for fast-onset saccades and away from emotion for slow-onset saccades was not found in this pilot study. This indicates that emotional information will engage the perceptual system more when it is more salient as well as more central to the visual field. Ideally, a follow-up study should adjust the present design to further examine this notion.

4.4.3 Conclusion

The present chapter presented a unique saccadic curvature paradigm using emotional faces as distractors, whilst the variable of saccade onset time was calculated for each individual. It was found that emotional expressions act as salient information on the oculomotor system. Stimulus properties draw fast-onset saccades toward emotional faces, whereas top-down control drives slow-onset saccades away. Additionally, this curvature may be modulated by social anxiety, which is potentially manifested in attentional avoidance of threat following initial orienting toward the emotional stimulus. Taken together, this paradigm has the potential to be applied to future attention bias research.

5 The ssVEP response to emotional expressions in social anxiety is task-dependent

The previous experimental chapters presented behavioural experiments that investigated attention toward emotional faces in social anxiety. This chapter investigates this same topic by measuring brain activity during emotional attention. Recently, a promising novel methodological approach to examining face processing has been developed: steady state Visual-Evoked Potentials (ssVEP). When stimuli are presented at a fixed rate, neurons in the visual cortex fire at the same frequency of the periodic visual stimulation. The power or amplitude of the activity at this frequency is called the ssVEP. Akin to adaptation, ssVEP power decreases over time, indicating that attention ceases to remain captured. This chapter explores ssVEP power in response to different emotional expressions under different task-demands and examines the effects of social anxiety. There were two tasks: first participants were responding to changes in identity of the stimulus and second, they were looking for changes in emotion. It was found that a) each emotion yielded a different ssVEP magnitude, and b) there was a potential interaction between task-type and social anxiety. Those with low social anxiety displayed larger ssVEP activity during identity decisions than emotion decisions, whereas those high in social anxiety showed an increase in ssVEP activity during the emotion-task relative to the identity task. In other words, neural differences between the groups are dependent on what individuals are directed to pay attention to. This may indicate that differential attentional captivation by social information in social anxiety is driven by top-down states of attention.

5.1 Background and Rationale

5.1.1 EEG and emotional processing

Electroencephalography (EEG) can be used to investigate neural activity toward emotional expressions as a measure of preferential attentional processing. One way to do this is by examining Event-Related Potentials (ERPs). For example, one ERP study found that, compared with participants low in trait anxiety, highly anxious participants detected deviant faces in an oddball paradigm faster than non-anxious participants, as reflected by an earlier P3 component; but showed more difficulty in processing the emotional content of the face, as reflected by a decrease N300 component (Rossignol, Philippot, Douilliez, Crommelinck, & Campanella, 2005).

A different approach to using EEG to explore the mechanisms that underpin face processing, is through examination of neural adaptation, which is also referred to as repetition suppression or habituation (Rossion & Boremanse, 2011). Neural adaptation refers to reduced activation when the same stimulus is repeatedly presented (Grill-Spector et al., 2006; Kovács et al, 2006). However, neural adaptation studies are methodologically challenging. Most importantly, effects of neural adaptation are small, resulting in the need of a large number of participants and trials (Rossion & Boremanse, 2011). Recently, a new method without these limitations has been developed: the steady-state Visual-Evoked Potential (ssVEP; see Rossion (2014) for a review).

5.1.2 The steady-state Visual-Evoked Potential (ssVEP)

When a stimulus is repeatedly presented at a fixed rate it generates a periodic change in voltage amplitude of occipital activation measured by EEG (Rossion, 2014). The advantage of the neuronal firing at the rate of this periodic visual stimulation lies in the fact that the stimulus frequency determines the response frequency. This yields a specific peak activity at the frequency of interest after applying a Fast Fourier Transformation to the EEG recording, which in turn allows for precise evaluation of a stimulus effect (Wieser, McTeague, & Keil, 2011). This technique was originally employed to investigate low-level visual features (e.g. Regan, 1966). However, recently ssVEP studies into face perception have been conducted (Rossion, 2014). In one of the first studies it was found that repetition of identical faces leads to a reduction of the ssVEP response compared with presentation of different faces, which indicates that the ssVEP response is akin to neural adaptation (Rossion & Boremanse, 2011; Gerlicher, Van Loon, Scholte, Lamme, & Van Der Leij, 2013).

An additional advantage of the ssVEP technique is that it requires relatively short experimental sessions. As the stimuli are presented in rapid succession, experimental duration is typically shorter than in ERP studies, making the ssVEP technique more efficient than methodologies such as typical neural adaptation studies (Rossion, Alonso-Prieto, Boremanse, Kuefner, & Van Belle, 2012).

Utilising ssVEP to study facial perception has only recently been employed, and has mostly focused on facial identity processing rather than investigating effects of emotional expressions. A number of interesting findings have nonetheless been presented in the literature. Most predominately, it has been found that larger ssVEP responses are elicited by novel/changing faces compared with the presentation of familiar/repeated faces (Alonso-Prieto, Van Belle, Liu-Shuang, Norcia, & Rossion, 2009; Rossion, 2014). A decreased effect was also found for inverted faces, reversecontrasted faces, and a combination of both (Rossion et al., 2012), indicating that the technique can be employed to study face-specific processing.

There are indications that the ssVEP technique can also be used to investigate emotion-specific effects. Gerlicher et al. (2013) presented identical and different faces with neutral, happy, fearful, or mixed (i.e. each face was either angry, contemptuous, disgusted, sad, or surprised) expressions. They found reduced adaptation for emotional stimuli compared with neutral expressions, indicating that emotional information receives preferential processing in the visual cortex. It should be noted that their control condition involved different and constantly varying emotional expressions relative to the conditions of interest. Therefore, it remains inconclusive if direct effects of emotion were measured.

The current thesis investigates attentional modulation toward emotional expressions in social anxiety. Interestingly, it is suggested that ssVEPs elicited by emotional faces may be modulated by social anxiety (Wieser et al., 2011; Wieser, McTeague, & Keil, 2012). One study investigated emotion-elicited ssVEPs in pre-screened high versus low social anxiety groups and found high socially anxious participants displayed larger ssVEPs than those low in social anxiety for emotional (happy, fearful, and angry) compared with neutral faces (McTeague, Shumen, Wieser, Lang, & Keil, 2011). This provides initial evidence that socially anxious individuals display an atypical neural response to emotional expressions.

The ssVEP studies described above did not require directed attention toward the emotion displayed. For example, in the study by Gerlicher et al. (2013), participants were required to respond to a brief colour change of the fixation cross that was superimposed between the eyes of the face. However, rather than neural fatigue, adaptation can also be a consequence of top-down modulation toward the stimuli

(Ewbank et al., 2011; Ewbank, Henson, Rowe, Stoyanova, & Calder, 2013). In other words, it may be driven by prior beliefs, or perceptual expectation (Ewbank, von dem Hagen, Powell, Henson, & Calder, 2016). Furthermore, in face processing visual areas, activation evoked by facial expressions occurs in addition to activation evoked by attention (Vuilleumier, Armony, Driver, & Dolan, 2001). The role of this top-down control in adaptation can be manipulated by varying the task-demands modulating the participant's attentional set. For example, the Attentional Blink chapter in this thesis found social anxiety-related effects when attention toward emotional expressions was required for the task, but not when it was implicit.

5.1.3 The current experiment

Altogether, the ssVEP technique provides an interesting and novel approach for studying attention toward emotional expressions in social anxiety. Previous studies have found a reliable adaptation effect by comparing ssVEP responses on multiple cycles with an identical face with the baseline of a different face per each cycle. This notion justifies removing the different face per cycle-baseline and instead comparing effects of different emotional expressions which are presented in identical repetition, i.e. a succession of cycles using the same face. This allows for a direct comparison of the ssVEP response for blocks of angry, disgusted, fearful, happy, and neutral faces during a relatively short experimental session.

Furthermore, whereas ssVEP studies in face perception have employed stimulus presentation frequencies between 3Hz and 17.5 Hz (Rossion, 2014), it has recently been suggested that the largest ssVEP responses to facial different versus identical faces are elicited at a presentation rate of 5.88Hz (Alonso-Prieto et al., 2013). One cycle at this frequency lasts 170ms, which interestingly matches the face-sensitive N170 ERP component (Bentin, Allison, Puce, Perez, & McCarthy, 1996). This offers a practical implication for paradigm optimization. Therefore, faces in this experiment will be presented at a rate of 5.88 cycles per second.

Finally, to examine the role of top-down attention toward emotional information in the environment, in the present study emotional relevance of the stimuli was modulated by task demands. Previous experiments, such as Gerlicher et al. (2013) used a more ‘passive viewing’ design, in which stimulus content was not made directly relevant to the participants’ direction of attention. The current experiment has two tasks. Participants are asked to either respond to changes in identity of the stimulus, *or* to changes in emotion of the stimulus. So far, this thesis has demonstrated that social anxiety-related attention bias might be modulated by task-characteristics, especially related to the relevance of the emotional face. For example, the Attentional Blink experiments in chapter 2 revealed that social anxiety-related effects only surfaced when identifying the emotion of the target was directly required for the task, but not when the emotion was not task-relevant. In the saccadic curvature experiment (chapter 4), where emotional faces appeared as task-irrelevant distractors, less convincing social anxiety-related effects were found. Therefore, it is predicted that individuals high in social anxiety will show less adaptation to emotional stimuli than low-socially anxious individuals when they are specifically attending to emotional information.

In sum, the following is hypothesised. 1) At the presentation frequency of 5.88, the angry, disgusted, fearful, happy, and neutral faces will evoke different amplitudes on occipital sites, with no specific prediction made about the direction of this effect or any influence of trait social anxiety therein. 2) When emotional expressions are task-relevant (i.e. when participants are asked to pay attention to changes in emotion of the face), high-socially anxious participants will show a larger ssVEP amplitude than low-socially anxious participants, which would indicate less adaptation. However, when emotion is not task-relevant, i.e. participants are asked to pay attention to changes in identity of the face, and not emotional expression thereof, no group differences in ssVEP amplitude are expected.

5.2 **Method**

5.2.1 Participants

33 right-handed participants took part in the study part in exchange for a payment of £10, of which 3 were excluded because of noisy data and/or too many artefacts (N = 30; 8 male, mean age = 22.7; *S.D.* = 3.57). All participants self-reported normal or corrected-to-normal vision. Further exclusion criteria were having a history of psychiatric or neurological disorders, migraines, epilepsy, consumption of psychoactive substances or medication, or loss of consciousness for more than five minutes.

5.2.2 Materials

Social Anxiety. The Social Phobia Inventory (SPIN; Connor et al., 2000) was used as a self-report measure of social anxiety (see Appendix A). Mean score in the current sample was 22.1 (*S.D.* = 12.1). Using the same cut-off score of 19 as in the previous experiments in this chapter, 13 participants were classified as low-social anxiety and 17 participants were classified as high-social anxiety.[10]

Stimuli. From 5 Caucasian male identities, selected from the Radboud Faces Database (RaFD; Langner et al., 2010), angry, disgusted, fearful, happy and neutral emotional expressions were selected. Anything outside the face area, such as background, was cropped from the stimuli to blend in with the grey background of the screen and images were resized to 560 x 560 pixels. These images were matched for luminance and presented in greyscale. The experiment was programmed in PsychoPy (Peirce, 2007; 2009).

EEG recording. EEG recordings were acquired with a 64-electrode BrainVision cap (Brain Products) with standard 10/20 layout. Electrode FT9 was attached to the left cheekbone to record eye-movements such as blinking. The ground and reference electrodes were in positions AFz and FCz respectively. The electrodes were fed through BrainAmp 64 Plus amplifiers and the signal was recorded with Brain Vision Recorder using a temporal resolution of 1,000Hz.

5.2.3 Procedure

EEG recordings took place in a lit room. Participants were sat at a distance of approximately 110cm from a 53 x 30cm screen with 60Hz refresh rate. After providing informed consent, participants were fitted with the cap and electrodes.

[10] Autistic traits were also recorded, using the Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). However, the relation between autistic traits and emotional face processing is beyond the scope of the study presented herein.

Impedance was held below 25kOhm and when noise levels were satisfactory, participants received task instructions before the experiment commenced.[11]

For each participant, a unique list of stimulus presentation order was constructed in python, using conditional randomization. In other words, the first stimulus was randomly selected, after which each subsequent face had to be either the same identity *or* the same emotional expression as the preceding face, until all 25 stimuli were used.

Each face was presented on the screen with sinusoidally increasing and decreasing contrast at a rate of 5.88Hz. At each presentation cycle, the face was presented at a random size between 85% and 115% of the original image size to avoid adaptation to low-level features (Boremanse, Palmero-Soler, Jacob, & Rossion, 2010; Rossion, 2014; Xu, Tanaka, & Rossion, 2013). After a trial of 35 cycles (about 6s) of the same face, a new face was presented with either the same identity but a different emotional expression, or with a different identity but the same emotional expression until all of the 25 faces were presented in the experimental block. One block therefore lasted approximately 150s. This procedure was then repeated for task 2.

During task 1, participants were instructed to press the spacebar if they noticed a change in identity and to ignore changes in emotional expression. However, for task 2, this was reversed: participants were instructed to press the spacebar when they saw a change in emotional expression, but were asked to ignore changes in identity of the stimulus. The order of these tasks was counterbalanced between participants.

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[11] The experiment described herein was preceded by another experimental task in support of an MSc-thesis. Consequently, it is beyond the scope of the current chapter.

5.2.4 Design and Analysis

Emotions across different identities were collated, resulting into segments for angry, disgusted, fearful and happy faces. Consequently, this study follows a 2 (SPIN; low anxious, high anxious) × 2 (Task; identity-attention, emotion-attention) × 5 (Emotion; angry, disgusted, fearful, happy, neutral) mixed design, with SPIN-score as a between subject variable and task and emotion as repeated measures variables.

The EEG data was processed in Brain-Vision Analyzer. After an ocular correction was applied, the EEG signal was referenced to a common average reference. The data was then filtered between 0.1 and 100 Hz (Butterworth filter, 24 dB/oct slope). Segments with artifacts in the posterior channels were removed. Data was selected from a 143-s window of stimulation starting 6-s after the beginning of stimulation (i.e. all blocks minus the first). This was done to avoid contamination from responses triggered by the onset of stimulation, to allow some time for the neurons to be entrained (Rossion & Boremanse, 2011), and for the steady-state response to establish (Rossion, 2014). A Fast Fourier Transformation (FFT) algorithm was applied to each emotional block; from which the highest average amplitude in the four 5.88 Hz surrounding bins per participant for each emotion was calculated (resolution was 0.12 Hz, resulting in extraction bins of 5.74 Hz, 5.86 Hz, 5.98 Hz, and 6.10 Hz). Typically, ssVEP activity for centrally presented stimuli is most pronounced on the occipital pole, centered around the Oz-electrode (Müller, Andersen, & Keil, 2008). Therefore, following McTeague et al. (2011), analyses in the current report are run on activity measured at Oz. Other studies, such as Gerlicher et al. (2013), chose to analyse a cluster of parietal-occipital channels. In these clusters the Oz is always included too. The statistical analyses were performed in IBM SPSS Statistics version 22 over log-transformed data (base-10) to meet assumptions of normality.

5.3 Results

A clear ssVEP peak was established around the 5.88Hz frequency, see Figure 13, which displays Grand Average activity across all conditions and all participants. Activity peaks were also found on the second and third harmonics, replicating typical ssVEP responses in the literature (e.g. Rossion, 2014).

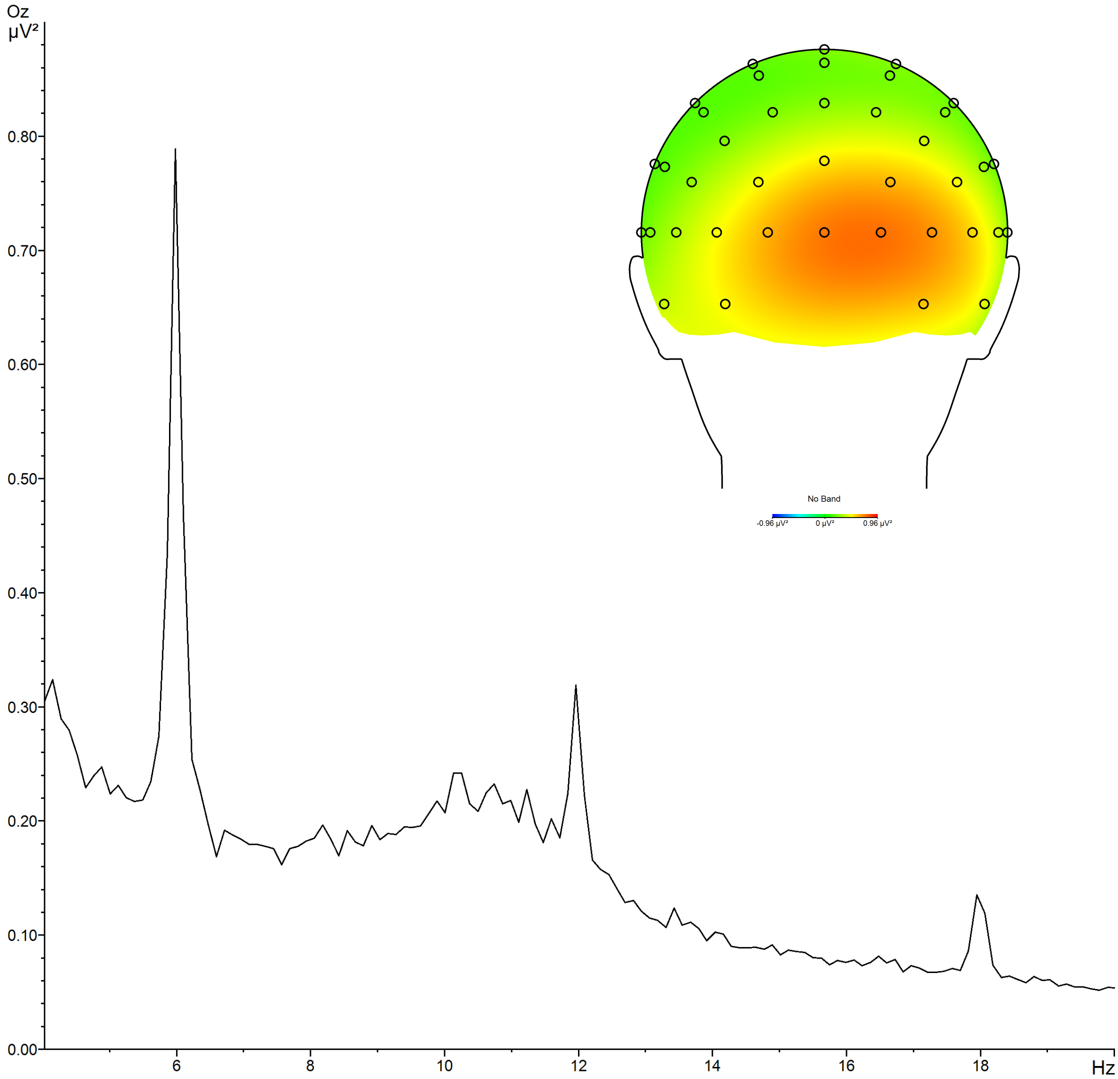

Figure 13. Grand Average frequency power across all trials and participants. Note the peak activity around the presentation rate of 5.88Hz as well as in the second and third harmonics.

A main effect of emotion was found, $F(4, 112) = 7.27, p < .001, \eta_p^2 = .204$. Pairwise comparisons (Bonferroni-corrected) yielded significant differences between angry-disgusted ($p = .040$), angry-happy faces ($p < .001$), and happy-neutral faces ($p = .003$). The difference between fearful and happy faces is only marginally significant at $p = .065$; see Figure 14. Numerically, the largest adaptation appears to occur for angry faces, respectively followed by neutral, fearful, disgusted and happy, for which ssVEP amplitude remains highest.

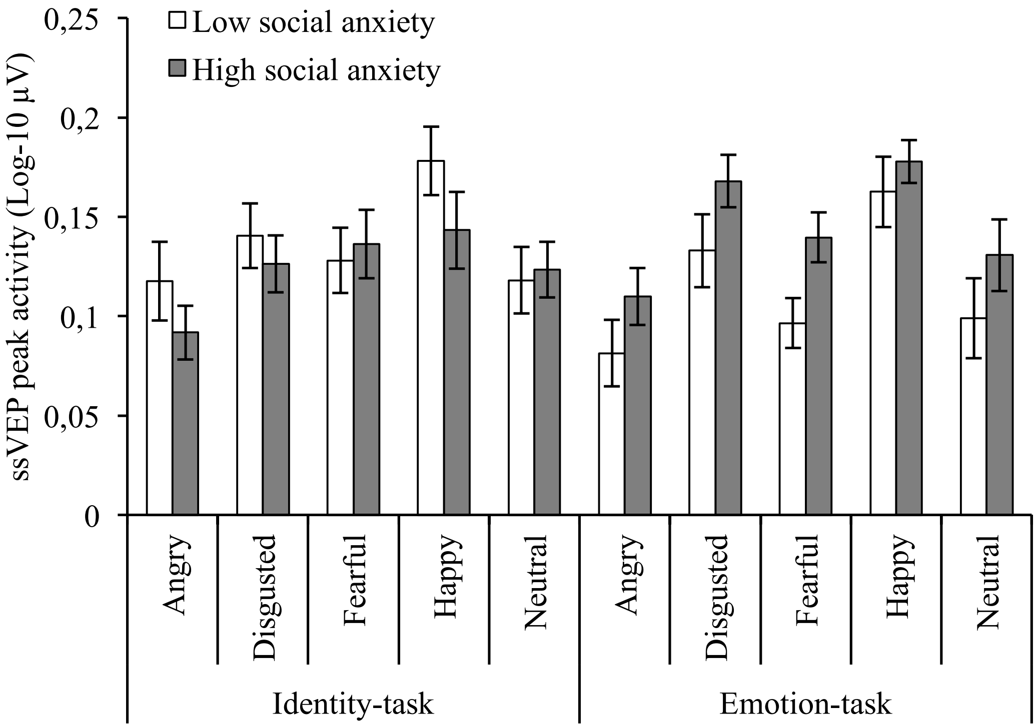

Figure 14. Oz ssVEP amplitude (log-10 µV) for the identity-task (left) and emotion-task (right) per emotion of the stimulus for both anxiety groups. There was a main effect for emotion on ssVEP amplitude. Specifically: angry < happy ($p < .001$), angry < disgusted ($p = .040$), and neutral < happy ($p = .003$). There was also a near significant two-way interaction between social anxiety and task-type: ssVEP amplitude for the high socially anxious participants was larger in the emotion-task relative to the identity-task; as well as relative to low socially anxious participants' ssVEP amplitude across both tasks. Error bars represent +/- 1 within-subjects standard error.

Neither a main effect for task-type or a between-subjects main effect of social anxiety were found; ps > .90, η_p^2s ≤ .001. However, there was a marginally significant Task × Social Anxiety interaction effect, $F(1, 28) = 3.25$, $p = .08$, $\eta_p^2 = .104$. No other interactions were statistically significant (lowest $p = .68$; largest η_p^2 =020). Figure 14 suggests that, during task 1, where participants paid attention to changes in identity, both groups had ssVEPs of similar magnitude. However, when participants paid attention to changes in emotion, ssVEP amplitude decreased for the low-social anxiety group, whereas it increased for those high in social anxiety, relative to the identity task. However, follow-up analysis of SPIN group differences per individual task-type yielded no statistically significant results (identity-task $p = .87$; emotion-task $p = .68$). In addition, follow up analyses per group yielded no statistically significant difference for task-type in the low anxiety group ($p = .32$) and in the high-social anxiety group ($p = .13$) but the high social anxiety group shows a larger effect size for task type ($\eta_p^2 = .139$) than the low-social anxiety group ($\eta_p^2 = .082$) [12].

In order to further investigate this effect, a similar analysis was run. A repeated measures GLM with mean-centered SPIN score demonstrated a significant Task × Social anxiety interaction effect; $F(1, 28) = 4.38$, $p = .045$, $\eta_p^2 = .135$. This is illustrated by contrasting the tasks (subtracting ssVEP log-10 amplitude during the identity-task from the emotion-task), which yielded a significant correlation between SPIN-score and ssVEP amplitude, $r = .37$, $p = .045$, see Figure 15.

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[12] Results similar to the ones reported here, were found in a median-split SPIN-score analysis with slightly larger effect sizes overall; e.g. Social Anxiety × Task $F(1, 28) = 3.39$, $p = .08$, $\eta_p^2 = .108$. Similarly, paired sampled t-tests showed no differences in task-type for the low socially anxious group. For the high socially anxious group, $p = .09$ (two-tailed).

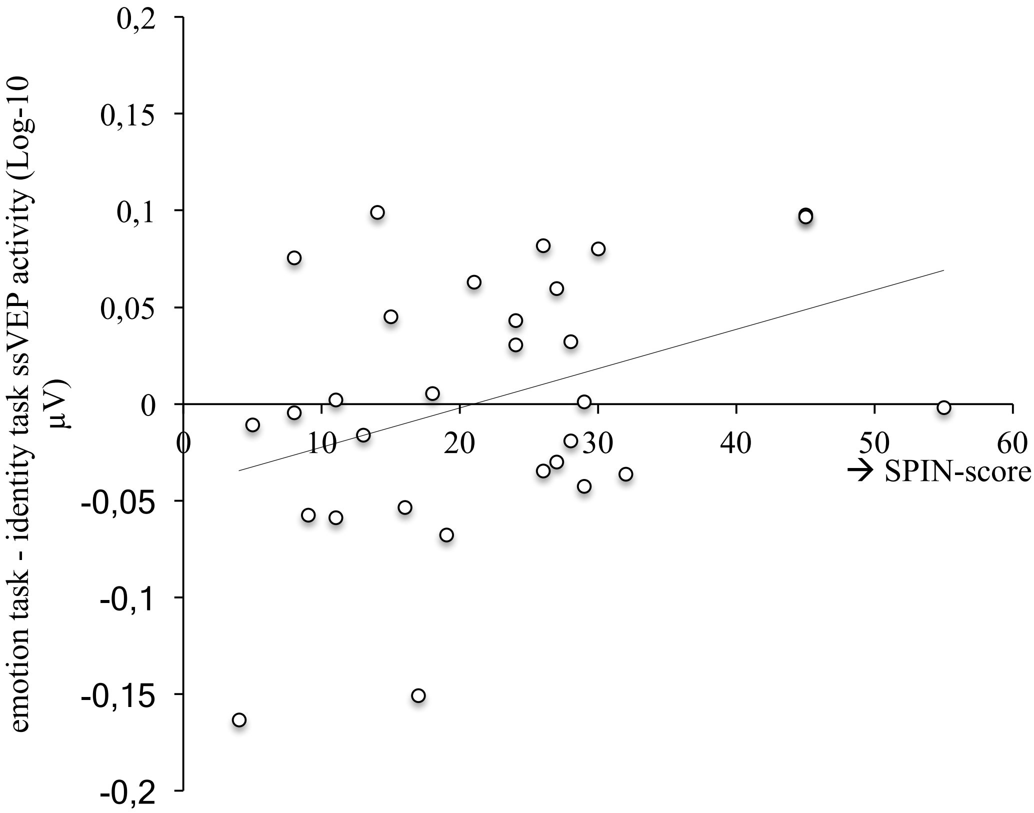

Figure 15. Scatterplot of participants' SPIN-scores on the x-axis and task-contrasted ssVEP peak activity on the y-axis. Higher values on the y-axis indicate more activity during the emotion-task compared with the identity-task. *Note:* trendline $r = .37$, $p < .05$.

5.4 **Discussion**

5.4.1 Is social anxiety-related attention toward emotion task-dependent?

The key interest to the current study was social anxiety-related differences in ssVEP amplitude. It was hypothesised that individuals high in social anxiety would show less adaptation to emotional stimuli than low-socially anxious individuals when they are specifically attending to emotional information. The results provide some support for this prediction. When SPIN group was examined, a marginally significant interaction between social anxiety and task-type was found. Follow-up analyses yielded numerical differences between tasks/groups that support the hypothesis but these were not statistically significant. When SPIN score was treated continuously however, the interaction between anxiety and task type was significant and follow-up analyses showed that the higher the individual's social anxiety, the larger the ssVEP response was in the emotion-task relative to the identity-task. To explore how robust this effect was, additional exploratory analyses were conducted using raw amplitude (rather than Log-10 transformed), splitting social-anxiety scores into groups in different ways (e.g. median split), using neighbouring electrodes, and exploring correlations, and all supported this conclusion. Consequently, these results were not likely to be solely subject to chance and there is a reasonable foundation for interpretation.

Overall, the finding that the attentional set modulates ssVEP amplitude differently for high-socially anxious individuals than for low-socially anxious individuals, suggests that there is a role of top-down processes in social anxiety-related attention bias. This role is highlighted in attentional control theory, especially regarding the anxiety-related impairment of attentional control, which is involved in inhibiting attention to task-irrelevant stimuli (Derakshan & Eysenck, 2009). This top-down control of incoming stimuli is thought to be competing with a pre-attentive threat evaluation mechanism in anxiety (Mathews & Mackintosh, 1998). From these accounts it could be derived that in the emotion-task, the high-socially anxious participants need to constantly suppress the effect of incoming emotional information in their threat evaluation mechanism to carry out the task-demands of indicating emotional changes, thus they show reduced adaptation for these stimuli. However, from the current experiment, it cannot be concluded whether a task-driven alertness toward emotion evoked the larger ssVEP response in the emotion-task, or whether inhibition of irrelevant emotional processing led to relatively more neural adaptation in the identity task.

It is noteworthy that no interaction between social anxiety and valence was found, which does not confirm some previous findings that attentional biases in social anxiety are specifically related to threat (Mogg & Bradley, 1998; Rossignol et al., 2005; Staugaard, 2010). However, attentional bias research in anxiety has not always revealed effects of valence, or threat specifically, and there could be a general bias for faces in anxiety. In generalised anxiety disorder for example, a bias for happy faces potentially coexists along a bias for threat faces (Bradley, Mogg, White, Groom & De Bono, 1999). This could indicate that socially anxious individuals are hypervigilant in scanning the environment for affective, or arousing, information rather than threat specifically or indeed that all social cues represent potential threat for a socially anxious individual. In another instance, a cueing paradigm with emotional faces, valence only affected response time, but not accuracy in socially anxious individuals (Fox, Russo, & Dutton, 2002). However, the time-course of hypervigilance and avoidance was not investigated with the paradigm presented here. Nevertheless taken together, this experiment provides further evidence that hyper-vigilance toward emotion is potentially modulated by task demands and, consequently, top-down control.

5.4.2 Neural adaptation toward different emotions

A secondary aim of the current experiment was quantifying neural steady-state responses to different emotions. Whilst a large main effect of emotion was found, follow-up analyses yielded curious results. Remarkably, most adaptation was found for angry faces, followed in order of most to least adaptation by neutral, fearful, disgusted, and happy faces. Only differences between angry-disgusted, angry-happy and happy-neutral were statistically significant.

Interpreting results for neutral faces presents a challenge for a number of reasons. First, they are not as ecologically valid as the emotional faces as neutral faces are not often experienced in real life. Second, neutral faces are open to interpretation and are often interpreted negatively. Third, response to neutral faces typically yields large inter-individual variance, perhaps as a result of being open to interpretation (Donegan et al., 2003; Lee, Kang, Park, Kim, & An, 2008; Somerville, Kim, Johnstone, Alexander, & Whalen, 2004). If we disregard neutral, one could argue for a valence effect: the ssVEP response decreases from happy to angry faces. However, the direction of this effect is in stark contrast with the literature. It has previously been found that ssVEP responses were larger for fearful than for happy faces (Gerlicher et al., 2013). However, Gerlicher and colleagues used changing identities in each cycle, with fearful faces as a negative condition. Other negative expressions were part of a 'mixed' category. Consequently, the researchers were interested to neural adaptation to *identity* modulated by emotional expressions. The current study used longer single-identity, single-emotion blocks across four different emotional expressions, in order to purely investigate adaptation to emotion. It is possible that these differences in paradigm characteristics play a role in ssVEP response to different emotions.

In addition, the reduced ssVEP amplitude for angry faces possibly makes sense from an emotion regulation point of view. Research suggests that low ssVEP responses may be a sign of neural adaptation, but also higher level processing (Rossion, 2014). This is built on the notion that neural adaptation itself can also be a consequence of top-down modulation toward the stimuli (Ewbank et al., 2011; 2013). Perhaps threatening stimuli were not adapted to, but a top-down process of emotion perception served to conserve neural activity to facilitate an immediate and effective response in the next stage of perceptual processing (Bar, 2003), such as a fight-or-flight response. In sum, a low ssVEP response in repeated emotional identities may be indicative of graduation into deeper levels of processing. However, future research is needed to establish whether the ssVEP response investigate here is related to neural adaptation characterised by neural fatigue or by depth of processing.

5.4.3 Limitations

A few methodological limitations exist in the current experiment. Firstly, it relied heavily on previous studies having employed same-versus-different face conditions. These studies (e.g. Gerlicher at al., 2013; Rossion & Boremanse, 2011) measured adaptation to identical faces in each cycle compared with different faces in each cycle. As high and narrow ssVEP responses were found consistently, it was thought that the paradigm could be taken beyond the different-face baseline condition. It could have been valuable to include a different-face condition as well. Participants' responses may be driven by expectations rather than mere observation (Rossion, 2014). In addition, a different-face condition would have provided an individual baseline for each participant. An additional consideration is that the data was log-10 transformed to meet assumptions of normality. Despite the raw data displaying the same numerical effects, the statistical results may have been skewed by the presence of peak amplitudes between 0 and 1 μV. Caution is required when applying logarithmic transformations to these values, as they result in negative values

(Osborne, 2005). However, adding an arbitrary constant is not recommended (Feng et al., 2014)[13].

A final limitation is that of presentation rate. A frequency of 5.88Hz was used, based on previous observations that it evokes large ssVEP amplitudes for face perception, potentially matching the N170 ERP face component (Alonso-Prieto et al., 2013; Nemrodov, Jacques, & Rossion, 2015; Rossion, 2014). However, recently published research suggested that, while 5.88 might be ideal for face identity processing, it could be moderately slower for emotional processing (Zhu, Alonso-Prieto, Handy, & Barton, 2016). More specifically, a presentation of different emotional expressions yielded the largest ssVEP response at 5Hz. It is interesting to note that this in turn potentially matched the P200 ERP component, which is a frontal component thought to be related to emotional processing (Ashley, Vuilleumier, & Swick, 2004). Whereas Gerlicher et al. (2013) found valence effects with an even slower presentation rate of 3Hz, perhaps adaptation to different emotional expressions, including social anxiety-related atypical processing, could be better differentiated by employing a paradigm with slower presentation rates.

5.4.4 Conclusion

A reliable ssVEP peak amplitude for faces was found on both tasks at a periodic presentation rate of 5.88 Hz, indicated by a narrow peak at this frequency in the spectrum, including the 2nd and 3rd harmonic. In addition, this peak was established during a relatively short presentation time per block (6s) compared with

[13] Preliminary analysis of Log10(x+1) data indicated a replication of the presented findings, but the data was not normally distributed.

the literature (10-15s). There was a strong main effect of emotion, with angry faces evoking the lowest amplitude and happy faces the highest. Furthermore, an effect of social anxiety was found; high-socially anxious participants showed an increased ssVEP response when they were explicitly paying attention to emotional cues rather than to identity cues relative to low-socially anxious participants. This provides some support that top-down processes may play a role in social anxiety-related hyper-vigilance toward threat.

6 General Discussion

The aims of this thesis were to explore a) attentional bias in social anxiety using b) novel experimental paradigms. The specific focus was on proposed anxiety-related attention bias components of facilitated orienting toward threat, difficulty in attentional disengagement from threat, and attentional avoidance. A review of the existing literature suggested that traditional paradigms such as the dot-probe task may not be suitable to disentangle these early and late components. To overcome the limitations of these designs, novel approaches to social-anxiety related attention bias were proposed, using emotional faces as stimuli: an emotional adaptation of the attentional blink in adults as well as child participants, saccadic curvature of recorded eye-movements, and ssVEP responses in the EEG signal. Potentially as a result of the exploratory nature of these designs, findings in regards to bias components were inconclusive. Moreover, it appeared that the attentional set of participants, modulated by task demands affected conclusions: overall, social-anxiety related differences in emotional face processes depended on whether participants had to actively pay attention to emotional information. In this general discussion, the results from the experimental chapters will be brought together, offering a reflective account of the presented research.

6.1 **Aims and findings**

6.1.1 Aims

The literature review (chapter 1) introduced potential mechanisms underpinning anxiety-related attention bias, discussing theories including the hypervigilance-avoidance hypothesis (e.g. Bögels & Mansell, 2004), and the components of facilitated orienting, delayed disengagement, and attentional avoidance (Cisler & Koster, 2010). Together, the evidence for these models in anxiety and the gap in the literature regarding *social anxiety* specifically influenced the decision to study the underpinnings of attentional bias in social anxiety.

Additionally, methods typically used to investigate these mechanisms were reviewed; most prominently, visual search, the emotional stroop, spatial cueing, and the dot-probe tasks (Bar-Haim et al., 2007). One limitation of these tasks was that they mostly examine attention bias in the spatial domain, with relatively little focus on the temporal domain. Furthermore, there have been sensible invitations to study attentional mechanisms using eyetracking (Armstrong & Olatunji, 2012) and EEG (Gerlicher et al., 2013; Rossion, 2014).

Taken together, the aims of this thesis were founded on the mechanisms of attentional bias, as much as driven by the methodological challenges of assessing attentional biases and teasing apart the components of bias. Specifically, the aims of this thesis can be summarised in the following questions.

A) Is attention bias for emotional faces in social anxiety underpinned by: a) facilitated orienting toward threat; b) delayed disengagement and/or difficulties disengaging attention away from threat; c) attentional avoidance of threat?

B) Are there techniques and experiments available beyond those typically used which would allow for a closer investigation into these components of attention bias?

Firstly, an overview of the results from each chapter will be provided. Secondly, these results will be brought together under three central themes: bias components, methods, and attentional set. The chapter ends with a reflective account of limitations, directions and implications as well as a final conclusion.

6.1.2 Results overview

This thesis presented four experimental chapters and each of these experiments used faces as stimuli. The first experiments were comprised of adaptations of the attentional blink paradigms, including a version for and with child participants in a separate chapter. To explore attention bias by recording eye-movements, a saccade curvature experiment was developed. Finally, an ssVEP paradigm was designed to explore whether social anxiety-related biases would manifest in differential neural activation. A summary of findings per chapter follows.

Chapter 2: Attentional Blink Adults. In this chapter, three adaptations of the attentional blink paradigm using animals as neutral targets and happy/disgusted faces as emotional targets were presented among a stream of scrambled faces as distractor items. When T1 was an emotional face and T2 an animal, only a main effect of lag was found. However, a surprising finding was revealed: T1 (face) analysis suggested that low socially-anxious participants identified happy faces less accurately than they did disgusted faces and less accurately than high-socially anxious participants identified both happy and disgusted faces.

Experiment 2 in this chapter followed a similar paradigm, except target order was switched. This time, T1 was an animal and T2 a face. A three-way interaction between social anxiety, emotion, and lag was present, but the results were in a surprising direction. At lag-1, when T2 follows T1 most closely, participants high in social anxiety performed equally well on both disgusted and happy faces. On disgusted faces, low socially anxious participants performed similarly, but they were less accurate for happy faces.

For experiment three, the paradigm with an animal T1 and face T2 was adjusted: it was made more difficult, single-target trials and dual-target trials were randomly presented rather than being presented in separate blocks, and thirdly, participants were asked to respond with yes/no to the question whether they saw a face rather than making an emotion decision. This time, disgusted faces were less often detected than happy faces overall but no social anxiety related effects were found. These findings suggest that social anxiety related differences in attention to emotional faces may depend upon the attentional set; being present when participants' task causes them to scan the environment for emotional information but not present when emotion is not relevant to the task at hand.

Chapter 3: Attentional Blink Children. The experiment presented in chapter 3 was an adaptation of chapter 2, experiment 2: animal T1 and face T2 with explicit emotion judgement. This time, child faces were used as stimuli, and participants were 11-year-olds. The hypothesis that highly-anxious participants would have higher accuracy on disgusted face T2 if it closely followed a neutral T1, relative to happy face T2s and to low socially anxious participants, could not be fully accepted based on the findings. Instead, social anxiety appeared to be negatively correlated with accuracy for both emotions on dual-target trials, whilst this was not found for single-target trials. This suggests impaired cognitive control in anxiety, in which emotional processing was hindered by an increase in task complexity.

Chapter 4: Saccade curvature. This experiment was designed with two aims. Firstly, it was predicted that laterally presented task-irrelevant emotional face distractors would be processed as salient stimuli and would attract attention at early onset saccades, whereas attention would move away from them at late onset saccades. Secondly, it was investigated whether social anxiety-related differences in this pattern would emerge. Strong support for the first aim was found, indicating that emotional faces grab attention at early stages of processing in a bottom-up, or stimulus-driven way, whereas avoidance, presumably driven by top-down control, occurs during later stages of processing. As for the second aim, marginal effect sizes indicated that high-anxious participants' gaze deviated more toward emotional distractors than low-anxious participants' gaze, regardless of saccade onset time. On the other hand, the measure of angle suggested a different pattern for angry faces at fast saccade onsets: low-anxious participants looked toward the emotion as normal, whereas high-anxious participants looked away, which may indicate a fast-acting top down avoidance. Examination of initial average saccade direction showed that the initial deviations of low-anxious participants replicated their trajectories on the other measures for emotional faces: toward for fast saccade onsets and away for slow saccade onsets. In contrast, high-anxious participants always appeared to initiate their gaze toward the emotion regardless of onset time. In other words, for slow onset saccades, they would still initiate their gaze toward the emotion first, which would provide partial support for delayed disengagement.

Chapter 5: ssVEP. This experiment explored a technique that was recently developed in the field of face processing. Here, five facial identities with angry, disgusted, fearful, happy, and neutral expressions were presented at a rate of 5.88Hz. Between tasks, participants were either asked to pay attention to changes in identity or to changes in emotion whilst their brain activity was recorded. The ssVEP response in occipital regions typically decreases over time, akin to neural adaptation. It was predicted that different emotional expressions would evoke different ssVEP amplitudes. Moreover, it was predicted that attentional set would play a role in social anxiety; thus differences in ssVEP amplitudes between high-anxious and low-anxious participants would be influenced by task type. Strong support was found for both hypotheses. Firstly, participants adapted most to angry faces and least to happy faces. This suggests that adaptation to threat stimuli occurs under a top-down mechanism, such as preparing the neurons for a potential fight-or-flight response. Secondly, a social anxiety by task interaction indicated that adaptation was reduced for high-anxious participants when they were explicitly instructed to pay attention to changes in emotion, relative to both low-anxious participants and to themselves when instructed to pay attention to changes in identity. In other words, when task demands drove attention to emotion, the high-socially anxious participants had less neural adaptation showed a decreased reduction, which potentially indicates delayed disengagement from threat.

6.2 Discussion of results

The findings highlighted above will be brought together across three central themes. The first two themes map onto the original aims of the thesis: 1) components of attentional bias in social anxiety with an emphasis on facilitated orienting, delayed disengagement, and avoidance; and 2) the novel techniques for assessing attentional bias in social anxiety. The third theme developed as the thesis evolved and focuses on the potential importance of attentional set.

6.2.1 Theme 1: Components of attention bias in social anxiety

This thesis set out to explore the temporal aspects of attention bias for emotional faces in social anxiety. One influential account of the time course of attention bias in social anxiety is the hypervigilance-avoidance theory (e.g. Bögels and Mansell, 2004). Hypervigilance is often seen as a heightened state of arousal or alertness with attentional avoidance driven by top down strategies (Mogg et al., 1997). Evidence for both mechanisms in anxiety has come from a large number of studies, from which it can be concluded that anxious individuals have a bias for preattentive detection of threat, as well as biases in later top down processes (Bar-Haim et al., 2007). Most recently a three-component model of biases in anxiety has been proposed: facilitated attention toward threat, delayed disengagement away from threat, and attentional avoidance of threat (Cisler & Koster, 2010). Consequently, the first major theme presented in this work, was assessing which of these components might underpin biases in social anxiety.

Facilitated attention toward threat. Facilitated attention refers to the relative speed or ease with which attention is oriented toward threatening information (Cisler & Koster, 2010). In other words, to explore whether facilitated attention plays a role in social anxiety-related attention bias, one could look into the findings of those experiments for which early processes were assessed. An example of this is experiment 2 (face-T2) in the series of attentional blink tasks (chapter 2). Facilitated attention toward threat would be demonstrated by differential performance between high-anxious and low-anxious participants when T2 closely followed T1, thus at lag-

1. Here, high accuracy on both happy and disgusted faces was found for high-anxious participants, whereas low-anxious participants performed equally on disgusted faces, but worse on happy faces. Following this finding, it could be argued that there may not be facilitated attention toward threat per se in social anxiety, but rather toward emotional information more broadly. This is opposed to low-anxious participants, whose attention may be drawn to relevant/salient/threatening information such as disgusted faces, but less to 'expected' information like happy faces.

Facilitated attention toward threat was investigated with this paradigm in a child sample too. Here, no evidence for facilitated attention toward threat in socially anxious children was found. In fact, a higher degree of social anxiety appeared to be related to poorer emotion recognition overall. It could be proposed that social anxiety in childhood is related to subtle deficits in emotion recognition. Through development, this lack of skills might drive attentional mechanisms to overcompensate, investing more resources in the processing of emotional input from the environment preferentially, which could plausibly lead to an attention bias toward emotional stimuli as seen in the adults in chapter 2. This idea cannot be further explored with the experiments offered here, but it could serve as a recommendation for future studies.

Fast-onset saccades in the saccadic curvature experiment also provide insight into the component of facilitated attention toward threat. However, even though socially anxious participants' gaze deviated toward emotional faces relative to neutral faces more than low-socially anxious participants, this effect occurred independently of onset time.

In review, the evidence for social-anxiety related facilitated attention toward threat brought forward from these experiments is weak.

Delayed disengagement from threat. This component refers to the attentional captivity by threat stimuli and how that captivity impairs the switching of attention to something else (Cisler & Koster, 2010). Therefore, evidence from experiment 1 (face-T1, neutral-T2) in the series of attentional blink tasks and differences in saccade onset-related trajectories in the eyetracking study will be discussed. (The ssVEP study was designed to investigate sustained attention toward threat rather than temporal components of bias like delayed disengagement).

It could be argued that a prolonged attentional blink following a threatening face in social anxiety indicates delayed disengagement. However, no results of this nature were found. Those high in social anxiety had no more difficulties in switching attention from an emotional target to a neutral target than low-socially anxious participants. From this experiment, it cannot be concluded that difficulties with disengaging attention away from threat are manifested in social anxiety.

The saccade curvature study could potentially highlight delayed disengagement as well. However, due to the uncertain sensitivity of the initial deviation (Ludwig & Gilchrist, 2002), this measure was only explored after-the-fact. Nevertheless, the findings are potentially revealing mechanisms of delayed disengagement. Overall, both anxiety groups deviated their curvature toward emotional faces on fast-onset saccades and away on slow-onset saccades. However, high-socially anxious participants always initiated their gaze to the emotional first. Seeing as this effect is also found on slow-onset saccades, delayed disengagement could be argued, as they take longer, relative to participants lower in social anxiety, to switch attention from the emotional information to typical emotion-processing patterns.

Taken together, these studies provide at best very modest support for the idea that attention bias in social anxiety is characterised by difficulties in attentional switching, or consequently, delayed disengagement. This matches the existing literature, which proposes that the link between anxiety and delayed disengagement is only present in certain contexts (Armstrong & Olatunji, 2012).

Attentional avoidance. Attentional avoidance is not so much a temporal component, as it is used to refer to a preference to attend to stimuli in a spatial location away from the potential threat (Cisler & Koster, 2010; Koster et al., 2006). Thus, presenting two stimuli simultaneously would examine attentional avoidance, which is why the saccadic curvature experiment lent itself well for this. There was a general avoidance of emotional stimuli at slow-onset saccades for all participants. However, the measure of angle also indicated a fast-acting avoidance mechanism for high-socially anxious participants, whereas no avoidance for fast-onset saccades of low-anxious participants was found. Because fast-onset saccades are thought to be stimulus driven (Van Zoest & Donk, 2006), perhaps this attentional avoidance mechanism could not act fast enough to be replicated in the other measures. Nevertheless, there is some indication that attentional avoidance plays a role in social-anxiety related attention bias.

Theme 1 summary. The present experiments only found partial support for facilitated attention, delayed disengagement, and attentional avoidance for emotional faces in social anxiety. However, more research needs to be done in order to conclude whether attention bias for emotional faces in social anxiety underpinned facilitated orienting toward threat, delayed disengagement or difficulties with disengaging attention away from threat, and/or attentional avoidance of threat. Suggestions for future directions following the present findings will be discussed later in this chapter.

6.2.2 Theme 2: Methods

The second theme revolves around the aim of exploring experimental techniques beyond the dot-probe which allow a closer investigation into attention bias in social anxiety. The lack of clear-cut findings from the experiments conducted within this thesis might easily mislead one to consider the tasks unsuitable for further study into attention bias. However, it is important to keep in mind that none of these experiments have been frequently used to explore attention bias in social anxiety. As such, there is much to learn from these experiments that can inform further investigation using these tasks. With this in mind, the following section will focus on what the methods offered as used here as well as methodological limitations and suggestions for future work to ensure that these methods are used to their full potential.

By far the largest limitation of the attentional blink experiments was that the tasks were too easy. Especially in the child study, but also in experiments 1 and 2 in adults, there was a strong ceiling effect of performance. This was despite extensive piloting and adjustments to the paradigm. It is likely that this ceiling effect stems from human's expertise for, and sensitivity to, faces (Kanwisher, 2000), as well as the tasks' targets and distractors perhaps not being similar enough (Müsch et al., 2012). To achieve larger and more normally distributed variance in the data to analyse individual differences better, future attentional blink studies with faces should aim for more task difficulty, for example by backward-masking the targets. Experiment 3 of chapter 2, which chronologically took place after the child study, implemented these suggestions. Indeed, the data for experiment 3 met assumptions for analysis. A further consideration is that disgusted faces may be less threatening than angry faces, and are therefore less successful for investigating threat bias. In conclusion, the attentional blink, with the right adjustments, has the benefit to potentially unlock the time course of attentional bias toward emotional faces in relation to facilitated attention as well as disengagement from threat in both children and adults but careful consideration must be given to task parameters to ensure an appropriate level of difficulty.

The saccadic curvature paradigm has the potential to look at early stages of facilitated attention to threat, later processing stages of delayed disengagement, as well as top-down driven spatial avoidance. To unlock this potential, a few suggestions are proposed. Firstly, the degree with which distractor items capture attention should be increased. As noted in chapter 4, a previous study was conducted with smaller images which were more peripherally located. This study found no effects. It can therefore be argued, that bottom-up saliency could be improved further by increasing the image size and placing the images more centrally, closer to the vertical saccade trajectory. A second suggestion for future studies is procedural. Whilst this design was unique in that it looked at fast-onset versus slow-onset saccades for each participant individually, the cue, target, and distractors appeared simultaneously on every trial. By varying the stimulus onset asynchrony as in previous studies (e.g. Nummenmaa, Hyönä, & Calvo, 2009; McSorley & Van Reekum, 2013), saccades driven by task-characteristics could be analysed alongside individual onset-times.

The ssVEP study was designed to investigate sustained attention toward threat under different task-demands (see theme 3). A benefit of the paradigm was that the evoked response emerged after brief stimulation, which makes this design powerful and efficient. Given how novel the method is, the results are insightful, but further improvements to the task could be made. One of the suggested adjustments would be implementing a different face condition. Currently, the stimulus changed after 30 flickers. Including a condition during which the face is changed at every flicker (see for example Gerlicher et al., 2013), would provide an individual baseline for each participant against which adaptation to repeated emotional stimuli could be measured. Furthermore, the current design used conditional randomisation of stimulus presentation order. The conditions were that relative to the presented stimulus, the subsequent stimulus had to be either the same identity, or express the same emotion. After stimulus presentation, it takes a few seconds for the ssVEP response to establish (Rossion, 2014; Rossion & Boremanse, 2011). For this reason, the first trial was omitted from the analysis. Due to the randomisation of order, there was no control over which stimulus was presented in the first trial, essentially leading to missing data for every participant. Future designs could include a neutral face at the beginning, which only serves for the ssVEP response to be evoked. With these minor adjustments to the approach the ssVEP offers a powerful and exciting tool for examining whether sustained attention toward threat is maintained in social anxiety,

Reflecting on this second theme of methods, with a few adjustments as highlighted the methods used in this thesis could offer unique insights into how emotional face processing exactly is impaired or preferentially allocated in social anxiety and to contribute to the fields of individual differences and social cognition more broadly.

6.2.3 Theme 3: Attentional set

Whereas themes 1 and 2 were driven by the aims of this thesis, theme 3 follows from reflection of the overall patterns found in the data. To summarise: task demands matter. That is to say, in this thesis overall, effects of social anxiety were only found when emotion was task-relevant.

For example, in the attentional blink task with explicit emotion judgement (face-T2; chapter 2, experiment 2), low socially anxious participants were not as accurate for happy faces as they were for disgusted faces, whereas high socially anxious participants processed both happy and disgusted faces accurately. However, in the implicit task (experiment 3) social anxiety related differences did not emerge. Furthermore, in the child sample (explicit emotion task) social anxiety related differences were found as well, this time as a main effect. In contrast, in the eye-tracking study (chapter 4) there was some evidence of social anxiety related attentional avoidance and perhaps delayed disengagement, as described above, but these findings were subtle at most. Finally, a social anxiety related effect emerged in the ssVEP study (chapter 5) which was designed with this task-relevance in mind. Again, social anxiety related differences were only found when emotion was task relevant. It would appear therefore that attentional biases may only surface when participants have a specific attentional set which promotes scanning of the environment for emotion.

The idea that task demands may affect attentional biases is consistent with an emerging body of research demonstrating that task relevance is important for performance of emotional-attention tasks. For example, Stein et al. (2009) found a stronger attentional blink for fearful than for neutral faces when the emotion was task-relevant, but not when the emotion was task-irrelevant., It has recently been suggested that inconsistencies in the literature regarding anxiety-related attention bias might exist, at least in part, because of differences in the task-relevance of emotional stimuli (Dodd, Vogt, Turkileri, & Notebaert, 2016).

A recent theory (Richards, Benson, Donnelly, & Hadwin, 2014) provided one explanation for how task-relevance might affect attention. For biases that occur during early stages of attentional processing, the terms hypervigilance and facilitated orienting might be confusing. These terms are often used interchangeably (e.g. Bar-Ham et al., 2007). However, Richards et al. (2014) proposed that early attentive biases can be divided into two distinct components that are unlikely to occur simultaneously: 1) hypervigilance and 2) selective attention. The review paper by Richards and colleagues provides models of each mechanism under which the facilitated attention component discussed in this thesis acts differently. Under hypervigilance, which is related to alertness for threat signals and scanning of the environment, facilitated attention leads to enhanced threat detection. When attention is narrowed onto threat under selective attention however, facilitated attention is responsible for rapid engagement with threat rather than enhanced detection. Outcomes of impaired attention are also different under hypervigilance than under selective attention. Under selective attention, when threat is present but task irrelevant, impaired attention can be reflected by attentional capture by threat or delayed disengagement from threat. However, under hypervigilance, when threat could be task relevant too, but also absent, impaired attention is reflected in difficulties focusing attention on the task. It is interesting to explore the results of the current experiments with these models in mind and have a closer look at task-relevance of threat.

In the saccade curvature task, threat was present but a) task-irrelevant, and b) not in a task-relevant location. Social anxiety related biases therefore would have emerged under conditions of hypervigilance, where the environment is excessively scanned. Under hypervigilance, impaired attention is highlighted by difficulties focusing on the task altogether and not necessarily by attentional capture by threat or delayed disengagement, which could explain why no strong evidence for either was found. From the ssVEP task, designed with task demands in mind, it could be derived that facilitated attention under selective attention may not only result in faster and better performance on eye-tracking tasks as proposed by Richards et al. (2014), but also to reduced neural adaptation, and therewith sustained emotional attention.

However, a number of findings from this thesis do not align particularly well with the predictions of the Richards et al. (2014) model. When threat was task relevant in the attentional blink task (chapter 2, experiment 2), the model would predict that impaired attention would be reflected in threat capture, but the high socially anxious participants did not show a preferential capture of disgusted faces. Similarly, when threat was present but task-irrelevant in the attentional blink (chapter 2, experiment 3), the model would predict social anxiety should affect tasks performance, but there was no social anxiety related general performance deficit.

Nevertheless, it is important to highlight that the studies in this thesis were not designed to address the effects of task relevance per se and this was not one of the original aims of the thesis. However, the overall pattern of results presented here together with the recent progress in theory and research discussed suggests that is a promising area for future research which may help to reconcile seemingly inconsistent findings in the field.

Theme 3 conclusion. In hindsight, the overall pattern of results reported in this thesis could potentially be explained by the varying task-demands affecting top down mechanisms of attention. Overall, stronger anxiety-related effects were found if participants' attention was directed toward the emotion by task-demands. Fewer convincing anxiety related effects were found when emotion, or threat specifically, was task irrelevant. Different task demands and characteristics could evoke different attentional sets, such as alertness in hypervigilance or preferential processing in selective attention. It is proposed that future studies should investigate under which conditions attention bias in social anxiety are present.

6.2.4 Clinical implications

Attention bias research has led to the development of Attention Bias Modification (ABM) training (Bar-Haim, 2010). A common task used in ABM is a modified dot-probe task, in which the probe is, for example, relatively more often presented under the non-threat than the threat-stimulus, to train attentional avoidance of threat (Bar-Haim, 2010; MacLeod & Clarke, 2015). There is some promising evidence that ABM can reduce threat bias in anxiety even after a single session, but the findings are not consistent. Specifically regarding social anxiety, a systematic review identified that ABM had only small effects on social anxiety symptoms and attention bias, that these effect sizes were moderated by factors such as study design and trait anxiety, and that ABM had no long-lasting effects (Heeren, Mogoașe, Philippot, & McNally, 2015).

To improve ABM, it is necessary to have a clear understanding of the specific attentional processes that are impaired in anxiety (Kuckertz & Amir, 2015). For example, if a clear social anxiety-related pattern of attentional avoidance of threat had been found in the saccadic curvature experiment (chapter 3) this would suggest that ABM should focus on decreasing attentional avoidance of threat. A recently proposed framework of the link between ABM and cognitive mechanisms such as initial orienting and threat avoidance further confirmed this suggestion (Mogg & Bradley, 2016).

Clarifying the nature of attentional biases in social anxiety was one of the aims of the work presented here. However, given that the findings are not clear-cut, it would be premature to make recommendations for changes to current interventions. Instead, the findings highlight the complexity of attentional biases in social anxiety and the relatively subtle nature of these biases, which may be found only under specific task conditions. Further research continuing to use novel and imaginative approaches is required to really fine-tune our understanding of attentional biases in social anxiety. It is hoped that the work and recommendations presented here provide a small step towards achieving that.

6.2.5 Limitations and directions

In the discussion of themes above, limitations relative to the experimental techniques used were highlighted and discussed, but a few general limitations remain.

- It must be acknowledged that sample sizes for each study were relatively small: $N = 30 – 39$. Moreover, due to the classification of low- and high-socially anxious groups based on suggested cut-off scores, group sizes were as small as $n = 12$. Consequently, whereas a lack of group effects or interactions with other variables has been reported as evident null-results, it is possible that the studies were underpowered and effects were not detected because of type-II errors.
- There was a reliance on student samples and questionnaire measures of social anxiety. The experiments offered here can potentially be extended to work with clinical participants. However, given the relative complexity of working with a clinical sample, it is important that task parameters are fine-tuned to ensure a robust design first. The work presented here represents a step toward this but further work in non-clinical populations to extend and replicate the current tasks

before extending these methods to research with clinical samples is recommended.

- The poorer emotion recognition in high socially anxious children relative to low socially anxious children was not found in the adult population. This may suggest that this subtle deficit plants a seed for attention bias in adulthood, but the cross-sectional design cannot rule out that this difference arose from certain confounds, such as variations between the tasks or testing environments. Longitudinal studies tracking the development of attention and emotion recognition skills in socially anxious children and adults is required to examine the hypothesis that early emotion recognition difficulties affect anxiety and attention bias later in life.
- Perhaps more definitive conclusions for the thesis overall would have been reached had the thesis had been focused on a single task as the task design and parameters could have been tweaked following the results of each study. Instead, a range of novel approaches to studying attention bias in social anxiety are introduced. Recommendations regarding how each of these could be improved upon and utilised in future work have been provided under theme 2.

6.3 **Conclusion**

This thesis aimed to provide a theoretical and experimental expansion of what is known about attentional biases in social anxiety using a mixed-method approach across a series of studies. Taken together, despite the methodological challenges that need to be overcome to investigate the exact underpinning mechanisms further (chapters 1, 2, 3, 4, 5 and 6), this thesis reveals some evidence for social anxiety related hypervigilance toward threat, delayed disengagement from threat and attentional avoidance of threat. Nevertheless, the results were not clear-cut (chapters 1, 2, 3, 4, 5, and 6), but it was found that social anxiety in children may be associated with subtle deficits in emotion recognition (chapter 2). Facilitated attention toward social information in social anxiety depends on whether the emotional information is task-relevant (chapters 2, 4, 5 and 6), whereas avoidance of threat in social anxiety might be driven by top-down mechanisms such as cognitive control or attentional set (chapters 3 and 4).

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Appendix A

Social Phobia Inventory (SPIN; Connor et al., 2000).

Social Phobia Inventory (SPIN)

Participant Number: Date:

Please read each statement and select a number; 1,2,3,4 or 5 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any one statement. This assessment is not intended to be a diagnosis. If you are concerned about your results in any way, please speak with a qualified health professional.

1 = Not at all 2 = A little bit 3 = Somewhat 4 = Very much 5 = Extremely

1	I am afraid of people in authority	1	2	3	4	5
2	I am bothered by blushing in front of people	1	2	3	4	5
3	Parties and social events scare me	1	2	3	4	5
4	I avoid talking to people I don’t know	1	2	3	4	5
5	Being criticised scares me a lot	1	2	3	4	5
6	I avoid doing things or speaking to people for fear of embarrassment	1	2	3	4	5
7	Sweating in front of people causes me distress	1	2	3	4	5

8	I avoid going to parties	1	2	3	4	5
9	I avoid activities in which I am the centre of attention	1	2	3	4	5
10	Talking to strangers scares me	1	2	3	4	5
11	I avoid having to give speeches	1	2	3	4	5
12	I'd do anything to avoid being criticised	1	2	3	4	5
13	Heart palpitations bother me when I am around people	1	2	3	4	5
14	I am afraid of doing things when people might be watching	1	2	3	4	5
15	Being embarrassed or looking stupid are among my worst fears	1	2	3	4	5
16	I avoid speaking to anyone in authority	1	2	3	4	5
17	Trembling or shaking in front of others is distressing to me	1	2	3	4	5

Appendix B

Brief Fear of Negative Evaluation, Straightforwardly worded (BFNE-S; Collins et al., 2005; Rodebaugh et al, 2011).

BFNE-S

ID: Date:

Please read each statement carefully and indicate how characteristic it is of you according to the following scale:

1 = Not at all characteristic of me
2 = Slightly characteristic of me
3 = Moderately characteristic of me
4 = Very characteristic of me
5 = Extremely characteristic of me

1	I worry about what other people will think of me even when I know it doesn't make any difference	1	2	3	4	5
2	I am frequently afraid of other people noticing my shortcomings	1	2	3	4	5
3	I am afraid that others will not approve of me	1	2	3	4	5
4	I am afraid that people will find fault with me	1	2	3	4	5
5	When I am talking to someone, I worry about what they may be thinking about me	1	2	3	4	5
6	I am usually worried about what kind of impression I make	1	2	3	4	5
7	Sometimes I think I am too concerned with what other people think of me	1	2	3	4	5
8	I often worry that I will say or do the wrong thing	1	2	3	4	5

Appendix C

Social Anxiety Scale for Children-Revised (SASC-R; La Greca & Stone, 1993).

This is not a test, there are no right or wrong answers. Please answer each a honestly as you can.

Use these numbers to show HOW MUCH YOU FEEL something is true for you:

1 = Not at all
2 = Hardly ever
3 = Sometimes
4 = Most of the time
5 = All the time

Now let's try these sentences first. How much does each describe how you feel?

a. I like summer vacation…. 1 2 3 4 5
b. I like to eat spinach…. 1 2 3 4 5

1. I worry about doing something new in front of other kids…….. 1 2 3 4 5
2. I like to play with other kids……………………………………. 1 2 3 4 5
3. I worry about being teased………………………………………1 2 3 4 5
4. I feel shy around kids I don't know…………………………….. 1 2 3 4 5
5. I only talk to kids that I know really well………………………1 2 3 4 5
6. I feel that other kids talk about me behind my back……………1 2 3 4 5
7. I like to read…………………………………………………….. 1 2 3 4 5
8. I worry about what other kids think of me..................................1 2 3 4 5
9. I'm afraid that others will not like me………………………….. 1 2 3 4 5
10. I get nervous when I talk to kids I don't know really well……. 1 2 3 4 5
11. I like to play sports……………………………………………..1 2 3 4 5
12. I worry about what others say about me……………………….1 2 3 4 5
13. I get nervous when I meet new kids……………………………1 2 3 4 5
14. I worry that other kids don't like me………………………….. 1 2 3 4 5
15. I'm quiet when I'm with a group of kids …………………….... 1 2 3 4 5
16. I like to do things by myself.. 1 2 3 4 5
17. I feel that other kids make fun of me.. 1 2 3 4 5
18. If I get into an argument with another kid, I worry that he or she will not like me.. 1 2 3 4 5

19. I'm afraid to invite other kids to do things with me because they might say no.. 1 2 3 4 5
20. I feel nervous when I'm around certain kids.............................. 1 2 3 4 5
21. I feel shy even with kids I know well... 1 2 3 4 5
22. It's hard for me to ask other kids to do things with me.............. 1 2 3 4 5